SCOTTISH HOSPITALS INQUIRY

Hearing Commencing 26 February 2024

Bundle 13 – Miscellaneous

Volume 3

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NHS LOTHIAN

Private Board Meeting
14 October 2020

Director of Finance

Board Position Paper for Public Inquiry

1 Purpose of the Paper

1.1 Lord Brodie, Chair of the Public Inquiry, has asked the Board for its initial view of what was wrong with the new hospital, the Royal Hospital for Children and Young People, the Department of Clinical Neurosciences, and Child and Adolescent Mental Health (the "facility"). The purpose of this paper is to give the Board an opportunity to review and approve its response to that request.

1.2 Any member wishing additional information should contact the Director of Finance in advance of the meeting.

2 Recommendations

2.1 The Board is invited to review this paper and approve its release in its entirety to the Public Inquiry.

3 Discussion of Key Issues

3.1 In an introductory meeting with Lord Brodie and David Anderson, Secretary to the Inquiry, it was agreed that a position paper from the Board would be welcomed in support of the information that the Inquiry requested.

3.2 Specifically the Inquiry team has asked the Board to identify the inadequacies in the key building systems that gave rise to impacts on patient safety and care. This request is relevant to paragraphs 1, and part of paragraphs 2 and 7 of the terms of reference of the Inquiry (Appendix 1).

The Inquiry team have asked that the list should describe:

- the issues in as much detail as possible (at least so as to be comprehensible);
- an indication of when they came to light (during construction, during commissioning, after handover etc);
- the impact, both at a functional/ maintenance level and at a patient care level.

3.3 The immediate response to the request is that by the time the Board was due to open the completed facility in July 2019, having taken possession from its private sector partner IHSL and commenced paying for the facility in February 2019, the only issue with the facility precluding the occupation of the building by patients was, in the Board's view, the incorrect number of air changes within parts of Paediatric Critical Care.

3.4 The Board had commissioned IOM, ventilation experts, to carry out independent testing, and that testing identified the issue. At the time it was the Board's view that the other issues with air handling units and ventilation which IOM identified could be rectified while the building was occupied. In the event, these have subsequently been rectified by the construction contractor, Multiplex. However, it was the incorrect number of air changes within single and multi-bed bays within Paediatric Critical Care that caused the Cabinet Secretary to delay the opening of the hospital.

3.5 Notwithstanding the Board's view of the patient safety issue which led to the delay in opening the hospital there were other technical issues identified throughout the course of the Project. The key technical issues that could have had an impact on patient safety and care are summarised in Appendix 3. Appendix 3 is not exhaustive and the Board can provide more information on other technical issues as required by the Inquiry.

3.6 At the initial meeting with Lord Brodie and the Secretary to the Inquiry, the Board was given an opportunity to submit a "narrative" which sets out the Board's view of the context in which the ventilation issues (and other issues addressed through the Settlement Agreement that was agreed between the Board and IHSL) arose. It is proposed that this paper, being the Board Position Paper for the Public Inquiry will be provided in its entirety to Lord Brodie once considered by the Board.

3.7 The Board has previously commissioned an internal audit by Grant Thornton. That audit determined why the issue of air changes for Paediatric Critical Care was missed and identified issues for the Board's system of internal control from which the Board could learn lessons.

4 Background

4.1 In 2008 the Board approved the business case for a new Children's Hospital. This was to be funded with capital from the Scottish Government and procured via an established procurement framework. This case concluded that the agreed location for the hospital was to be on the Royal Infirmary of Edinburgh (RIE) campus, attached to the Board's tertiary hospital, in support of the development of the RIE as a major trauma centre. In November 2010, the Project team was at the point of submitting a planning application and finalising the contract with BAM, the Principal Supply Chain partner, for the construction of the hospital to be completed by 2013.

4.2 However, the Scottish Government announced in November 2010 that there was no capital funding available and that the new facility would be revenue

funded. That is, it would take the form of a Public Private Partnership (see below).

4.3 Immediately following this announcement, the Scottish Government confirmed that the hospital would now be financed, built, and maintained through the new Non-Profit Distributing model (NPD), developed by the Scottish Futures Trust (SFT). NPD is a form of Public Private Partnership (PPP), unique to Scotland, in which funding for the project is provided by the private sector via loans which are repaid over the contract term. In NPD, the private sector's return on investment is limited by a cap that forms part of the bid submission, with further profits above the cap returned to the public sector. It was also announced by the Scottish Government that the new hospital would also include the Department of Clinical Neurosciences (DCN). This was welcome news for the Board as the inclusion of DCN completed the service requirement to deliver a full major trauma service at the RIE. A full timeline for the Project is included in Appendix 2.

5 Site constraints

5.1 The Board had, during the process of developing its plan, already identified that there were a number of site constraints for the delivery of a new Children's Hospital on the selected site. These constraints included the physical space available, the topography of the site, and the need to adjoin and physically integrate with the existing RIE. However, despite these constraints, it was the Board's view that the benefits offered by delivering a major trauma centre, with its safety and quality benefits, adjacencies and proximity to University teaching facilities, outweighed the disadvantages of the constraints.

5.2 The decisions to use the NPD model and to include DCN added complexity. The project would now involve parties that would not have been involved in a traditionally funded capital project. Furthermore, the physical scale of the project was increased by including DCN, and this placed more pressure on an already constrained site. Taken together with the commercial considerations, these factors increased the risk profile not only for this project but also for the existing PFI contract for the RIE. It is understood by the Board that this project would be the first PPP-type project to be delivered on an existing PPP site (the RIE was a first generation Private Finance Initiative facility), with different contracts and private sector partners for each.

5.3 Nonetheless, the Board welcomed the announcement that the new facility was going to receive funding and therefore would be able to proceed, given the limitations of the facilities at the existing Children's Hospital and Department of Clinical Neurosciences. The Board accepted the Scottish Government's policy decision that it was to be funded by the new NPD model and formed a multi-disciplinary Project Team and governance structure to take the procurement forward, supported by external technical, legal and financial advisors.

5.4 One of the key principles of PPP models is that the public sector is essentially procuring a service by specifying a set of outputs that the chosen private sector partner must deliver, which includes the creation of an asset to be designed, built and maintained during the operational period. The risk that the design and subsequent construction of the asset will meet the output specification rests with the private sector partner.

5.5 The link below to the SFT website explains the NPD model in more detail:

https://www.scottishfuturestrust.org.uk/storage/uploads/Explanatory_Note_on_the_NPD_Model_(Updated_March_2015).pdf

5.6 The remedies available to a board if the asset fails to meet the specification would be to refuse acceptance of the building and not pay for it, or accept the building and to apply contractual remedies, for instance payment deductions. In reality, a board's priority is the delivery of a hospital and its ability to walk away from a project if the contractor fails to deliver the specification is questionable.

5.7 The NPD model is similar to other PPP models in that it utilises a contractual vehicle called a Special Purpose Vehicle (SPV) to deliver the overall requirements. This SPV is set up to receive loans from both senior debt lenders (such as banks or pension funds) and risk-bearing debt from other investors. The SPV holds and manages the contracts to construct the asset and deliver hard facilities management services and life cycle services for the building once constructed.

5.8 By the time the NPD funding route was announced by the Scottish Government, the Board had already developed a design for the new Children's Hospital. The Board took the decision to make use of the design work already done to create a 'Reference Design' to be provided to prospective bidders under the NPD procurement process. The use of the Reference Design went beyond what is usually provided to bidders, known as an 'Exemplar Design', being an architectural representation of the Board's requirements. However, both a Reference Design and an Exemplar Design are indicative of one possible visualisation amongst many.

5.9 Our specific and non-negotiable requirements represented graphically in the Reference Design were:

1. **Site constraints** – required by Consort Healthcare ("Consort") (the Board's private sector partner for the RIE PFI contract) and accepted by the Board and the Scottish Government when enshrined in an agreed Supplementary Agreement ("SA6"). These requirements gave no latitude or licence to bidders which they would normally have in an Exemplar Design. In physical terms this meant very specific points of access and egress both during construction and in the final development, set points for utilities and drainage connections, predetermined physical connections with the RIE and a number of working restrictions during the construction phase.

2. **Planning in Principle** (PiP) **-** granted by the City of Edinburgh Council (CEC) dictated the building's height and floor area.

3. **Operational Functionality -** The relationship and adjacencies between hospital departments and between rooms within hospital departments, the quantity, description and area (m2) of those rooms and spaces. This is known as **"Operational Functionality"**, for which the Board retains design responsibility.

The Board, with the full support of SFT as 'owners' of the NPD model, issued the Reference Design with the suite of tender documents to bidders. However, it was made clear to bidders that this was being issued for information only.

5.10 Before the procurement process could commence, the Board required to carry out major preparatory work. Firstly, given that the intended site for construction of the new facility was on land leased by the Scottish Ministers to Consort, a contract variation had to be agreed with Consort to secure the land required. This transaction was enacted in a Supplementary Agreement ('SA6') between the Board and Consort.

5.11 Secondly, significant enabling works were required to prepare the site, such as roads and flood defences. The enabling works were designed and commissioned by Consort. This was agreed via a further Supplemental Agreement ("SA7") between the Board and Consort. The enabling works by Consort were concluded in February 2013, at which point the Board was able to commence procurement of the new facility.

6 NPD model/ Project difficulties

6.1 This was the first acute hospital project to utilise the new NPD model. SFT provided standard generic procurement documentation, including a contract (known as a 'Project Agreement') for the project, and prescribed an overall procurement approach to be taken, using the 'Competitive Dialogue' process. Competitive Dialogue is an EU-defined process for use in more complex procurements where the final specification is the subject of discussion and refinement between the parties prior to contract award. Use of the standard documentation and approach was a condition of the revenue support to be provided by the Scottish Government for the project. This standard documentation and approach were then augmented by the Board and its advisors, with amendments signed off by SFT, to render it specific to the new facility.

6.2 One aspect of the procurement approach to be taken was the bid evaluation process, which stipulated that qualitative aspects of each bid would be given a percentage weighting of 40% in overall evaluation, with a 60% weighting applied to price. The Board's preference would have been to invert these weightings to emphasise quality, but this was not SFT's agreed weighting for NPD funded projects. The Board compensated for this by introducing a

number of mechanisms into the evaluation that maximised the effect of the quality evaluation. For example, commercial and financial qualitative aspects of submissions were included in the price score rather than the quality score. A pass/fail system was used for a large proportion of the quality criteria, with a 'pass' equating to what was viewed as a compliant and acceptable proposal.

6.3 The combination of the quality and price score produced a result that indicated the 'most economically advantageous tender', that is, the bid that produced the highest overall score given the weightings stipulated. The outcome of this process was to identify IHSL as the preferred bidder. At that time, the evaluation process did not identify any issues of non-compliance with IHSL's bid.

6.4 Once IHSL were awarded preferred bidder status, a period of development was entered into to agree the final details of the contract and specification. In Competitive Dialogue procurements, this period should not be used to conduct further negotiation, only to clarify and finalise. However, in this case, a considerable amount of design development was required to produce the clarity required. SFT had agreed with the Board a challenging timeline to sign the contract (known as 'Financial Close' in NPD projects); this, combined with Multiplex (IHSL's construction contractor) advising that they would not undertake any further design development without a contractual commitment, led to Financial Close in February 2015. IHSL had passed design risk for construction to Multiplex and so supported Financial Close. The Board did so in the knowledge that certain aspects of design development were still to be completed in the post-Financial Close period. At the time of Financial Close, IHSL's contractual commitment to the Board for completion of the hospital was July 2017. Multiplex were liable for liquidated damages to IHSL if this completion date was missed. IHSL were liable to commence their debt repayments to senior lenders further to the contractual completion date in July 2017, even if it was missed.

6.5 Initially there was good progress made on site, but by 2016 it was clear that Multiplex were behind programme due to a number of major issues, including sub-contractor failure. The Project Team, including the Board's technical advisers, during the course of that year became increasingly aware of evidence of cost cutting on site, and potential as well as actual compromises to the Board's construction requirements as set out in its output specification. This led to a deterioration in relationships and increasing scrutiny of workmanship and compliance with specification by the Project Team. By late 2016/early 2017 there were two specific issues that the Project Team had identified and escalated which could not be resolved with either IHSL or Multiplex: the pressure regime for multi-bedded rooms (for which there is no reference in the relevant Scottish technical guidance) and the High Voltage distribution systems.

6.6 The requisite technical guidance is called the Scottish Health Technical Memorandum (SHTM) and is issued by Health Facilities Scotland on behalf of the Scottish Government. The SHTM defines technical standards but some of these were found to be outdated, imprecise and contradictory. This lack of

clarity contributed to many of the subsequent technical disputes in the project. These standards were mandatory for this NPD project, and formed part of the specification that IHSL was obliged to meet. However, as evidenced in the Internal Audit report and elsewhere, the SHTM was not consistent with other elements of the specification.

6.7 Despite active engagement with both IHSL and Multiplex by Board representatives, no agreement could be reached on the interpretation of the specification that should apply. In essence, IHSL and Multiplex believed they were in compliance and the Board did not.

6.8 In January 2017, IHSL formally notified the Board that it would be unable to complete the facility by the contracted date of July 2017. At the same time, IHSL also indicated to the Board that Multiplex had suffered significant losses on the Project. Prior to this date, there had been no acknowledgment by IHSL that the facility was unlikely to be completed by the contracted date.

6.9 Both parties engaged experts on ventilation in relation to the contractual obligations on the pressure regime for the multi-bedded rooms (and not air changes) and ultimately sought a legal opinion from Counsel on the matter. The Board was, reluctantly, on the brink of going to court for resolution when Multiplex indicated they wished to enter negotiations for a Settlement Agreement that would allow a solution to be found by mutual consent. A key consideration for the Board was the time, cost, and the uncertainty for delivery of the facility that would be created by such Court action. The parties agreed a set of principles that would underpin the Settlement Agreement that allowed Multiplex to progress with the rectification of the pressure regime for the multi-bedded rooms while the detail of the agreement was negotiated.

6.10 Under the terms of the contract, IHSL would not begin to receive payment for the new facility until it was available to the Board. Therefore, at this time, IHSL had no income with which to service their debt obligations to their senior lenders. Under the terms of IHSL's contract with Multiplex, IHSL could seek damages from Multiplex to replace the lost income that would allow debt service payments to commence and avoid a default under the terms of the loans with their senior lenders. However, while the process of agreeing the Settlement Agreement was taking place, the Board became aware that, as well as the losses Multiplex was facing on the Project, they had not been paying damages to IHSL.

6.11 As a consequence, IHSL faced financial distress and insolvency. If IHSL became insolvent, they would be in default of the contract, which may have led to their termination, leaving the Board to then complete the facility or to find another party willing to take over the contract. However, prior to the Board being in a position to exercise any termination rights under the Project Agreement, the Board are obliged under the terms of a direct agreement with IHSL's senior lenders to give them prior notice of an intention to exercise the termination rights. Following the service of such a notice, Senior Lenders have extensive rights to step-in and seek to resolve the default. This scenario, or any alternative approach such as Court action, would have

resulted in a timescale for completion of the facility that would have been completely unknown. Further, even if the Board were in a position to pursue termination under the terms of the project documents, the facility would only revert to NHS following agreement or determination of the applicable compensation payable to IHSL / Senior Lenders. The compensation would likely have been in excess of £150 million, a sum that would have had to be funded from the Scottish Government's capital programme. Avoiding this scenario became a key driver of the Settlement Agreement and the quantification of the settlement sum that it entailed.

6.12 Unfortunately, progress on site suffered a further severe setback in June 2018 when a major release of water occurred from what transpired to be a faulty crimped pipe joint. This further amplified the Board's concern over the quality of workmanship and lack of supervision by Multiplex.

6.13 For all parties, not least the Board, securing a negotiated Settlement Agreement was important to gain certainty on all aspects of the disputed items. Under the terms of the NPD contract, the Board and IHSL, once construction is complete, have a contractual relationship in the operational period for the facilities management and Life Cycle maintenance of the built hospital.

6.14 Prior to finalising the Settlement Agreement, the Project Team and the Board's technical advisers identified further issues that the Board considered to be non-compliances in relation to drainage, void detectors and heater batteries, all of which would require further remedial works. The Settlement Agreement ultimately covered 81 technical issues ranging in size and complexity. As noted, the key technical issues that could have had an impact on patient safety and care are summarised in Appendix 3. The Board can provide more information on the other technical issues as required by the Inquiry. To further preserve IHSL's financial stability, and to introduce a higher degree of certainty over completion timescale, the Board agreed that their own commissioning programme to facilitate commencement of clinical services would run concurrently with the remaining works.

6.15 The business case for a financial settlement to IHSL was agreed by the Scottish Government in February 2019. The Settlement Agreement was signed in February 2019, signifying formal completion of the facility and allowing the flow of payments from the Board to IHSL to commence. However, the agreed works to address the various outstanding issues would continue until June 2019, at which point it would be possible for the Board, its staff and patients to occupy the facility.

7 Delay to the Hospital Opening

7.1 Immediately prior to the June date at which full occupation was planned, the Board undertook a planned testing of the ventilation system (as well as other critical systems). This was undertaken by IOM, a specialist ventilation expert. Unfortunately, this could not be completed any earlier because the joint completion/commissioning programme was still ongoing and the facility was

still, in effect, a construction site. It is not possible to test ventilation systems while other work is ongoing. It was this testing that identified only 4 air changes in Paediatric Critical Care instead of 10 and led to the decision to delay the opening of the facility.

7.2 The Scottish Government subsequently commissioned NSS to produce two reports on Water, Ventilation and Drainage (September 2019) and Fire, Electrical and Medical Gas Systems (October 2019). An Oversight Board was established by the Scottish Government to oversee the findings of these reports, and to agree any action to be taken by the Board.

7.3 Most of the issues raised by NSS had already been identified by the Board in the construction and commissioning phases and remedial works put in place. However, there are four points where the Board continue to disagree with NSS's view, and it is the Board's view that none of these are considered material to the safe opening of the facility. They are as follows.

Water

7.4 Without formal guidance on methodology and how to interpret the results and with a lack of accredited laboratories to test the samples, the Board do not intend to test for fungi or mould.

7.5 NSS consider chlorine dioxide should be added to the backwash water tank to counter microbiological and biofilms development on filters. The Board do not deem this necessary but will consider new advice as it is produced and incorporate this into the water management plan as necessary. This position has been considered by the Oversight Board.

Fire

7.6 NSS's view is that remotely resettable fire and smoke dampers should be fitted to prevent the travel of smoke between sleeping accommodation areas where ducting leads to a corridor serving as an evacuation route. The Board maintains that this is not a requirement of SHTM-04-01. However, following consideration by the Oversight Board, these enhancement works were undertaken to reflect NSS's view at a cost of £2m.

7.7 It is NSS's view that all half leaf doors should be fitted with the same self-closing device as on the main leaf. The Board maintain this is not a requirement of SHTM-04-01. However, following consideration by the Oversight Board these enhancement works were undertaken to reflect NSS's view. The Board also consider these enhancements impair operational functionality.

7.8 The Board's views are shared by Richard Walker BEng(Hons), PhD, GIFire, consultant Fire Engineer.

8. Key Risks

8.1 The Board do not take the opportunity to learn from this project, leading to similar problems occurring in future projects.

9. Risk Register

9.1 The risk associated with the RHCYP/DCN hospital is already on the corporate risk register.

10. Impact on Inequality, Including Health Inequalities

10.1 Impact on inequality arising from the capital programme is reported through the business case and governance for each project.

11. Duty to Inform, Engage and Consult People who use our Services

11.1 This paper is providing a summary to support the conduct of a public inquiry.

12. Resource Implications

12.1 The overall resource implications of the changes and rectifications for the RHCYP/DCN have already been considered and approved.

Susan Goldsmith
Director of Finance
20 October 2020
[redacted]

List of Appendices

Appendix 1: Terms of Reference
Appendix 2: Timeline for Project
Appendix 3: Key Technical Issues

Cabinet Secretary for Health and Sport
Jeane Freeman MSP

Scottish Government
Riaghaltas na h-Alba
gov.scot

[redacted]

Issued via NHS Lothian Communications

r}_,J February 2020

Dear Patients, Parents and Carers

On the 17 September 2019, I announced that a Public Inquiry would be held into matters of concern at the Queen Elizabeth University Hospital Campus, Glasgow (QEUH) and the Royal Hospital for Children and Young People, Edinburgh (RHCYP).

On the 28 November 2019, I announced that the Inquiry would be chaired by the Right Honourable Lord Brodie QC PC, and that I had a statutory obligation to consult the Chair on the Remit and Terms of Reference. It is very important that the Remit and Terms of Reference are fit for purpose and in consultation with Lord Brodie, time has been taken to carefully consider the content.

Lord Brodie and I are committed to ensuring that the Inquiry addresses the concerns of those who have been affected by the delayed opening of the RHCYP. I would therefore like to take this opportunity to invite those who wish to do so, to provide their comments on the draft Remit and Terms of Reference attached at **ANNEX** A.

At this stage, I am specifically asking for comments on the attached document only.

When the Remit and Terms of Reference are finalised and the Inquiry is formally set up, Lord Brodie, as Chair of the Inquiry, is keen to hear from those affected, and his team will make the necessary arrangements to support this. It is important that these discussions are recorded as part of the evidence to the Inquiry and therefore independent of Scottish Ministers.

Lord Brodie and I are keen to move forward with the Remit and Terms of Reference in order that the Inquiry can be formally set up. I would therefore be grateful if you could respond, with any comments by Friday 13th March.

Comments should be provided on the Remit and Terms of Reference only to the following email address: [redacted]; or in writing to:

QEUH/RHCYP Sponsor Team
Scottish Government
St Andrew's House
Regent Road
Edinburgh
EH13DG

Kind regards

[redacted]

[redacted] **JEANE FREEMAN**

ANNEX A

Remit and Terms of Reference

Inquiry into the construction of the Queen Elizabeth University Hospital (QEUH), Glasgow and the Royal Hospital for Children and Young People (RHCYP), Edinburgh

Remit

The overarching aim of this Inquiry is to consider the planning, design, construction, commissioning and, where appropriate , maintenance of both the Queen Elizabeth University Hospital (QEUH), Glasgow and the Royal Hospital for Children and Young People (RHCYP) Edinburgh. The Inquiry will determine whether defects in key building systems occurred; if the occurrence of such defects could have been prevented; whether the buildings provide a suitable environment for the delivery of safe, effective person-centred care and; make recommendations to ensure that any past mistakes are not repeated in future NHS infrastructure projects. The Inquiry will do this by fulfilling its Terms of Reference.

Terms of Reference

1. To examine the key building systems in the QEUH and RHCYP, to identify whether and to what extent they were defective in the sense of:

    a. Not achieving the outcomes or being capable of the function for which they were planned, specified or designed.
    b. Not conforming to relevant statutory regulation and other applicable recommendations, guidance, and good practice.

2. To examine the arrangements for strategic definition, preparation and brief, and concept design, including the contractual structure adopted for the financing and construction of the buildings, to determine whether any aspect of these arrangements has contributed to such defects, in the sense of specific instances in which the key building systems are defective and which relate to risks to public health, patient safety and infection control.

3. To examine during the delivery of QEUH and RHCYP projects:

    a. Whether the Boards of NHS Greater Glasgow and Clyde and NHS Lothian put in place governance processes to oversee the projects and whether they were adequate and effectively implemented, particularly at significant project milestones;
    b. Whether operational management provided by the Boards of NHS Greater Glasgow and Clyde and NHS Lothian was adequate and effective for the scale of such infrastructure projects;
    c. The extent to which decision makers involved with the projects sought and facilitated the input and took account of the advice and information provided by, or available from, the clinical leadership team; infection control teams; estate teams; technical experts and other relevant parties to ensure that the built environment was optimal for the delivery of clinical care;
    d. Whether, the organisational culture within the Boards of NHS Greater Glasgow and Clyde and NHS Lothian encouraged staff to raise concerns and highlight issues in relation to the projects at appropriate times throughout the life cycles of the projects and;
    e. Whether failures in the operation of systems were a result of failures on the part of individuals or organisations tasked with specific functions.

4. To examine whether, based on the governance arrangements in place, national oversight and support of such large-scale infrastructure projects is adequate and effective.

5. To examine, during the life cycle of the QEUH and RHCYP projects, how the Boards of NHS Greater Glasgow and Clyde and NHS Lothian secured assurance and supporting evidence that:

    a. All necessary inspection and testing had taken place;
    b. All key building systems had been completed and functioned in accordance with contractual specifications and other applicable regulation , recommendations, guidance, and good practice and;
    c. Adequate information and training were provided to allow end-users effectively to operate and maintain key building systems.

6. To examine what actions have been taken to remedy such defects and the extent to which they have been adequate and effective.

7. To determine the physical and emotional effect of such defects on patients and their families (in particular in respect of environmental organisms linked to infections at the QEUH) and to determine whether communication with patients and their families supported and respected their rights to be informed and to participate in respect of matters bearing on treatment.

8. In the case of the QEUH, to examine whether the choice of site was appropriate or gave rise to an increased risk to patients of environmental organisms causing infections.

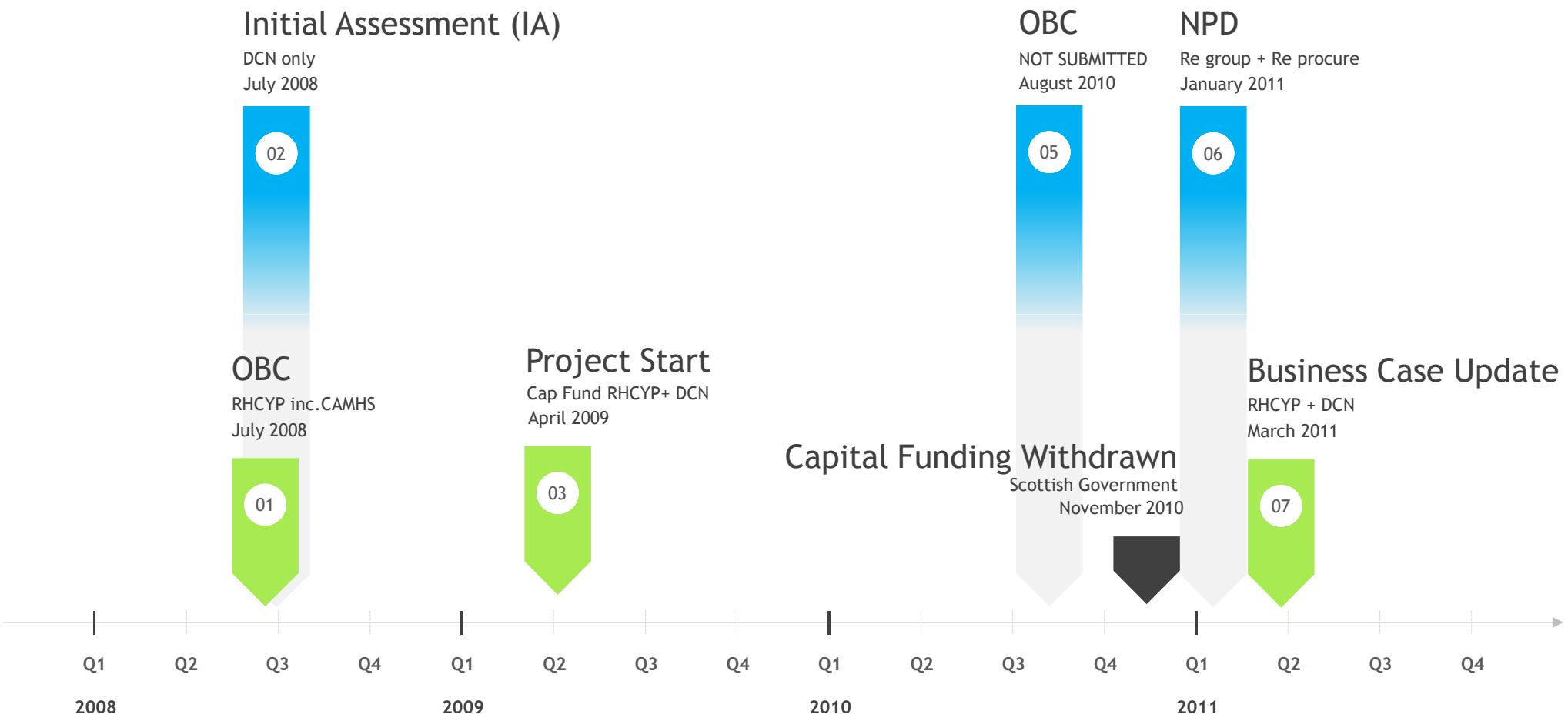
9. To examine whether there are systematic knowledge transfer arrangements in place to learn lessons from Healthcare construction projects and whether they are adequate and effective.

10. To examine whether NHS Lothian had an opportunity to learn lessons from the experience of issues relating to ventilation, water and drainage systems at the QEUH and to what extent they took advantage of that opportunity.

11. To report to the Scottish Ministers on the above matters, and to make recommendations identifying any lessons learnt to ensure that any past mistakes are not repeated in any future NHS infrastructure projects, as soon as reasonably practicable.

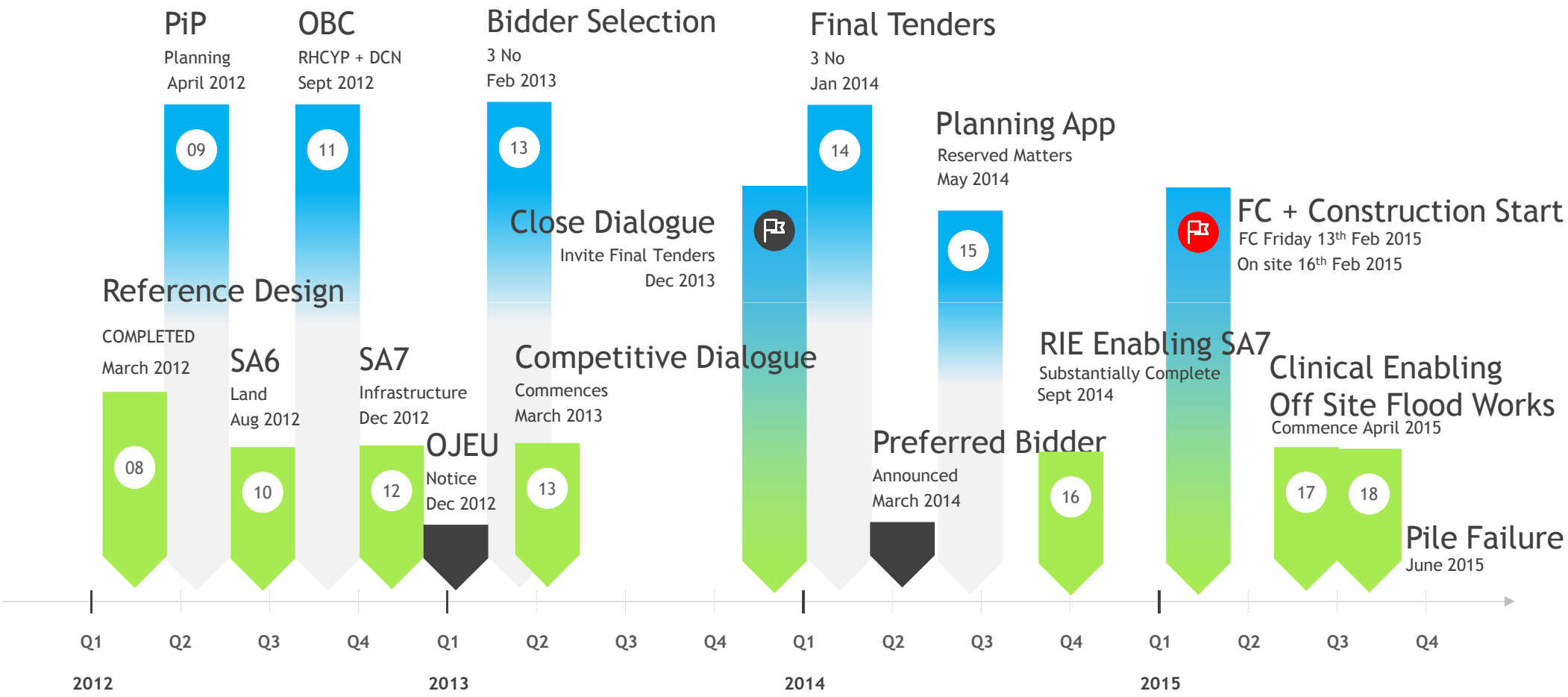
RHCYP + DCN Timeline

2008 - 2011



RHCYP + DCN Timeline

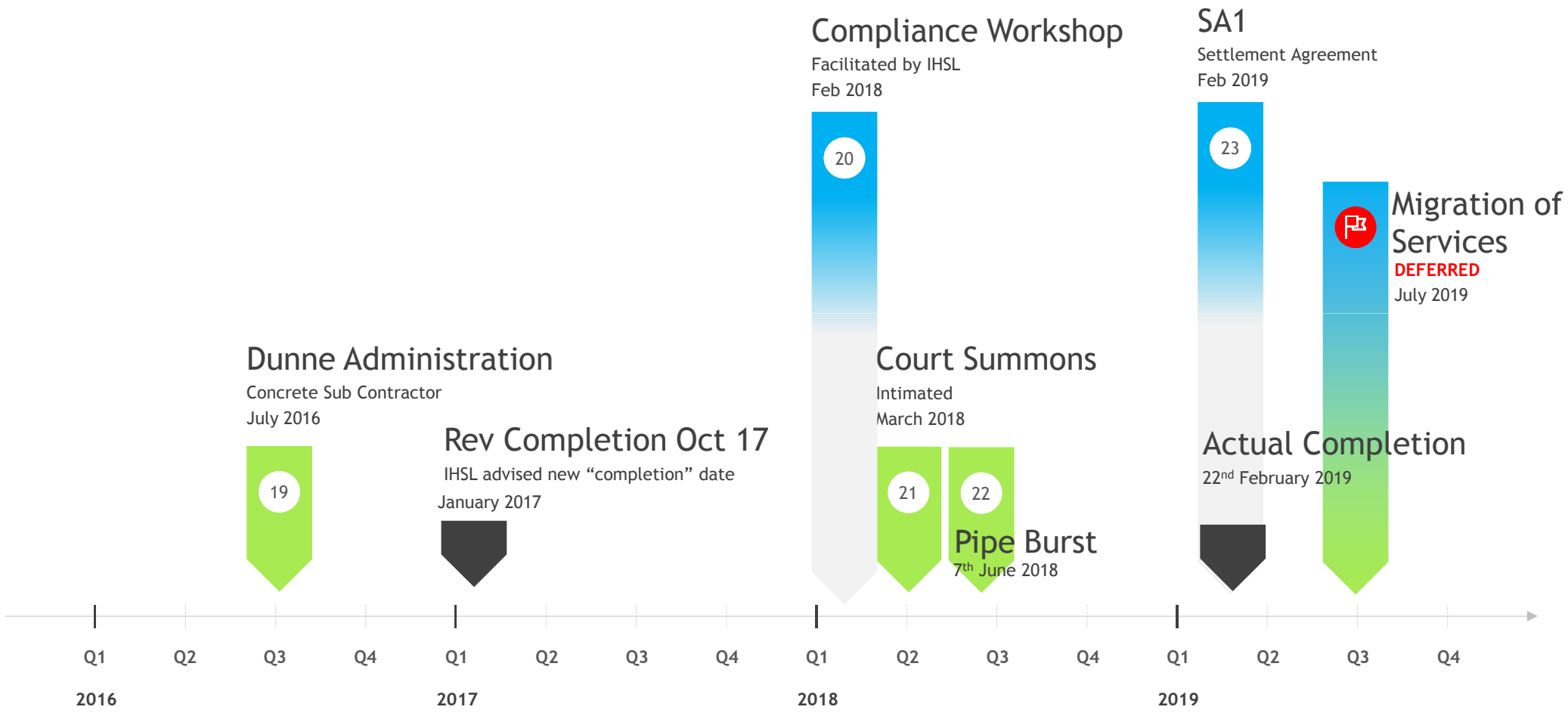
2012 - 2015



A47168969

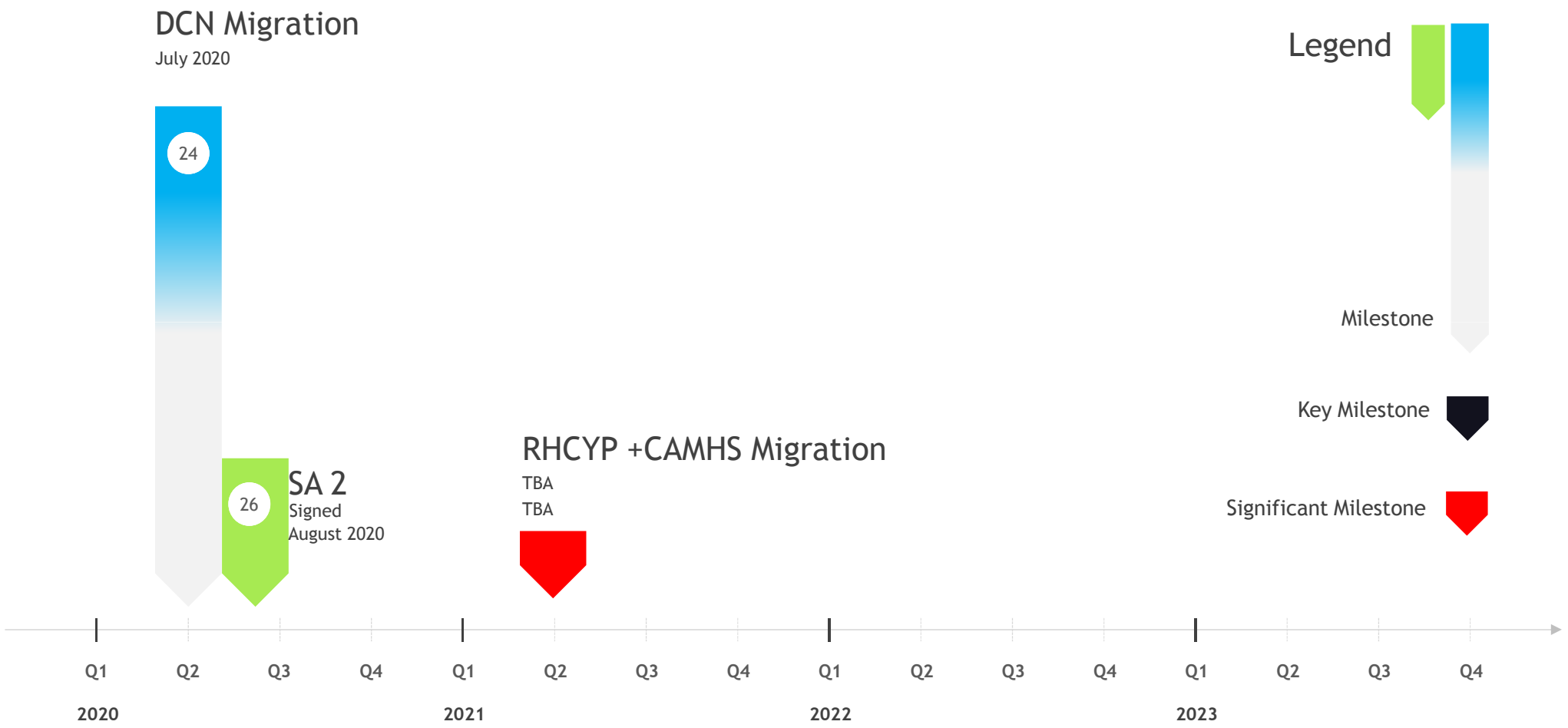
RHCYP + DCN Timeline

2016 - 2019



RHCYP + DCN Timeline

2020 - 2023



RHCYP + DCN – Selected Technical Issues from Preferred Bidder to Operational Phase which prejudice directly patient/staff/visitor safety

13 October 2020

Please note this is a summary list and does not include all the issues encountered that had a direct patient/staff/visitor safety implication. Information on any other technical issues can be made available on request.

Glossary

ac/h – air changes per hour

BCR – Board Construction Requirements

CAMHs – Child and Adolescent Mental Health

DCN – Department of Clinical Neuroscience

FC – Financial Close

HV – High Voltage

IPS – Isolated Power Supply

LV – Low Voltage

NHSL – NHS Lothian

PARU - Paediatric Acute Receiving Unit

PB – Preferred Bidder

PCo – Project Co

PCP – Project Co Proposals

PICU – Paediatric Intensive Care Unit

RCB – Residual Current Breaker

RDD – Reviewable Design Date

RDS – Room Data Sheet

SA1 – Settlement Agreement 1

SHTM – Scottish Health Technical Memorandum

SOA – Schedule of Accommodation

UPS – Un-interruptible Power Supply

Table 1 – Table of Technical Issues

Item	Date	Issue	Description	Consequences	Steps taken to remedy
001	June 2019	**Critical Care – non compliant ventilation system**	During the NHSL independent validation of the critical ventilation systems, air change rates were found not to meet current guidance for the Critical Care Areas.	Potential increased infection control and odour risk affecting: • Dilution of airborne contaminants • Comfort of room occupants • Dispersal of odours • Risk that occupants may leave the door open to improve ventilation, creating additional safety risk.	Remedial works are currently ongoing.
002	Feb 2019	Settlement Agreement 81 List Item 2 of 81 **Non-Fire rated IPS / UPS cabling**	The Board believes that Project Co has installed non fire rated cables to UPS boards serving critical areas.	The implication of this is, in the event of a fire, power may be lost to essential life safety medical equipment in critical areas.	Project Co made changes to 11 Number sub mains cables from UPS switchboard to UPS distribution boards changing these to fire rated.
003	Feb 2019	Item 4 of 81 **Bedroom ventilation for neutropenic patients**	Rooms for neutropenic patients should be designed as isolation rooms (+10 positive pressure). However, there are 12 single rooms which Project Co have designed to balanced pressure.	Non complaint with SHTM 03-01 Table A1. Less flexibility in the department and neutropenic patients would need to be accommodated in isolation rooms.	Board compromised and risk assessed Project Co's design for 12 single bedrooms.
004	Feb 2019	Item 6 of 81 **HV distribution**	Non-compliances with: 1. Resilience of the HV main intake switch room, 2. HV cable distribution, 3. HV / LV substations creates potential single points of failure at the HV side of the electrical distribution network.	Loss of electrical supply to critical equipment.	Changes made to the switch panels within the energy centre to capture the generator panel as part of the ring circuit of high voltage cables and switches. Fire protection applied to the HV cables in the fire hazard rooms. Gas suppression has been agreed to be provided within Sub Station 2A (SS2A) and Sub Station 2B (SS2B).

Item	Date	Issue	Description	Consequences	Steps taken to remedy
005	Feb 2019	Item 7 of 81 **4-bedded rooms ventilation**	Ventilation pressure regimes, intake air change rate and the extract air change rate are non-compliant with SHTM 03 - 01. Project Co were treating 4 bedded rooms as a General Ward, and providing a positive pressure regime.	Unacceptable risk of the spread of bacterial airborne infections into corridors and surrounding patient rooms (positive to the corridor).	14 No 4 bedded rooms to be balanced or negative to the corridor at 4 ac/hr. The remaining 6 No 4 bedded rooms remain as per the environmental matrix.
006	Feb 2019	Item 13 of 81 **Single Bedroom Ventilation air changes**	4ac/h supply provided to the bedrooms instead of the required 6ac/h. The en suite extract rate proposed in excess of 10ac/h where requirements of SHTM 03-01 is 3ac/h.	Potential increased infection control and odour risk affecting: • Dilution of airborne contaminants • Comfort of room occupants • Dispersal of odours • Risk that occupants may leave the door open to improve ventilation, creating additional safety risk.	The Board compromised to a reduced ac/hr in single bedrooms.
007	2016 - Feb 2019	Item 71 of 81 **Movement Joint**	Project Co constructed movement joints in critical clinical spaces which is explicitly prohibited in the BCR's.	Infection control risks – inadequate cleaning, dust accumulation and physical space compromised resulting in reduced bed circulation space for patient care. Example locations - access to theatre 36, and bedroom 1 in Haematology and Oncology.	The Board compromised and although Project Co made minor alterations e.g. the type of joint was altered, the movement joints remain in the critical clinical areas. Physical changes to the rooms were required to attempt to cover the joints and mitigate infection control risk.

Item	Date	Issue	Description	Consequences	Steps taken to remedy
008	Jan 2014 - Feb 2019	Settlement Agreement 1 (post completion works) **Fire Detection**	Project Co's design and installation of the fire detection and alarm system in relation to: 1. The void detection in voids with patient dependent services, detection in staff toilets and ensuites to bedrooms; and 2. In relation to provision of manual call point are non-compliant with SHTM 82.	Fire Risk – inadequate detection in ceiling voids. Inadequate and non-compliant fire alarm system, non detection of a fire, and loss of patient dependent services (medical gas and electrical supplies).	Project Co carried out and completed works to the fire detection and alarm system.
009	Feb 2019	Settlement Agreement 1 (post completion works) **Isolation room heating**	Project Co has installed heater batteries within critical areas in contravention of SHTM 03-01.	Infection control risk associated with maintenance and the presence of moisture above ceiling in a clinical area.	Project Co made changes to the location and support infrastructure on heater batteries in all location except Isolation rooms. In Isolation rooms, the heater battery was replaced by radiant panels.
010	Feb 2019	Settlement Agreement 1 (post completion works) **Internal and external foul drainage**	The number and location of sanitary appliances discharging into the basement and PARU sumps, as installed by Project Co, is in contravention with the BCR's (including the non-domestic technical handbook) and the PCPs.	- Potential unavailability of the PARU gardens or PARU department. - Clinical areas on all floors subject to water usage restrictions resulting in increased workload for staff. - Potential unavailability of the kitchen / basement. - Restrictions on use of corridor during maintenance. - Increased pest control activities during maintenance. - Possible noise issues on ground floor when the pump is discharging. - Lack of resilience within the original design.	Project Co have provided additional resilience in the case of an emergency.

be aware that the Edinburgh Health and Social Care Partnership were forecasting a £6M deficit for social care. It was important to note that the NHS Lothian contribution of £4M was to be matched by Edinburgh council with an addition contribution of £2.5M from the Edinburgh IJB taking the total contributions to £10.5M. It was also noted that there was £6M of undelivered social care savings which were unlikely to be delivered through current savings plans; if delivery of this was pushed then it was recognised that a direct way of doing this was through reduction of capacity.

- **2018/19 Annual Operational Plan (AOP): Access Funding to Support Additional Capacity** -The Chair requested that it be made clear in public papers that there was not current the resources available to achieve the March 2017 waiting times. Mr Davison reported that this action appeared to have been overtaken by events with the Cabinet Secretary for Health and Sport's announcement about a new waiting times improvement plan. Mrs Goldsmith, Miss Gillies and Professor McMahon were heavily involved with this work as they chaired national groups. This waiting times work would be a major programme of improvement over the next 30 months to March 2021, about which full details would emerge shortly. The Committee welcomed the update and looked forward to receiving a detailed briefing around this issue at the next F&R meeting. The Committee also requested that the IJB members on F&R take these discussions forward with the IJBs.

15.2 Update on the RHCYP/DCN Project - Mrs Goldsmith tabled a position paper on a proposed settlement agreement. The paper provided detail and an update on the current situation with the RHCYP/DCN project. There was discussion on the IHSL financial difficulties; the need for a finalised supplemental agreement to move forward, the factors delaying the signing of this and the position of senior funders; residual technical issues with the key issue being around drainage systems; amendments to the business case; the leadership and competence around IHSL and the next steps to make progress.

15.2.1 The Committee noted the current position with the project and gave its absolute support to the project team in terms of the current strategy and approach. The Committee asked that work begins now on a communications strategy around this current situation and supported the recommendations as outlined in the paper:

- To continue to seek resolution to these issues via the supplementary agreement (SA) process, and to put in place a solution that is entirely governed by the SA or SAs
- To pursue a SA solution that consists of two agreements, a primary agreement as outlined previously and as negotiated with IHSL and a second SA to govern the delivery of the drainage aspect of the facility
- To seek formal contact with funders to provide assurance that the Board is committed to a SA solution and a request for this commitment to be reciprocated
- To submit an addendum to the business case for approval once details on timescale and technical arrangements are clear
- To address the Board's concerns in relation to IHSL's management of the Project, particularly moving into the operational phase.

15.2.2 Mrs Goldsmith stated the intention to have something circulated in relation to the terms of the supplementary agreement and said there would be further discussion on this under the Private Session of the 3rd October 2018 Board Meeting.

30.2.2 It was noted that the priorities in relation to Emergency Access Standard and front door redesign only covered the Royal Infirmary of Edinburgh and St John's Hospital. This now needed to be updated to include the Western General Hospital front door with recommendations around this coming back to the March F&R meeting.

NB

30.2.3 The Committee considered the report recommendations. The point was made that the wording of the first recommendation referred to process and did not clarify the efficiency or effectiveness of the programme.

30.2.4 Subject to acknowledging the wording in the first recommendation to committee agreed to take significant assurance around the effectiveness of processes. The Committee approved the output of the prioritisation process 2019/20, in terms of prioritised lists as recommended by LCIG and accepted significant assurance that the output of prioritisation supports delivery of the Board's Strategic Plan, Our Health, Our Care, Our Future, IJB Strategic Plans and Lothian Hospitals Plan. The Committee also endorsed the next steps in terms of gap analysis and identifying resource requirements and approach to subsequent reporting to F&R.

30.3 <u>The Royal Hospital for Children & Young People, Department of Clinical Neurosciences, Child & Adolescent Mental Health Services - Update on Progress</u> -

30.3.1 Mrs Goldsmith updated the Committee on the current position on completion of the new facility and commercial arrangements with IHSL, such position being documented in a settlement agreement between the Board and IHS Lothian Limited ("IHSL") (the "Settlement Agreement").

30.3.2 The Committee noted the contents of the paper and the progress made in recent weeks. The Committee continued to support the commercial and technical position as described which will be reported to the Board for approval at its February meeting.

30.4 <u>Draft Medical Devices and Equipment Strategic Direction Framework</u> - Mrs Goldsmith presented the completed draft of the Board's Medical Devices and Equipment Strategic Direction Framework document. The report was to provide the Committee with assurance on the arrangements being put in place to ensure that the Board's Property and Asset Management Strategy fully addresses the issue of medical devices and equipment.

30.4.1 Mrs Goldsmith stated that the document had been discussed already at LCIG and was now much more aligned to medical devices. Discussion had started around how to handle commissioned work which was not currently covered by the framework. Miss Gillies pointed out that this framework sought to help address the blurred area between medical equipment and medical devices.

30.4.2 Mr McCann stated that this was good work and that it was important to have this and clinical engagement. It was also pleasing to note that various aspects of this work linked into the Board's existing track and trace project. It was noted that there was further work to in pulling clinical silos together and involving healthcare scientists and clinicians. There would also be further updates through board development sessions.

36.3.7 The Committee supported swift resolution of land purchase on the Edinburgh BioQuarter site for this new build and accepted moderate assurance of revenue affordability of the preferred option, estimated as an increase of £1.54m since IA submission. This estimate was currently based on assumptions around a direct, linear relationship between increase in activity and increase in expenditure. In order to provide additional assurance, a working group had been established to more clearly identify drivers and timing of step changes in expenditure and what control the Board might have over these.

36.3.8 Finally the Committee noted that as this proposal was part of the national Elective Centre expansion programme, it was anticipated that the revenue impact will be funded through the Waiting Times Improvement Plan funding.

36.4 HSDU Improvement Re-provision - update on strategic assessment and development of Initial Agreement - Mr Curley and Dr Hopton introduced the Initial Agreement for the re-provision of the Hospital Sterilisation and Decontamination Unit (HSDU) for approval and progression to Outline Business Case.

36.4.1 The Committee approved the IA to proceed to development of the OBC. The Committee noted that six options had been reviewed with two of these being rejected as either unlikely to meet the investment objectives or not possible to implement without disrupting existing production. This left four remaining options recommended to be carried forward to closer evaluation under the OBC. These were:

- Do minimum
- New single HSDU at scale
- New HSDU and full refurbishment of existing HSDU
- Local HSDU provision (3 or more HSDU)

36.5 The Royal Hospital for Children & Young People, Department of Clinical Neurosciences, Child & Adolescent Mental Health Services – Update on Progress - Mrs Goldsmith provided the Committee with confirmation that the commercial arrangements with IHSL were now documented in a settlement agreement between the Board and IHS Lothian Limited on 22 February 2019.

36.5.1 The Committee accepted significant assurance that the conclusion of the Settlement Agreement was in line with the previous reports to the Committee and Board. The Committee noted that a due diligence report had been received from Macroberts Solicitors and that all parties were now working to the programme and contract as amended by the Settlement Agreement, with a planned full service operational commencement date of 15th July 2019.

37 Revenue

37.1 2019/20 Financial Outlook - Mrs Goldsmith provided the Committee with an assessment of the 2019/20 financial position based on the 18/19 forecast outturn, anticipated growth and assumptions around additional resources.

37.1.1 There was discussion on achieving financial balance in a challenging situation; supporting further development of IJBs; fair and equitable approaches to funding; addressing the care deficit; demographic pressures; the Board's NRAC position; brokerage; financial sustainability; heavily reliance on non recurring resources and the struggle to generate efficiency savings.

LOTHIAN NHS BOARD

Minutes of the Meeting of Lothian NHS Board held at 9.30am on Wednesday, 4 April 2018 in the Carrington Suite, Scottish Health Service Centre, Crewe Road South, Edinburgh, EH4 2LF.

Present:

Non-Executive Board Members: Mr M Hill (Chair); Mr M Ash; Mr M Connor; Cllr R Henderson; Ms C Hirst; Mr A Joyce; Professor T Humphrey; Ms F Ireland; Mr A McCann; Mrs A Mitchell; Mr P Murray; Mr B McQueen and Cllr F O'Donnell.

Executive and Corporate Directors: Mrs J Butler (Director of Human Resources and Organisational Development); Ms J Campbell (Chief Officer of Acute Services); Mr J Crombie (Deputy Chief Executive); Miss T Gillies (Executive Medical Director); Mrs S Goldsmith (Director of Finance); Professor A K McCallum (Director of Public Health & Health Policy); Professor A McMahon (Executive Director, Nursing, Midwifery & AHPS – Executive Lead REAS & Prison Healthcare) and Dr S Watson (Chief Quality Officer).

In Attendance: Mr H Edmiston (Director of Corporate Services, University of Edinburgh); Dr K Lindsay (Shadowing the Executive Medical Director); Ms J Mackay (Director of Communications); Professor J Seckl (Vice-Principal, University of Edinburgh) and Mr D Weir (Business Manager, Chair, Chief Executive, & Deputy Chief Executives Office).

Apologies for absence were received from: Mr T Davison, Mr B Houston, Cllr D Milligan, Cllr J McGinty and Professor M Whyte.

Valedictory Comments

The Chairman advised that this would be Cllr Henderson's last meeting of NHS Lothian. He thanked Cllr Henderson for his considerable efforts and contributions over his tenure as a Board member and wished him well in future.

Chairman's Introductory Comments

The Board noted that the Board Chair had submitted his apologies for the meeting advising that he felt that his health was beginning to improve and he would hope to be back to work in the very near future.

Welcome and Introduction:

The Chairman welcomed members of the public and press to the Board meeting.

In particular he welcomed Professor J Seckl, Vice-Principal of Edinburgh University who was also an NHS consultant and Mr H Edmiston, Director of Corporate Services, University of Edinburgh who would be providing a presentation entitled "Data Driven Innovation – the Data Capital for Europe". He also welcomed Dr K Lindsay, Scottish Clinical Leadership Fellow who was shadowing the Executive Medical Director.

Changes in Board Membership

LOTHIAN NHS BOARD

Minutes of the Meeting of Lothian NHS Board held at 9.30am on Wednesday, 27 June 2018 at the Scottish Health Service Centre, Crewe Road South, Edinburgh, EH4 2LF.

Present:

Non-Executive Board Members: Mr B Houston (Chair); Mr M Ash; Cllr I Campbell; Mr M Connor; Mr M Hill (Vice-Chair); Mrs C Hirst; Professor T Humphrey; Mr A McCann; Cllr J McGinty; Cllr D Milligan; Mrs A Mitchell; Mr P Murray and Mr B McQueen.

Executive and Corporate Directors: Mrs J Butler (Director of Human Resources and Organisational Development); Ms J Campbell (Chief Officer of Acute Services); Mr J Crombie (Interim Chief Executive); Miss T Gillies (Executive Medical Director); Mrs S Goldsmith (Director of Finance); Professor A K McCallum (Director of Public Health & Health Policy); Professor A McMahon (Executive Director, Nursing, Midwifery & AHPS – Executive Lead REAS & Prison Healthcare) and Dr S Watson (Chief Quality Officer).

In Attendance: Ms J Mackay (Director of Communications & Public Engagement) and Mr D Weir (Business Manager, Chairman, Chief Executive & Deputy Chief Executive's Office).

Apologies for absence were received from Mr T Davison, Ms F Ireland, Mr A Joyce, Cllr F O'Donnell and Professor M Whyte.

Chairman's Introductory Comments

The Chairman welcomed members of the public and press to the meeting.

Changes in Board Membership

The Chairman welcomed Councillor Ian Campbell to his first Board meeting advising that he was the City of Edinburgh Council Stakeholder member replacing Councillor R Henderson.

Declaration of Financial and Non-Financial Interest

The Vice Chairman reminded members they should declare any financial and non-financial interests they had in the items of business for consideration, identifying the relevant agenda item and the nature of their interest. There were no declarations of interest.

13. Items for Approval

LOTHIAN NHS BOARD

Minutes of the Meeting of Lothian NHS Board held at 9.30am on Wednesday, 5 December 2018 at the Scottish Health Service Centre, Crewe Road South, Edinburgh, EH4 2LF.

Present:

Non-Executive Board Members: Mr B Houston (Chair); Mr M Ash; Mr M Connor; Dr P Donald; Mr M Hill (Vice Chair); Ms C Hirst; Ms F Ireland; Mr A Joyce; Mr A McCann; Cllr J McGinty; Councillor D Milligan; Mrs A Mitchell; Mr P Murray; Mr W McQueen and Dr R Williams.

Executive and Corporate Directors: Mrs J Butler (Director of Human Resources and Organisational Development); Ms J Campbell (Chief Officer of Acute Services); Mr J Crombie (Deputy Chief Executive); Mr T Davison (Chief Executive); Miss T Gillies (Executive Medical Director); Mrs S Goldsmith (Director of Finance); Professor A K McCallum (Director of Public Health & Health Policy); Professor A McMahon (Executive Director, Nursing, Midwifery & AHPS – Executive Lead REAS & Prison Healthcare) and Dr S Watson (Chief Quality Officer).

In Attendance: Mrs J MacKay (Director of Communications, Engagement and Public Affairs) and Mr D Weir (Business Manager, Chair, Chief Executive & Deputy Chief Executive's Office)**.**

Apologies for absence were received from Cllr I Campbell, Professor T Humphrey, Cllr F O'Donnell and Professor M Whyte.

Chairman's Introductory Comments

The Chairman welcomed members of the public and press to the Board meeting.

Cllr D Milligan was welcomed back following his period of ill health.

The Chairman welcomed Ms Hirst's Paired Learning Partner, Dr Nicola McCulloch who was shadowing her at the Board meeting. It was noted that Dr McCulloch was a consultant in Emergency Medicine and recently had become the Clinical Director for Emergency Medicine at St John's Hospital.

In addition Ms McDowell was shadowing Mr Joyce. Ms McDowell was the St John's Hospital / Princess Alexandra Eye Pavilion Partnership Lead.

The Chairman also welcomed four students taking the 'clinical governance and improvement in practice' module at Masters level at Edinburgh Napier University who were accompanied by Ms Campbell a former Director of Nursing at the Royal Infirmary of Edinburgh (RIE). It was noted that attending the Board meeting gave the students the opportunity to see accountability in action.

From:	Roche R (Rowena)
To:	McLaughlin C (Christine)
Subject:	FW: SG Health and Social Care Strategic Group Action Grid 09 July 2019 - NHS Lothian - Edinburgh Children"s Hospital Building Delay
Date:	09 July 2019 15:51:55
Attachments:	image007.jpg NHS Lothian - Edinburgh Childrens"s Hospital - Action List 9 July 2019.docx image002.jpg image003.jpg

Christine,

Regarding action 8: SG Finance to check lines of advice and preparation of Cabinet Secretary's statement to parliament Director of Finance

The question in parliament on 27 June on sick kids was a follow up on an oral PQ (led by HAI) relating to the QUEH inquiry. Michelle Ballantyne who asked if lessons from QEUH have been applied at sick kids and Cab Sec provided assurance that they had – including on ventilation. No briefing was provided on this specific matter for this session. Cab Sec's response appears to have been based on previous information provided on QUEH and follow up with other Boards, including NHSL. I've included the transcript below.

The Sunday post reported on the Cab Sec providing these assurances days before it was announced that the opening would be delayed due to ventilation issues: https://www.sundaypost.com/fp/freeman-said-hospital-was-safe-days-before-stopping-its-opening/

Briefings provided to Cab Sec, state that DG Health and Social Care and the Chief Performance Officer, NHSScotland were alerted by NHSL on 2 July to an emerging issue with the ventilation systems which could impact on when services transfer over to the new hospital. A briefing provided by NHSL states that they became aware on the evening of 1 July.

Transcript from 27 June
Queen Elizabeth University Hospital Inquiry
4. Michelle Ballantyne (South Scotland) (Con): To ask the Scottish Government what progress has been made with the inquiry into the Queen Elizabeth university hospital. (S5O-03458)

The Cabinet Secretary for Health and Sport (Jeane Freeman): Since their appointment, the co-chairs of the independent review have consulted extensively with experts and established systems for stakeholder contact. In line with the Britton report recommendations, at a meeting today they will publicly present the preliminary terms of reference and ask for feedback—they will consult on those. They will also formally seek submissions of evidence and launch the review's website and contact details. That is all important, because it is critical that a wide range of views and information is considered.

Michelle Ballantyne: Given that the Royal hospital for children and young people—the sick kids—in Edinburgh is due to open on 9 July and shares the same design concept and is being built by the same contractors as the Queen Elizabeth university hospital, has the cabinet secretary received assurance that the same issues will not be experienced there?

Jeane Freeman: As Ms Ballantyne will know—it is a reply I have given previously in the

Parliament—NHS Lothian, for the sick kids hospital in Edinburgh, and other boards where we have new buildings, such as in Orkney, were tasked with ensuring that they had the proper assurance that the immediate lessons that we had learned from the Queen Elizabeth university hospital in relation to air ventilation, water supply and the use of sinks had been applied in the design and construction of those new buildings. We have that assurance. NHS Lothian did not take ownership of the site until it was absolutely assured that those steps had been taken.

Kind regards,

Rowena

Rowena Roche
Directorate of Health Finance
Scottish Government | Floor BR | St Andrew's House | Regent Road | Edinburgh EH1 3DG
☎ Tel: [redacted] ✉ Email: [redacted]

Please note that I do not work on Thursday afternoons or on Fridays.

From: Healy M (Michael) [redacted] **On Behalf Of** Scottish Government Health Resilience Unit
Sent: 09 July 2019 13:42
To: DG Health & Social Care [redacted]; Smith G (Gregor) [redacted]; Connaghan J (John) (Health) [redacted]; Rogers S (Shirley) [redacted]; McLaughlin C (Christine) [redacted]; Murray D (Diane) [redacted]; Hart S (Suzanne) [redacted]; Aitken L (Louise) [redacted]; Henderson C (Calum) [redacted]; Roche R (Rowena) [redacted]; Calderwood C (Catherine) [redacted]; Chief Medical Officer [redacted]
Cc: Scottish Government Health Resilience Unit [redacted]; Low S (Stuart) [redacted]
Subject: SG Health and Social Care Strategic Group Action Grid 09 July 2019 - NHS Lothian - Edinburgh Children's Hospital Building Delay

Colleagues

Attached is action list (with key actions) from meeting this morning. If you have any comments then please advise by cop today. Grateful if colleagues can now progress actions and provide updates to the Health Resilience mailbox (copied in).

The meeting tomorrow will take place after HSCMB and a calendar update will be sent out

The standard agenda will be circulated in advance of next meeting.

Thanks

Mike

Michael Healy
Head of Health Resilience
Performance and Delivery Directorate
Scottish Government
T: [redacted]
M: [redacted]

From: Healy M (Michael) [redacted]
Sent: 08 July 2019 13:35
To: DG Health & Social Care [redacted]; Smith G (Gregor) [redacted]; Connaghan J (John) (Health) [redacted]; Rogers S (Shirley) [redacted]; McLaughlin C (Christine) [redacted]; Murray D (Diane) [redacted]; Hart S (Suzanne) [redacted]
Cc: Scottish Government Health Resilience Unit [redacted]; Low S (Stuart) [redacted]
Subject: SG Health and Social Care Strategic Group Action Note 08 Juy 2019 -NHS Lothian Sick Kids Buidling Delay

Colleagues

Attached is action list (with key actions) from meeting this morning. If you have any comments then please let me know by 2:30pm. Grateful if colleagues can now progress and provide updates to the Health Resilience mailbox (copied in).

A daily meeting will be dropping into your calendar for the next few weeks. Please accept these. These are placeholders and will be held where needed I would anticipate that we will schedule calls this week.

A standard agenda has also be produced and will be circulated in advance of any meeting.

Thanks

Mike

Michael Healy
Head of Health Resilience
Performance and Delivery Directorate
Scottish Government
T: [redacted]

M: [redacted]

From: Healy M (Michael)
Sent: 08 July 2019 10:46
To: DG Health & Social Care [redacted]; Smith G (Gregor) [redacted]; Connaghan J (John) (Health) [redacted]; Rogers S (Shirley) [redacted]; McLaughlin C (Christine) [redacted]; Aitken L (Louise) [redacted]; Murray D (Diane) [redacted]; Hart S (Suzanne) [redacted]
Cc: Scottish Government Health Resilience Unit [redacted]; Low S (Stuart) [redacted]; Lacey R (Reanne) [redacted]; McPherson G (Grant) [redacted]; Morrison A (Alan) [redacted]; Sheriff C (Carmel) [redacted]
Subject: Health Resilience Support - NHS Lothian Sick Kids
Importance: High

Hi All,

Following discussion this morning Health Resilience will provide support to the management of activity with NHS Lothian regarding sick kids hospital. Christine McLaughlin is the lead director.

As of now the Health Resilience room has been opened to support work. Grateful if you can ensure the following going forward:

- ensure that the following email address is added when you are contacting Health Resilience [redacted] regarding NHS Lothian Sick Kids activity. The email address should also be copied in where you are sending correspondence between SG and NHS Lothian.
- The telephone number of the room is [redacted] (this will be manned between 9am-5pm for this week and will be kept under review)
- Team members in the room will be advised once I have spoken to staff. For today I will be in the hot seat with support from Grant and Reanne.

If there any names missing from the list of SG people please let the room know and these will be added.

We will produce a working battle rhythm once I have spoken to Christine today.

Thanks

Mike

Michael Healy
Head of Health Resilience
Performance and Delivery Directorate
T: [redacted]

M: [redacted]

Scottish Government
St Andrews House
Regent Road
Edinburgh EH1 3DG

To report incidents, urgent situations and emergencies **out-of-hours (17.00 to 08.30)**, contact Health Resilience Duty Officer via pager: [redacted] Unit email: [redacted]

Preparedness, Resilience and Response

Official Sensitive

In attendance (includes in room and on Line)

Malcolm Wright	John Connaghan	Shirley Rogers	Christine McLaughlin	Catherine Calderwood	Gregor Smith
Diane Murray	Mike Healy	Louise Aitken	Calum Henderson	Rowena Roche	

ACTIONS From SGH&SC Directorate Calls:

Number	Actions as at 13:00 Tuesday 9h July	Lead Officer	Comments	Completed (Yes/No/In Progress)
1 (8/7)	SG Finance to make immediate contact with NSS to ensure that HFS and HPS are on site at NHS Lothian.	Director of Finance	HFS/HPS engaged with Board Monday 8th July to scope and commence work. Director of Finance is meeting NSS Chief Executive 9th July on NHS L work	Yes
2	SG Finance to put in place appropriate audit with NHS Lothian and Terms of Reference to be produced.	Director of Finance	Engagement discussions held with KPMG. In principle agreed to undertake work and work can commence this week. Director of Finance meeting KPMG 9th July to scope out terms of reference.	Yes
3	SG Finance to establish and confirm reports that are in place in addition to the initial 'snagging' list received and confirm whether the report sent covers the whole building or part of the building.	Director of Finance	Response from NHS L was that snagging list was not part of a fuller report. Further confirmation requested from NHS L (by 10am 9th July) that no other assessment/reports have been produced.	In progress
4	Health Resilience arrangement to be set up for Health & Social Care Directorates to support activity.	Head of Health Resilience	Resilience Room operational	Yes
5	Group to meet up before meeting Cabinet Secretary on Tuesday 9th July	DG Office	Cabinet Secretary meeting to be confirmed by private office (proposed time 2:30pm). A meeting request will be scheduled in advance once known. Post Huddle note – meeting confirmed at 2:30	Yes
6. (9/7)	SG Finance to have discussion with NHS L Director of Finance on various information and reporting requests as discussed at huddle	Director of Finance		

7.	SG Finance to circulate audit engagement terms of reference for comment before finalising.	Director of Finance		
8.	SG Finance to check lines of advice and preparation of Cabinet Secretary's statement to parliament	Director of Finance		
9.	SG Delivery and Resilience to prepare paper for HSCMB to discuss escalation on 10 July 2019. Escalation grid to be circulated in advance.	Director of Delivery & Resilience		
10.	Health Resilience to invite NSS representative to provide update to huddle meetings	Head of Health Resilience		
11.	All to consider support (if any) needed to supplement management capability at NHS Lothian (to be considered at HSCMB as part of action point 9)	All		
12	Communications Healthier to work with NHS L on developing communications plan going forward. Update to be provided at Cabinet Secretary meeting.	Communications Healthier		

From:	Henderson C (Calum)
To:	Cabinet Secretary for Health and Sport
Cc:	McLaughlin C (Christine); Murray D (Diane); Wright M (Malcolm); DG Health & Social Care; Calderwood C (Catherine); Morrison A (Alan); Ives J (Josephine); Birch J (Jason); Hutchison D (David)
Subject:	Weekend information request from Cabinet Secretary regarding Ventilation
Date:	23 September 2019 12:01:29
Attachments:	Letters and responses on built environment.zip NHSL Letters as Discussed .msg

Andy

Please find responses to the questions the Cabinet Secretary raised over the weekend

Regards

Calum

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1. What does the evidence actually say – the evidence covers a wide range of the topics, but is well captured in the letter from the convener to the Cabinet Secretary noted below.

On ventilation specifically, anonymous submission A2, says 'Inadequate ventilation systems have been installed in new build hospitals; these are not fit for purpose for the specialist patient groups they are intended for, e.g. bone marrow transplant and haematology wards. The systems did not supply sufficient air changes, pressures and HEPA filtration.'

As detailed under question 5, DG wrote to all boards in January 2019, asking them to confirm that all critical ventilation systems inspected and maintained in line with the SHTM 03-01. As the Cabinet Secretary is aware, SHTM 03-01 specifies the number of air changes required for different areas. All Boards responded to HFS (see attached) confirming that they were in compliance.

2. Did committee write to me highlighting this or any other matter and when – Yes, this was received on 2 May 2019 – https://www.parliament.scot/S5_HealthandSportCommittee/Inquiries/20190502_Ltr_OUT_to_CabSecHS_HHHE_FINAL.pdf

Within this letter the H&SC draw attention to the above wording from A2 and then ask: 'Will the Scottish Government undertake a review of recently built facilities to assess their compliance with the appropriate installation, maintenance, decontamination and monitoring of vital systems?' and 'Will the Scottish Government also undertake a review to ensure all high risk clinical areas, in both new and existing facilities, have the appropriate equipment for minimising infection?'.

3. What did we say in response - https://www.parliament.scot/S5_HealthandSportCommittee/Inquiries/20190514_Ltr_IN_CabSecHS_Health_Hazards.pdf. This response reflected input from both HFS and HPS in addition to CNO and Health Finance.

On ventilation specifically, we responded to HSC with the following:

Q17. Do you believe employing a team of authorising engineers [to manage water and ventilation systems] at a national level will improve access to this expertise for individual NHS boards, reduce risk and be more cost effective?

Yes and this is the policy which HFS implement.

Q18. Will the Scottish Government undertake a review of recently built facilities to assess their compliance with the appropriate installation, maintenance, decontamination and monitoring of vital systems?

A. HFS work with boards that have recently completed major capital projects to ensure compliance with relevant guidance.

Q19. Will the Scottish Government also undertake a review to ensure all high risk clinical areas, in both new and existing facilities, have the appropriate equipment for minimising infection?

A. NHS boards are responsible for ensuring that they have the appropriate equipment for minimising infection, as they are best placed to determine what equipment is required.

In our response to Q8, we made reference to the work to consider broader compliance and governance structures.

Q8. Do you believe consideration should be given to greater monitoring by external bodies of NHS boards usage of HAISCRIBE, SCART and other risk assessment processes or do you believe the current process enables issues to be identified and where required improved?

NHS boards should have appropriate control processes in place for these issues to be addressed, however, as detailed above, active consideration is currently being given to broader compliance and governance structures.

4. Detail of every communication we have had with NHSL seeking assurances and their response – see attached which includes the following:

- RHCYP.PDF – Original letter sent by HFS to NHS Lothian seeking and requesting assurance documents on **8 March 2019.**
- 010419L1 HFS…PDF – Response from NHS Lothian (Additional info was also provided on Disk) on **1 April 2019**
- Susan Goldsmith…PDF – Letter issued last week (With Appendix 1…PDF) seeking information as well as question set on **16 July 2019.**

In essence, even before the current problems with the ventilation systems were known, in March HFS requested information from NHS Lothian on a broad range of engineering compliance issues (which covered nine main areas including ventilation, water, electrical, drainage, fire etc). While NHS Lothian confirmed that the engineering systems were in compliance, HFS thought there were a lot of assertions and were looking to gather more evidence to support the position that NHS Lothian were reporting. The issues at QEUH earlier this year became the focus of HFS during the first half of the year, so that evidence gathering had not progressed as quickly as we would want given the current position.

The return in April included a letter from IHSL (page 19 of the attachment) which confirmed compliance on a wide range of issues with the ***project agreement*** (my emphasis ie project agreement not national standards/guidance). As the project agreement is contractual what IHSL was required to provide, it is not surprising, but there may be a focus on the distinction.

5. Detail of every communication we have had with all boards since Jan seeking assurances on any building related matter and the response –

- In January 2019, DG wrote to all Boards seeking assurances on plant rooms and ventilation systems. All Boards responded to HFS (see attached) confirming that they were in compliance.
- On 8 March 2019, Board Chief Executives were asked to ensure that all relevant aspects of the Requirements and Recommendations contained in the QEUH report were implemented in their Boards as standard practice. The DG letter and NHSL response are attached above.
- On 12 March, Malcolm Wright and CNO held a Teleconference with Board CEOs - the meeting discussed DG's letter of 8 March, covering safety and cleanliness and the built environment.
- In June 2019, CNO wrote to Board CEOs and Chairs to reemphasis the importance of high standards of building cleanliness, including plant rooms and an instruction to advise of compliance with the guidance.

6. When will NSS complete work re Dumfries and Orkney and on fire etc for Edinburgh sick kids – Fire report is expected by Friday 11 October. No timeline for the D&G and Orkney work yet, but I expect HFS to provide a timeline and also what other projects will be included in their review once they are finished at the Sick Kids.

Director-General Health & Social Care and
Chief Executive NHSScotland
Paul Gray

T: [redacted]
E: [redacted]

Scottish Government
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NHS Chief Executives

Copy to Directors of Estates

25 January 2019

Dear Colleague

Queen Elizabeth University Hospital – follow up actions

This letter sets out actions following the meeting of the Strategic Facilities Group on Wednesday 23 January. There are a number of controls that I would like you to confirm are in place and working effectively:

- All plant rooms must be secure and have adequate access controls in place at all times;
- All plant rooms maintained clean and free of vermin;
- Standard Operating Procedures for the management of plant rooms are in place and being followed;
- All critical ventilation systems inspected and maintained in line with 'Scottish Health Technical Memorandum 03-01: Ventilation for healthcare premises'.

I have asked Health Facilities Scotland to co-ordinate the responses and would ask that you reply to [redacted] copied to [redacted] by Friday 1 February.

In addition to these control measures, the Strategic Facilities Group has undertaken to share best practice on relevant Standard Operating Procedures and anti-pest management. The Ventilation Group, which reports direct to the Scottish Engineering and Technology Advisory Group (SETAG), is also considering urgently whether SHTM 03-01 needs to be revised and updated in view of recent developments. I will ensure that you are kept in touch with any changes to that.

Yours sincerely

[redacted]

Paul Gray

Assurance Control Questions – Ventilation Systems

Summary of Responses – 01 February 2019

Control Questions	A&A	GG&C	LAN	D&G	FV	LOT	BOR	FIFE	TAY	GRAM	HIG	WI	SHET	ORK	GJ	STATE	SAS	24	NSS	HS	HIS	NES
Question 1: All plant rooms must be secure and have adequate access controls in place at all times	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Included within NSS Response (Meridian Court & South Gyle Office Premises)	✓	✓
Question 2: All plant rooms maintained clean and free of vermin	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Question 3: Standard Operating Procedures for the management of plant rooms are in place and being followed	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Question 4: All critical ventilation systems inspected and maintained in line with 'Scottish Health Technical Memorandum 03-01: Ventilation for healthcare premises'.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Additional Information Provided:			✓	✓	✓		✓											✓				
Summary Status (Given response)																						

Director-General Health & Social Care and
Chief Executive NHSScotland
Malcolm Wright

T: [redacted]
E: [redacted]

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NHS Board Chief Executives

Copy : NHS Board Chairs

8 March 2019

Dear Colleagues

Healthcare Improvement Scotland Unannounced Inspection Report – Safety and Cleanliness of Hospitals: Queen Elizabeth University Hospital

Implementation of relevant aspects of the report's Requirements and Recommendations in all NHSScotland Boards

I am writing to make you aware that Healthcare Improvement Scotland is today publishing the report of the Healthcare Environment Inspectorate Unannounced Inspection of the Queen Elizabeth University Hospital, which took place on 29-31 January 2019.

I would like to seek confirmation from Board Chief Executives that all relevant aspects of the Requirements and Recommendations contained in that report are implemented in your Boards as standard practice. I should be grateful for confirmation to be submitted in writing to Fraser Judge, [redacted], by 15 March 2019, and also confirmation that this will be taken through your Board's Clinical Governance Committee in early course.

Yours sincerely

[redacted]

Malcolm Wright
Director General for Health & Social Care and Chief Executive of NHSScotland

NHS LOTHIAN

Assessment of Position against Recommendations and Requirements Contained in the Healthcare Environment Inspectorate Report on the Queen Elizabeth University Hospital.

Requirement	NHS Lothian Position
Requirement 1 NHS Greater Glasgow and Clyde must improve the governance arrangements in both estates and infection prevention control teams to assure themselves of safe patient care in line with Scottish Government's guidance, *NHS Scotland Health Boards and Special Health Boards – Blueprint for Good Governance* (2019) (see page 10).	• There are links through Pan Lothian Infection Control Committee and Domestic Managers & Infection Prevention Control Managers forum – both are quarterly meetings. In addition Facilities have representation on Lothian Infection Control Advisory Committee. • There are local site based infection control committees and the Health and Social Care Partnership & Royal Edinburgh Hospital Infection Control Committee that report into the Pan Lothian Infection Control Committee. • Areas we wish to increase governance in are the sharing of information at the more operational level. The Infection Control team are developing HAI Dashboards in Tableaux. • Work is in progress to develop a facilities services intranet resource to share Standard Operating Procedures and Guidance
Requirement 2 Boards must ensure functioning negative pressure isolation rooms are available in the hospital in line with Healthcare Facilities Scotland, Scottish Health Planning Note 04. (a) Where these are not available, staff are provided with clear guidance on how to manage a situation where a patient would require this type of isolation. 8.1 and 6.5 priority 1 (b) Staff in ID will be reminded of facilities available for admission of patients with infectious diseases of high consequence	• We have mechanical ventilation that provides isolation rooms in a number of hospitals, including sites under the control of PfI partners and Estates. They are following relevant guidance to ensure functionality. • We are reviewing all our arrangements for negative pressure systems and Estates are developing a comprehensive register and template of rooms and a system by which information can be shared with relevant stakeholders and therefore checks can be interrogated more robustly.
Requirement 3 NHS Greater Glasgow and Clyde must ensure all staff involved in the running of water are clearly informed of their roles and responsibilities in this and a clear and accurate record is kept to allow early identification of any water	• Domestic staff undertake daily flushing, this should significantly reduce risk associate with concern around infrequently used outlets, the process however is under review to ensure practice is undertaken in a consistent manner.

outlets that are not being run	• Facilities and ICN have undertaken an evaluation of the proposed draft on pseudomonas A. Testing and has developed an SBar including evaluation of costs. It has done sampling in a number of sites, and would recommend its introduction for vulnerable client groups.
Requirement 4 NHS Greater Glasgow and Clyde must ensure all clinical areas across comply with the current national guidance in relation to the use of bladeless fans	• HPS information was circulated – advice was given to remove bladeless fans. These should only be used in exceptional circumstances subject to documented local risk assessment. There is work ongoing to make the local risk assessments more robust.
Requirement 5 NHS Greater Glasgow and Clyde must ensure that information on the expressed breast milk recording charts is in line with national guidance. This will ensure that the storage of expressed breast milk is managed in a way that reduces the risk to patients.	• No significant issues identified in relation to this in Lothian. There is an SOP for Expressed Breast Milk which is due for review in June 2019. Communication will be reinforced on release of updated SOP.
Requirement 6 Is there a strategy that ensures the environment in the emergency department is clean and patient equipment is clean and ready for use to ensure infection prevention and control can be maintained?	• There will be challenges in addressing some of the findings of the reports- based on footfall in ED, the diversity of a challenging patient (and public) population who access ED. We will review domestic resources and as appropriate increase frequencies of cleaning (floors, public toilets, and hand gel dispensers). • NHS Lothian Cleaning matrix is under review with and options appraisal see requirement 7.
Requirement 7 NHS Greater Glasgow and Clyde must ensure the patient environment, and patient equipment, is clean and ready for use to reduce the risk of cross infection	• A short life working group (led by Lead IPCN) developed an options appraisal paper for NHS Lothian to consider how nursing time might be released to care, and how equipment cleaning activity might be more effectively achieved. The final options appraisal is due to go to April Directors of Nursing Group for consideration. Additional domestic resource is one of the options for consideration in this paper. • Additional resource implications for domestic services for the new RHSC and DCN building have been considered- additional staff hours

	have been made available.
Requirement 8 The board must ensure that domestic cleaning schedules are signed as complete by domestic supervisors with evidence and satisfaction that the domestic cleaning has been completed as detailed within the cleaning schedule	• There is a schedule and protocol presented and signed of by the supervisor. For assurance purposes Facilities will undertake an audit for compliance.
Requirement 9 The board must ensure domestic staff have the necessary equipment to perform their cleaning duties, to keep the environment clean and safe	• Processes are in place to ensure domestic services have a good compliment of resources to carry out there duties.
Requirement 10 NHS Greater Glasgow and Clyde must provide staff with suitable and functioning domestic services rooms to minimise the risk of cross contamination from the disposal of soiled water after cleaning regime	• Some buildings have DSR which are sub optimal due to the age and lay out of the building (e.g. WGH, RHSC) – there is limited scope to improve this. • However no issues identified to IPCT in Lothian but as a precaution facilities will carry out 'toolbox talks' for domestics re disposal of soiled water.
Requirement 11 The board senior management must ensure all staff are aware of the correct cleaning method for cleaning hand wash basins and that the correct cleaning products are used to clean all sanitary fittings in line with current national guidance	• Routine use of chlorine 1000ppm av chlorine has been explicitly communicated by IPCT and Domestic services managers. • However it has been an issue that has been identified by HEI Inspectorate during visits to Acute hospitals in NHS Lothian • As a result of HEI reports NHS Lothian undertook 'Tool box' talks with staff. These will continue to reinforce/refresh this message to domestics
Requirement 12 The board must ensure that the built environment is effectively monitored to ensure it is maintained to allow effective cleaning to ensure effective infection prevention and control	• A mixed methods approach is used – paper based records, ward diaries, domestics and estates electronic reporting system. • There is currently no electronic interface between estates electronic log for issues and the National Facilities Monitoring Tool Framework. Estates are working with clinical teams to streamline the process for

	a more robust electronic maintenance management system.
Requirement 13 The Board must ensure the estates reporting system is reliable and effective and acted on. Staff should also be informed of timescales for completion.	• As part of governance review NHS Lothian will address compliance with reporting systems and reporting back to staff works completions.
Requirement 14 The board must ensure that ventilation panels are cleaned	• NHS Lothian has a monitoring schedule in place but we acknowledge this does not in itself give assurance. Access can also be an issue as many are in close proximity to occupied beds. NHS Lothian will work to improve this.
Recommendation a NHS Greater Glasgow and Clyde should ensure that access to audit information is not person dependent to ensure the continuity of the audit programme	• The IPCT have undertaken a review of the audit programme – the revised programme specifically does NOT include reporting of aggregated scores and more clearly highlights areas of non compliance of highest risk. The IPC audit also reports individual rather than aggregated data. • Audits are reported through an electronic system which is accessible to the clinical teams.

Chief Nursing Officer Directorate
Fiona McQueen, Chief Nursing Officer

Scottish Government
Riaghaltas na h-Alba
gov.scot

T: [redacted]
E: [redacted]

NHS Board Chief Executives

Copy : NHS Board Chairs

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6 June 2019

Dear Colleagues

Safety and Cleanliness of Hospitals: Managing the Risk of Contamination of Ventilation Systems by Fungi from Bird Droppings

On 21 December 2018, Health Protection Scotland informed the Scottish Government of two cases of *Cryptococcus neoformans* in the Queen Elizabeth University Hospital, NHS Greater Glasgow and Clyde.

This outbreak was one of the issues that led to the establishment of an Independent Review of the Queen Elizabeth University Hospital, commissioned by Jeane Freeman MSP, Cabinet Secretary for Health and Sport, in January 2019. In March 2019, NSS Health Facilities Scotland issued interim guidance to all health boards on 'Managing the Risk of Contamination of Ventilation Systems by Fungi from Bird Droppings', which is attached.

On 2 June 2019, The Sun on Sunday published an article and pictures of a plant room at Gartnavel Hospital, NHS Greater Glasgow and Clyde, which was found to be covered in pigeon droppings.

I would like to re-emphasise to you all that adhering to the highest standards of building cleanliness, including in plant rooms, is a required action. Please note and confirm you are complying with the guidance by replying to Alan.Morrison@gov.scot by 21 June 2019. If this deadline presents problems, I would be grateful if you could contact that address.

Fiona McQueen

Lothian NHS Board

Waverley Gate
2-4 Waterloo Place
Edinburgh
EH1 3EG

Telephone

www.nhslothian.scot.nhs.uk

NHS Lothian

Sent by email to Alan Morrison
Ms Fiona McQueen
Chief Nursing Officer Directorate
Scottish Government
St Andrew's House
Regent Road
EDINBURGH EH1 3DG.

Date 4 July 2019
Your Ref
Our Ref GC/BD/KAB

Enquiries to: Karen Burnside
[redacted]

Dear Ms McQueen

SAFETY AND CLEANLINESS OF HOSPITALS : MANAGING THE RISK OF CONTAMINATION OF VENTILATION SYSTEMS BY FUNGI FROM BIRD DROPPINGS

Further to your letter of of 6 June, NHS Lothian's response is as follows:

We are complying with the "bird dropping" guidance and have setup a Ventilation Assurance Group with a more generic scope to monitor operational management and performance verification of our systems – first meeting scheduled for 4th July 2019. This group supplements existing annual audits carried out by our Authorising Engineer (Ventilation) as per Scottish Health Memorandum (SHTM) 03-01 Part B - Ventilation for healthcare premises.

Yours sincerely

[redacted]

GEORGE CURLEY
Director of Operations - Facilities

From: JAMES, Gordon (NHS NATIONAL SERVICES SCOTLAND)
To: Morrison A (Alan)
Subject: NHSL Letters as Discussed
Date: 23 July 2019 08:40:05
Attachments: RHCYP.PDF
Susan Goldsmith - NHSL RHCYP 16th July 2019 v.1.pdf
Appendix 1 - RHCYP Phase 1 Review Question Set.pdf
010419L1 HFS ~ RHSC & DCN Project.pdf

Alan,

Attached are the following letters as discussed:

RHCYP.PDF – Original letter sent by HFS to NHS Lothian seeking and requesting assurance docuements.

010419L1 HFS…PDF – Response from NHS Lothian (Additional info was also provided on Disk)

Susan Goldsmith…PDF – Letter issued last week (With Appendix 1…PDF) seeking information as well as question set.

Thanks
Gordon.

Gordon James
Director of Health Facilities Scotland
Health Facilities Scotland
NHS National Services Scotland
[redacted]

3rd Floor Meridian Court, 5 Cadogan Street, Glasgow G2 6QE
[redacted]

Health Facilities Scotland
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Mr T. Davidson
WaverleyGate
2-4 Waterloo Place
Edinburgh
EH1 3EG

Date: 08/03/2019
Your Ref:
Our Ref: RHCYP, Edinburgh

Enquiries to: Ailsa Atkinson
[redacted]

Dear Tim,

The Royal Hospital for Children and Young People, Edinburgh (RHCYP)

We have been learning lessons from projects over the past few years, relating to the implications for safety and efficacy of engineering systems, of failure to ensure thorough discharge of client duties in construction projects. In response to recent issues where the financial and safety issues for the service have been very significant, Scottish Government has asked that we seek assurances about the management of projects in progress and those which have been recently completed, and provide a report for the Director for Health Finance.

To ensure that the engineering services in new and refurbishment projects are safe and effective, we are seeking assurances regarding the management of these projects, with specific reference to the engineering services listed below. In addition to documentary evidence, we may seek to visit projects at various stages of construction to assess the risks and mitigating actions in collaboration with operational colleagues.

Lessons learned from recent projects:

- Water systems contaminated by bacteria during construction and not managed suitably after being filled, allowing biofilm to grow, incurring costs and management resource for the life of the system.
- Pre commissioning checks not fully carried out, recorded and handed over, allowing shortcomings to pass unchallenged.
- Commissioning of services not carried out properly leading to maintenance, energy and rectification costs over the life of the systems, equipment (thermostatic valves and taps, controls etc) not set up and set to work prior to handover.
- Safe access not provided for maintenance and replacement of services in accordance with legal requirements, entailing health and safety risks for staff and contractors over the life of the building.
- Routine maintenance not implemented, entailing deterioration of safety critical systems and health and safety risks for staff, patients and visitors, as well as increased running costs.

It has become clear that, although much of the above is the responsibility of the contractor, the management of the contractor and any supervisory contractor by the client is essential to ensure the desired quality of the completed project. It proves complex and costly, or impractical to pursue the contractor for rectification if the client role has not been adequately discharged.

Can you therefore please provide evidence of:

1. How the Board sought assurance that engineering systems have been designed and are being installed and commissioned to meet current guidance and statutory requirements.
2. How the Board is assured that the project was managed on site to ensure safety, quality and compliance of the engineering systems,
3. How the Board is assured that the engineering systems are commissioned, validated and set to work to ensure safety, quality and compliance,
4. How the Board is assured that its staff and appropriate contractors are adequately trained to ensure engineering systems are managed and operated competently,
5. How the Board is assured that the systems to be handed over meet the specified requirements and are safe and effective.
6. How the Board is assured that engineering systems will be maintained and operated safely and in compliance with guidance and legal requirements.
7. How the Board is assured that the systems delivered are maintainable, minimise operating cost and maximise reliability and efficacy.
8. How the Board is assured that the records of construction and as fitted documents are complete and stored and managed correctly.

Engineering systems include:

1. Electrical HV/LV
2. Hot and cold water services
3. Heating
4. Ventilation, including specialised ventilation in isolation rooms, theatres etc
5. Medical gas and vacuum systems
6. Pressure systems
7. Drainage
8. Fire precautions and equipment
9. Lifts and escalators

Example of evidence:
Evidence that Board Senior Engineer or other appropriate professional skilled in the area under consideration, has seen and accepted signed commissioning certificates, test results, microbiological results, as fitted drawings and operation and maintenance manuals etc.

I would be most grateful if you could provide evidence to show that the above duties have been appropriately discharged in relation to the current stage of The Royal Hospital for Children and Young People, Edinburgh (RHCYP) by 1st April 2019. If you are unable to provide the required information by this date, could you please provide what is available and advise when the remainder will be available?

Yours sincerely,

[redacted]

Gordon James
Director of Health Facilities Scotland

CC: Edward McLaughlan
George Curley
Iain Graham

Health Facilities Scotland
Meridian Court
5 Cadogan Street
Glasgow
G2 6QE
[redacted]
www.nhsnss.org

Susan Goldsmith
NHS Lothian
Director of Finance
Waverly Gate
2-4 Waterloo Place
Edinburgh
EH1 3EG

Date 16/07/2019
Your Ref
Our Ref

Enquiries to Kelly McGrogan
[redacted]
Email

Dear Susan,

HFS & HPS review of the NHS Lothian Royal Hospital for Children and Young People

Further to our meeting on 11th July 2019, I can confirm that we have now agreed a commission to review the technical aspects relating to the RHCYP. The initial scope of the review will focus on the Water, Ventilation and Drainage systems as these relate to the main HAI Built Environment Risks. The review will also have a specific focus on the Clinical Neurosciences area, notwithstanding the work across the wider campus.

I have attached an initial question set in Appendix 1 and would request that this is reviewed with the necessary evidence and response submitted to Kelly McGrogan at [redacted] by close of business on Friday 19th July. I appreciate the timescale is short, but we are all working to support a successful and safe migration as quickly as possible.

The question set reflects the assurance request letter issued from Health Facilities Scotland to the Chief Executive of NHS Lothian and subsequent response by NHS Lothian on the 08 March 2019 and 01 April 2019 respectively. These questions have been further refined based on our discussion, initial site visit and learning elsewhere across the health systems.

Please do not hesitate to contact me if you have any questions.

Yours sincerely,

JIM MILLER
Director, Procurement, Commissioning & Facilities, NSS
Senior Responsible Officer RHCYP review group, NSS

Attachment: Appendix 1 – Question Set

cc: Gordon James HFS

Health Facilities Scotland and Health Protection Scotland

Review

RHCYP Edinburgh

July 2019

Document required for review

NOTE: the focus of these initial questions are on water, ventilation, drainage and HAI.

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
1.	NHS Lothian ACR					
2.	Original contract					
3.	Any amendments to contract					
4.	Settlement agreement					
5.	HAI SCRIBE (all iterations)					
6.	Contractor MEP design proposal					
7.	Contractor M design specifications					
8.	Contractor E design specifications					
9.	Contractor P design specifications					
10.	Derogations schedule (and detail)					
11.	Contractor competency checks by NHS L					
12.	Sub-Contractor competency checks by Contractor					
13.	Design drawings (M)					
14.	Design drawings (E)					
15.	Design drawings (P)					
16.	RDD schedule					
17.	Contract instructions					
18.	Sub-contractor deviations from design (M)					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
19.	Sub-contractor deviations from design (E)					
20.	Sub-contractor deviations from design (P)					
21.	Sub-contractor drawings (M)					
22.	Sub-contractor drawings (E)					
23.	Sub-contractor drawings (P)					
24.	Commissioning documentation (M)					
25.	Commissioning documentation (E)					
26.	Commissioning documentation (P)					
27.	Contract supervisor progress reports					
28.	Independent tester progress reports					
29.	Independent tester validation reports					
30.	Independent tester completion certificates					
31.	NHS L independent validation test certificates and supporting documentation					
32.	As installed drawings (M)					ZUTEC access?
33.	As installed drawings (E)					ZUTEC access?
34.	As installed drawings (P)					ZUTEC access?
35.	NHS L Project risk register					
36.	NHS L schedule of unresolved issues					
37.	NHS L technical advisors reports					
38.	NHS L IPC team records					
39.	Paymech (payment mechanism)					
40.	Confirmation that FM contractor has competent staff in place					
41.	Confirmation that FM contractor has AE/AP and CP in place					
42.	PPM schedules					
43.	Contractor critical care vent proposal					
44.	HAI SCRIBE associated with vent proposal					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
45.	Unresolved snagging schedule					
46.	Schedule of known issues post completion					
47.	NHS L water management plan					
48.	Contractor water management plan					
49.	Provide comprehensive timeline of water system indicating when system was pressure tested, initially filled, dried and refilled, water treatment added, commissioning, handover and water management routines.					
50.	Test results and certificates for incoming water					
51.	Test results and certificates for water tanks					
52.	Test results and certificates for hot and cold pipe work					
53.	Test results and certificates for hot water system					
54.	Water treatment test results and certification					
55.	Contractors pre handover risk assessment					
56.	Water system handover documentation					
57.	Evidence of any issues with water system during construction or handover					
58.	Extent of flexible hose installations					
59.	Commissioning documentation for flexible hose installations					
60.	Pressure testing records					
61.	O&M instructions for water system including any recommendations for PPM					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
62.	Specification for water services pipe work					
63.	Records of pipe work inspection during construction					
64.	NHS L initial water risk assessment					
65.	Authorising Engineer (water) initial audit with recommendations					
66.	Appointment letters for Competent Persons (water)					
67.	Appointment letters for Authorised Persons (water)					
68.	Appointment letters for Designated Person (water) Responsible Person (water) Deputy Responsible Persons (water)					
69.	Training records for all AP(W) and CP(W)					
70.	Minutes of all water safety group meetings					
71.	Results of any organisms found and water treatment to eradicate same					
72.	Cold water temperature records (system)					
73.	Hot water temperature records (system)					
74.	Tap temperature records (mixed, hot, cold)					
75.	Main filtration system PPM					
76.	Water storage tank turnover versus storage volume					
77.	Competency of company and individuals carrying out risk assessment					
78.	Details of PPM water systems					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
79.	Details of chemical treatments on any part of the water system post hand over					
80.	Details of thermal treatments on any part of the water system post hand over					
81.	Details of testing regime (frequency, for which organisms, TVC results, organism results etc)					
82.	Details of company taking water samples, training records, methodology.					
83.	Provide details of all sanitary ware types (including taps, clinical wash hand basins and showers)					
84.	Children hospital commissioning results for taps					
85.	PPM records for taps					
86.	Drop tests for taps					
87.	Children hospital commissioning results for taps					
88.	PPM records for taps					
89.	Drop tests for taps					
90.	Children hospital commissioning results for showers					
91.	Confirm all shower hose lengths meet the requirements of SHTM 04-01 part A paragraph 9.54					
92.	PPM records for showers					
93.	Drop tests for showers					
94.	Details on all shower types					
95.	Records for shower hose and head replacements since handover					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
96.	Design brief for requirements including dimensions					
97.	Details of what has been installed					
98.	Records of PPM					
99.	Records of any organisms found and treatment to eradicate.					
100.	Point of Use Filters Cleaning regime					
101.	Point of use Filters Replacement regime					
102.	Ventilation commissioning certification					
103.	Theatre ventilation validation certification					
104.	Details of control system and operational parameters for switching UCV theatre to conventional mode					
105.	Isolation room validation certification					
106.	AHU drawings and specifications					
107.	Air conditioning plant commissioning certification					
108.	BMS certification					
109.	Fire damper test certificates					
110.	Recent Calidus Health and Safety Report					
111.	Details of all water meters					
112.	Details of all water valves (all sizes)					
113.	Details of above ground drainage systems(s)					
114.	Details of below ground drainage system					
115.	Test certificates for above ground drainage system					
116.	Test certificates for below ground drainage					

Ref	Document	Date requested	Date received	Electronic or hard copy	Filed	Comments
117.	NHS L response to HFS “bird dropping “ Guidance					
118.	Details of vermin control measures					
119.	Operational protocol to protect vulnerable patients when a helicopter is landing/taking off.					
120.	Formal training records for all NHS L and FM Contractor staff.					
121.	CDM File					
122.	Can access be provided (read only) to ZUTEC for members of HFS/HPS team					
123.	Confirm the level of involvement of NHS L Infection Control at the following stages of the project: ACR Project Agreement Side Agreement Commissioning Handover					
124.	Confirm the derogation from 100% single side rooms and confirm how the decision was arrived at.					
125.	Confirm compliance with HPS SBAR regarding flooding issue.					

PROUD HISTORIES | NEW CHAPTERS

NHS Lothian

Gordon James
Director of Health Facilities Scotland
Health Facilities Scotland
Meridian Court
5 Cadogan Street
GLASGOW

Date: 1 April 2019
Our Ref:
Enquiries to: Brian Currie
Extension:
Direct Line: [redacted]
E-mail: [redacted]

Dear Gordon

The Royal Hospital for Children and Young People and Department of Clinical Neuroscience, Little France, Edinburgh ("RHSC & DCN Project")

Thank you for your letter dated 8 March 2019 addressed to our Chief Executive, Mr Tim Davison. I have now had an opportunity to consider and discuss with the project team engaged on behalf of the Board to manage the delivery of the RHSC & DCN Project.

We have set out below our response to the assurances requested at points 1-8 in your letter. As the RHSC/DCN Project has been procured via the Scottish Government's non-profit distributing initiative (a form of public/private partnership procurement – we have attached a short report). This provides context for our response.

Evidence Requested

Set against the background of the Contract Structure and Roles and Responsibilities of the Respective Parties, we have set out below the evidence we have produced in the appendices to this letter to demonstrate that the duties have been appropriately discharged and will continue to be discharged in relation to the RHSC & DCN Project. The supporting documents are too large to email with this response, so will be delivered separately.

1. How the Board sought assurance that engineering systems have been designed and are being installed and commissioned to meet current guidance and statutory requirements.

The Project Agreement including the Board's Construction Requirements (BCRs) are explicit in the need for the engineering systems to comply with current guidance and statutory requirements. Over and above this core requirement, additional measures have also been implemented including:

Role of the Independent Tester – As explained below, the Independent Tester was appointed to, amongst other things, carry out regular inspections. As part of his function, the Independent Tester produced monthly reports setting out compliance issues. In terms of final certification and sign off, the Independent Tester sought evidence from Project Co of their compliance with each clause of the Board's Construction Requirements.

Regular Meetings – Throughout the construction phase, Board representatives have attended regular meetings including the weekly Project Management Group, monthly Construction Progress meeting, FM specific monthly meetings, User Group meetings, M&E focused meeting and Commissioning Meetings. At these meetings, development of the design and construction was closely reviewed.

Review Procedure – As explained below, overall contractual responsibility to comply with current guidance and statutory requirements sits with IHSL, nonetheless, the Board and its Technical Advisor, Mott Macdonald, collaboratively reviewed the submitted Reviewable Design Data (RDD) on an ongoing basis throughout the construction period, and any noticeable compliance issues with the Board's Construction Requirements and Project Co Proposals were raised through the contractual Review Procedure, and also through the joint NHS Lothian / IHSL, Project Management Group.

External Advice – throughout the construction process, the Board has worked collaboratively with all relevant stakeholders and as and where necessary and appropriate sought advice and participation from Authorising Engineers in the following disciplines: Ventilation, Water Safety Management & MGPS as well as specialist advice from HFS, and, from within NHS Lothian, the clinical teams, the director of facilities, Infection Control Team, and radiation protection team all with the intent of verifying that the engineering systems meet the Board's Construction Requirements.

Appendix B – Supporting information for evidence requested in point 1:

- Examples of PMG meeting notes;
- Examples of Commissioning / Witnessing meeting note; and
- Examples of Independent Tester reports including IT's tracker compliance list.

2. How the Board is assured that the project was managed on site to ensure safety, quality and compliance of the engineering systems.

The Project Agreement including the BCRs are explicit in the need for safety, quality and compliance of the engineering systems. Over and above this core requirement, additional measures have also been implemented including:

IHSL including its Contractors employed on the RHSC & DCN Project were obliged to comply with IHSL's own Quality Management Plan (included as part of Project Co's Proposals) which in turn was compliant with relevant standards including ISO 9001:2008 International Quality Management System.

Project Co's Quality Management Plan for the RHSC & DCN Project is available, and we would be happy to share with you if required.

Management on site - The Board, its technical advisors, and the Independent Tester have participated throughout the project in regular site meetings, inspections, commissioning, testing, design review, and change process and have highlighted issues to IHSL where necessary and / or appropriate. These meetings include the weekly Project Management Group, monthly Construction Progress meeting, FM specific monthly meetings, User Group meetings, M&E focused meeting and Commissioning Meetings.

Site walkrounds - At the request of the Board project team, Mott MacDonald also undertook building services related site visits that focused on selective areas of building services related concerns, raised through the Review Procedure. Any readily apparent issues were highlighted to the Board project team and then raised with IHSL either as an observation on Zutec (IHSL's online data storage system), or for the more significant issues, raised as an 'Request For Information' (RFI) to IHSL. The RFI schedule would then be discussed at the weekly Project Management Group meetings and then each RFI would then by responded to by IHSL.

Examples of the PMG Meeting notes, commissioning / witnessing meeting notes and Independent Tester reports have been produced in support of item 1 above and we would refer you to these notes and reports which also demonstrate management of safety, quality and compliance. In addition, we enclose in Appendix C:-

- Screenshot of zutec for the sample RAMS for ventilation systems, water systems and electrical systems; and
- Samples of selected RAMS.

3. How the Board is assured that the engineering systems are commissioned, validated and set to work to ensure safety, quality and compliance.

The Project Agreement including the BCRs are explicit in the need for the engineering systems to be commissioned and validated with respect to safety, quality and compliance. Over and above this core requirement, additional measures have also been implemented including;

The role of the Independent Tester is key to this process. They were required to review 100% of the engineering systems commissioning testing certification for compliance, over and above this, they were required to actually witness first hand 25% percent of the tests, targeting critical systems.

We enclose screenshots of sample lists of certification which was produced by IHSL for the Independent Tester for the purposes of issuing a Certificate of Practical Completion. We also enclose copies of the certificates for specific examples enclosed. As you will see, there is a comprehensive suite of testing and commissioning documentation all of which has been approved and / or signed off by the Independent Tester as appropriate.

In addition, during the commissioning phase of the project, the Board's project team with the support of Mott MacDonald also witnessed selective commissioning and testing of specific areas / systems in the Facilities.

The Board's Project Team also reviewed the commissioning risk assessments and method statements relative to compliance with guidance.

Appendix D – Supporting information for evidence requested in point 3:

- Screenshot of Arcadis (Independent Tester) approved certificates;
- Examples of sample actual certificates (water/ventilation/electrical) and;
- Sample extract of MPX RDD tracker.

4. How the Board is assured that its staff and appropriate contractors are adequately trained to ensure engineering systems are managed and operated competently.

The Project Agreement including the Service Level Specifications are explicit in the need for Project Co staff managing the engineering systems to be adequately trained. Over and above this core requirement, the following is highlighted:

In accordance with Good Industry Practice, IHSL are contractually obliged to provide sufficient staff with the requisite level of skill and experience for the provision of the maintenance and operation of the Engineering Systems.

The Board is entitled to review training records and training programs at its discretion and has undertaken this exercise in preparation for the handover of the facilities. In addition to this the Board is requesting updated records via the helpdesk of new staff as they commence work. NHSL has reviewed the training records to check that appropriate training and certification is in place.

Whilst the Board's team has no direct responsibility for managing and operating engineering systems the Board has put in place a contract management function staffed from the NHS Lothian Estates and Facilities Team to oversee the contract. This is staffed by resources experienced in healthcare facilities and the maintenance of engineering systems.

The wider clinical staffing of the hospital has been provided with familiarization training of the site including the user interfaces for engineering systems where appropriate to their roles. Additional guidance on these user interfaces is being included in the Building User Guide for the hospital.

Appendix E – Supporting information for evidence requested in point 4:

- Screenshot of sample PPMs; and
- Sample PPMs.

5. How the Board is assured that the systems to be handed over meet the specified requirements and are safe and effective.

It should also be noted that the engineering systems are handed from IHSL's construction contractor, to IHSL's operations contractor (Bouygues) and as such, Bouygues were

involved in the Review Procedure, Commissioning and Witnessing of the handover of the Facilities. The documentation produced in Appendix D are examples of the procedures adopted by the Board to ensure the systems handed over meet specified requirements and are safe and effective.

6. How the Board is assured that engineering systems will be maintained and operated safely and in compliance with guidance and legal requirements.

Facilities management (hard maintenance services and lifecycle replacement of equipment components) is the responsibility of IHSL and their supply chain. However, as noted in the response to 4 above, the Board's contract management team will continue to oversee the maintenance and operation of the facilities.

A key component of IHSL's management and operation of the facilities is the annual Planned Preventative Maintenance Schedule that sets out all scheduled maintenance against all building elements within the IHSL remit. IHSL and Bouygues have adopted the SFG20 standard to underpin their maintenance regime.

All building elements including engineering systems are to be maintained to retain compliance with Board Construction Requirements, manufacturers' and warranties, NHS Guidance and Legislation. Adhering to this is directly tied into the Project Agreement payment mechanism, and therefore IHSL are incentivised to adequately maintain and operate the engineering systems safely.

We refer you to the documentation produced in Appendices D and E which are examples of the procedures adopted by the Board to ensure the engineering systems will be maintained and operated safely and in compliance with guidance and legal requirements.

7. How the Board is assured that the systems delivered are maintainable, minimise operating cost and maximise reliability and efficacy.

Again, the Project Agreement including BCRs establish the need for the engineering systems to be maintainable, minimize operating costs and maximise reliability and efficacy. Over and above this core requirement, the following is highlighted:

IHSL have been obliged to deliver a clear access and maintenance strategy that also provides for maintenance access that minimises disruption to the patient experience whilst providing safe access. The Access and Maintenance strategy has been reviewed by both the Board and Bouygues as the FM Provider through Review Procedure.

In addition, IHSL take responsibility for the maintenance and long-term lifecycle replacement of the building elements including engineering systems, and are incentivised through the payment mechanism to do so. There are specific provisions in the Project Agreement which provide for the ongoing maintenance and replacement of the building elements including engineering systems. In addition, IHSL's FM Provider, Bouygues, have attended various technical submittal workshops and design workshops during the construction phase where specific systems were collectively reviewed by all parties

including the Board and Bouygues to ensure that the systems could be operated reliably and efficiently.

In addition, as the energy costs are a pass through cost to the Board, the Board have specifically reviewed the Energy model, and developed in the conjunction with the SFT the Energy Strategy mechanism. This incentivizes IHSL to operate and maintain plant efficiency.

The information provided in Appendices D and E are examples of the procedures adopted by the Board to ensure the systems delivered are maintainable, minimize operating costs and maximize reliability.

8. How the Board is assured that the records of construction and as fitted documents are complete and stored and managed correctly.

The Project Agreement including BCRs are explicit in the need for adequate records. Over and above this core requirement, the following is highlighted:

IHSL have implemented an online data storage system ("Zutec") that is being used for the collation of the Operation and Maintenance manuals. The Operation and Maintenance manuals contain the as fitted documentation, alongside other information such as commissioning and testing certificates.

The Board reviewed and commented upon a draft copy of the O&M's and are currently awaiting the final copy in accordance with the Project Agreement timelines.

Once completed, this information will be managed and maintained by Project Co (Bouygues) including a BIM model for the facilities.

In addition to the documentation already produced in relation to points 1 – 7 in this letter, please find enclosed at Appendix F a screenshot of the as built drawings which are being produced by IHSL's supply chain.

Summary and Conclusion

We trust that the foregoing demonstrates the robust processes the Board has in place in order to ensure that IHSL complies with their contractual obligations.

To demonstrate that these processes are operating effectively and efficiently we would refer you briefly to the commercial settlement that has recently been entered into between the Board and IHSL. As you will be aware, the Project is running significantly behind programme. One of the reasons for this is that while construction was progressing, the Board's project team and their technical advisers together with the Independent Tester identified issues which they considered represented significant technical non-conformances with IHSL's contractual obligations. There were disagreements between

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NHS Lothian

IHSL and the Board about the extent of any non-conformances and / or the relevant contractual obligations. Ultimately, in order to resolve these issues, a commercial settlement which was entered into between IHSL and the Board in terms of which IHSL have agreed to undertake certain works in line with a specification and programme which has been agreed with the Board following extensive negotiation and technical review. The short point to note is that these issues were identified early and ultimately resolved to the satisfaction of the Board, illustrating that the processes for overseeing IHSL's performance have been operating effectively.

It should be noted that part of the commercial settlement involves the Board undertaking their commissioning activities whilst IHSL and their supply chain are still carrying out isolated packages of construction works. The Project Team have been and will continue to work closely with IHSL and their supply chain to programme all of the relevant works and ensure that all operations are carried out appropriately and in line with the relevant contractual obligations. There are robust rights and remedies available to the Board in the event of a failure by IHSL to deliver in line with their agreed programme and specification.

Finally, for completeness, please note that we have also liaised directly with IHSL and asked them to provide the assurances sought in your letter. We enclose a copy of our letter dated 12 February 2019 and IHSL's reply dated 13 March 2019.

Yours sincerely

[redacted]

For and on behalf of Lothian Health Board

cc.
Dep. Chief Exec – NHSL
Finance Director – NHSL
Director of Capital Planning and Projects – NHSL
Project Director – NHSL

Enc

The Royal Hospital for Children and Young People and Department of Clinical Neuroscience, Little France, Edinburgh ("RHSC & DCN Project")

The Contract Structure and Roles and Responsibilities of the Respective Parties

Contract Structure

The Board entered into a Project Agreement with a Project Company, IHS Lothian Limited ("IHSL") for the design, build, finance and maintenance of the RHSC & DCN Project at a new build adjacent to the Royal Infirmary of Edinburgh at Little France. The project was procured via the Scottish Government's non-profit distributing initiative (a form of public private partnership procurement).

Pursuant to the Project Agreement (which is in line with the Scottish Future Trust standard form), all aspects of design, construction, ongoing facilities management (hard maintenance services and lifecycle replacement of equipment components) and finance throughout the course of the project term is the responsibility of IHSL.

Project Co's Responsibilities

In order to ensure that the facilities are designed, constructed and commissioned in line with current guidance and statutory requirements, the Project Agreement provides that IHSL are solely responsible for procuring that the design, construction, commissioning and ongoing facilities management (hard maintenance services and lifecycle replacement of equipment components) are performed, amongst other things:-

- in compliance with all laws and consents;
- in a manner not likely to be injurious to health or cause damage to property;
- in a manner consistent with the Board discharging its statutory duties and other functions;
- in compliance with all applicable NHS Requirements;
- in compliance with the Board's Construction Requirements and Project Co's Proposals; and
- in accordance with Good Industry Practice

The Board's Construction Requirements referred to below are, in effect, the Board's detailed specification for the RHSC & DCN Project and were prepared by the Board with specialist input from clinical teams and external advisers (Mott Macdonald). Project Co's Proposals set out IHSL's design to ensure compliance with the Board's Construction Requirements and these were scrutinized by the Board and their specialist advisers during the procurement phase of the Project.

In addition, there are specific provisions within the Project Agreement pursuant to which IHSL warrant to the Board that it has used, and will continue to use, the degree of skill and care in the design of the facilities that would reasonably be expected of a competent professional designer experienced in carrying out design activities of a similar nature, scope and complexity to those comprised in the works. Accordingly, design responsibility,

together with ongoing responsibility to ensure compliance with applicable laws and standards, sits with IHSL.

During the construction phase, where there are elements of design development, the Project Agreement provides for the Board's project team to review the design, albeit responsibility for that design remains with IHSL (with the exception of certain limited matters regarding the clinical functionality of the hospital spaces).

Project Co's supply chain

As you are aware, IHSL is a special purpose vehicle set up to deliver the RHSC & DCN Project and the project documents provide for IHSL sub-contracting the design and construction to Multiplex Construction Europe, a large multinational construction firm. In effect, the obligations incumbent upon IHSL to the Board pursuant to the Project Agreement are passed down by IHSL to Multiplex. Multiplex, in turn, sub-contracts various aspects of the design and construction to specialist sub-contractors.

Similarly, IHSL have sub-contracted the facilities management services to Bouygues E&S FM UK Limited, a large multinational facilities management company. Again, the obligations incumbent upon IHSL to the Board are passed down by IHSL to Bouygues.

The Board's Project Team

From business case development to the delivery of a live hospital and for a period after the Board has had and will have in place an appropriately resourced and experienced project team. Complimentary skill sets are evident ranging from project management of large projects, healthcare building services, soft FM services and medical equipment provision through to extensive clinical and operational knowledge of all key services being re provided. The majority of the current team of twenty individuals have been in place for 5 years or more bringing continuity through all key project stages.

In addition, to assist the Board team, the Board made the following key appointments for the provision of adviser support for the RHSC & DCN Project. The following team has advised on the Project during the procurement stages and continued to advise NHS Lothian through completion of construction works and into commissioning:

- Technical – Mott Macdonald Limited
- Legal – MacRoberts LLP
- Financial – Ernst & Young LLP
- Insurance – Willis

As you will no doubt be aware, each of the above companies are recognized specialists in their respective areas of expertise.

It should be noted, in particular, that Mott Macdonald Limited, assisted the Board team in the preparation of the Board's Construction Requirements and the Completion Criteria. MacRoberts LLP advised on the terms of the Project Agreement.

Independent Tester

Pursuant to the project documents, an Independent Tester was appointed by the Board, IHSL and IHSL's funders as an independent adviser to provide certain services independently, fairly and impartially in connection with the RHSC & DCN Project. In particular, the Independent Tester provides the following services:-

- design review
- construction review services, including monitoring and inspecting the works for compliance with the Project Agreement, Board's Construction Requirements, Project Co's Proposals and the Completion Criteria
- selective checking of the works for compliance with the Construction Quality Plan
- reviewing the written mechanical and electrical engineering services testing and commissioning procedure and undertaking selective witnessing of mechanical and electrical works
- inspection of rectification works
- checking the production of operating manuals, relevant approvals, test results, inspection records and as built drawings and monitor the timely handover of this documentation.

Crucially, the facilities cannot be certified as practically complete, allowing the Board commissioning to commence and thereafter the hospital to become operational until the Independent Tester is satisfied that the works have been completed in accordance with the Project Agreement, the Board's Construction Requirements, Project Co's Proposals and the Completion Criteria. A copy of the Completion Criteria are set out as Appendix A to this letter. As you will see, it sets out a detailed list of inspection, testing and acceptance activities and documentation which require to be actioned before completion can be certified by the Independent Tester.

The foregoing processes have been carried out by the Independent Tester on an ongoing basis throughout the construction phase of the Project and the Independent Tester issued a Certificate of Practical Completion on 22 February 2019.

Funders

As outlined below, IHSL finance the RHSC & DCN Project and this is facilitated via a loan from their funders. As part of the funder's due diligence process there is a lender's technical adviser who reviews compliance by IHSL and their supply chain with their contractual requirements.

City of Edinburgh Council and Environmental Health

The remit of the building standards system is to protect the public interest by setting out the standards to be met when building or a conversion takes place, to the extent necessary to meet the building regulations. The public interest is a critical success factor – ensuring compliance with regulations and above all – keeping the public safe.

The Building (Scotland) Act 2003 provides for the appointment of verifiers by Scottish Ministers. At present the only appointed verifiers are the 32 Scottish local authorities, each covering their own geographical area, the City of Edinburgh Council in this project's case.

The main function for local authorities in their verification role, is granting building warrants and accepting completion certificates. This work is central to the delivery of the following key objective contained in the 2003 act: *To secure the health, safety, welfare and convenience of persons in and about buildings and others who may be affected by buildings or matters connected with buildings.**

The Board have no direct contact or relationship with Building Control, this being the role of IHSL and their building contractor Multiplex.

The City of Edinburgh Council's Environmental Health Department is also responsible for investigating, enforcing and resolving public health, health and safety and all aspects of environmental health problems and issues in relation to relevant legislation.

The Board's only direct contact with the Council's Environmental Department has been in relation to catering facilities within the new facility.

** Building Standards Verification – Key Performance Outcomes Handbook (from May 2012); Building Standards Division, Scottish Government.*

Scottish Future Trust

The NPD standard form project agreement used on this project was developed in full consultation with SFT to adapt it to the specific risks and requirements of the major acute healthcare sector. SFT value for money guidance is also mandatory for all capital programmes and projects for the Scottish Government, its Associated Directorates, Executive Agencies, Non Departmental Bodies and for all public bodies in receipt of funding from the Scottish Government or its agencies.

It is a condition of Scottish Government funding support that all projects in the revenue funded programme are, in addition to any existing projects approvals processes, externally validated by SFT. SFT undertook Key Stage Reviews at appropriate key stages in the project's procurement. SFT also conducted a detailed review of the design and specification of the project and provided comment to the Scottish Ministers and Project Sponsor as part of a general project support function.

In summary, the Project Agreement and associated documents are a robust suite of contracts which provide for the transfer of risk for the design, construction, commissioning and facilities management (hard maintenance services and lifecycle replacement of equipment components) to IHSL and their supply chain. As well as being overseen by the Board project team, the City of Edinburgh Council, Scottish Future Trust, Lender's Technical Adviser and Independent Tester all have responsibilities in managing and supervising IHSL's compliance with the Project Agreement including applicable statutory

requirements and guidance, Good Industry Practice and the Board's Construction Requirements.

NHS Lothian
1 April 2019

Appendices

Appendix A – Completion Criteria

Appendix B – Supporting information for evidence requested in point 1:

- Examples of PMG meeting notes;
- Examples of Commissioning / Witnessing meeting note, and;
- Examples of Independent Tester reports including IT's tracker compliance list.

Appendix C – Supporting information for evidence requested in point 2:

- Screenshot of zutec for the sample RAMS for ventilation systems, water systems and electrical systems, and;
- Samples of selected RAMS.

Appendix D – Supporting information for evidence requested in point 3:

- Screenshot of Arcadis approved certificates;
- Examples of sample actual certificates (water/ventilation/electrical) and;
- Sample extract of MPX RDD tracker.

Appendix E – Supporting information for evidence requested in point 4:

- Screenshot of sample PPMs, and;
- Sample PPMs.

Appendix F

- Screenshot of As Built drawings.

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NHS Lothian

Wallace Weir
IHS Lothian Limited
C/O Pinsent Masons
13 Queens Road
Aberdeen
AB15 4YL

Date: 12 February 2019
Our Ref : BC/IHSL
Enquiries to: Brian Currie
Extension: [redacted]
Direct Line: [redacted]
E-mail: [redacted]

Dear Sirs,

Re-Provision of RHSC and DCN at Little France
Assurance

We would be grateful if you could provide your written assurance:

1. That engineering systems have been designed and are being installed and commissioned to meet current guidance and statutory requirements.
2. That the project is and will be managed on site to ensure safety, quality and compliance of the engineering systems,
3. That the engineering systems have been commissioned, validated and set to work to ensure safety, quality and compliance,
4. That your staff and appropriate contractors are adequately trained to ensure engineering systems are managed and operated competently,
5. That the systems to be handed over at Actual Completion meet the specified requirements and are safe and effective.
6. That engineering systems will be maintained and operated safely and in compliance with guidance and legal requirements.
7. That the systems delivered are maintainable, minimise operating cost and maximise reliability and efficacy.
8. That the records of construction and as fitted documents are complete and stored and managed correctly.

RHSC + DCN Project Office
Little France Crescent
EDINBURGH
EH16 4TJ

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NHS Lothian

Engineering systems include:

1. Electrical HV/LV
2. Hot and cold water services
3. Heating
4. Ventilation, including specialised ventilation in isolation rooms, theatres etc
5. Medical gas and vacuum systems
6. Pressure systems
7. Drainage
8. Fire precautions and equipment
9. Lifts and escalators

We look forward to hearing from you.

Yours faithfully

[redacted]

Brian Currie
Board's Representative
For and on behalf of Lothian Health Board

cc.
Dep. Chief Exec – NHSL
Finance Director – NHSL
Director of Capital Planning – NHSL
LTA – Currie + Brown
IT - Arcadis

RHSC + DCN Project Office
Little France Crescent
EDINBURGH
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IHS LOTHIAN LTD

190313 IHSL.LHB Assurance

Brian Currie
Board's Representative
Lothian Health Board
Waverley Gate
2-4 Waterloo Place
Edinburgh EH1 3EG

13th March 2019

Dear Sirs

Re-Provision of RHSC and DCN at Little France
Assurance

All references in this letter to the "Project Agreement" are references to the Project Agreement entered into between Lothian Health Board (the "Board") and IHS Lothian Limited ("Project Co") dated 12 and 13 February 2015, as amended by an amendment agreement between the Board and Project Co dated 19 December 2018, and a settlement and supplemental agreement between the Board and Project Co dated 22 February 2019 (the "Settlement Agreement").

Further to your letter dated 12 February 2019 requesting our written assurances, we can confirm the following:

1. The engineering systems are designed and have / are being installed and commissioned to meet the relevant Project Agreement standards.

2. The project has been managed on site to procure the safety, quality and compliance of the engineering systems in accordance with the Project Agreement.

3. The engineering systems have been commissioned and validated in accordance with the Project Agreement.

4. Project Co's staff and contractors involved in installing, commissioning and operating the engineering systems are trained and qualified in accordance with the Project Agreement.

5. The engineering systems handed over at the Actual Completion Date were designed and constructed to meet the specified requirements set out in the Project Agreement.

6. The engineering systems will be maintained and operated in accordance with the Project Agreement.

7. The engineering systems are maintainable and have been constructed within the Project Agreement parameters with regard to operating cost, reliability and efficacy.

8. As at the Actual Completion Date, the records of construction and as fitted documents are complete (save for those varied under the Settlement Agreement), and are stored and managed in accordance with the Project Agreement.

Yours faithfully,

[redacted]

Wallace Weir
For and on behalf of IHS Lothian Limited

cc.
LTA - Currie & Brown
IT - Arcadis

IHS LOTHIAN LTD

EDINBURGH CHILDREN'S HOSPITAL - UPDATE

Purpose
1. Following our discussion yesterday this provides an update on the current situation regarding the opening of the new Edinburgh Children's Hospital.

Priority
2. High.

Background
3. The Edinburgh Children's Hospital was originally expected to be completed in July 2017, but due to a number of technical issues the project completion date was delayed. The principle and most serious problem was the positive/negative air pressure of the four bedroom general wards. To address these issues, NHS Lothian, in conjunction with Scottish Government, agreed a £11.6 million Settlement Agreement which would allow the hospital to be completed. The terms of the agreement however were not agreed until February 2019 which enabled a project completion date of 7 February 2019. The Board would accept the facility as being essentially complete once all outstanding issues, which the parties have agreed can be undertaken post–completion, had been resolved. This agreement was intended to allow patients to be moved to the new hospital in July 2019.

Current Issues
4. On Tuesday 2 July, NHS Lothian alerted DG Health and Social Care to an emerging issue with the ventilation systems in the 21 critical care beds which could potentially impact on when services transfer over to the new hospital. In order to keep to the agreed timeline, a decision on whether to continue with the transfer of patients to the new hospital, would need to be taken today at the latest.

5. The relevant ventilation guidance, Scottish Health Technical Memorandum 03 (SHTM03): Heating and Ventilation systems, requires there to be ten changes of air per hour, but recent testing conducted on Monday 1 July, as part of final validation tests have indicated that air is only being changed four times an hour. At this point, it would appear that the requirement was mis-specified in the Settlement Agreement and therefore it is NHS Lothian's responsibility to resolve.

6. NHS Lothian, supported by Health Facilities Scotland and Health Protection Scotland, have been considering the various options available. They were concerned with the risks associated with undertaking invasive rectification works within a live patient environment and recommended that critical care beds do not move until the problem has been fixed. The main risks are that while a technical solution has been identified it requires further testing and challenge before we can be confident the solution works and can be delivered and there is concern about the impact on national capacity if beds are taken out during works.

7. On that basis, I decided that the Health Board should not proceed as planned and 'retro fix' and I instructed all work on that to stop, and instead for NHS Lothian to concentrate on the inpatient and critical care element of the move until later, once modification of the ventilation was compliant with SHTM03.

8. In the meantime, NHS Lothian are considering a modified transition plan which would see the Department of Clinical Neurosciences (DCN) move as planned with other non-critical children's services potentially to follow before critical care services transfer; this will be clarified later today.

Why was this not noticed earlier?
9. As part of the Settlement Agreement, NHS Lothian agreed that ventilation for general wards could be four changes per hour. They should have specified that critical care beds were not part of that derogation, but they did not so the contractor has used this as evidence that only four changes an hour were required. When the first test was undertaken, the critical care beds 'passed' the test because the tester was looking to see whether four changes an hour was being achieved. At that point no-one realised that they were testing it against the wrong benchmark. Clearly NHS Lothian should have been clearer in

the settlement agreement and they should have picked up that the original test was not correct, so they will be looking at this to understand what went wrong.

Summary

10. In order to ensure that patients are being treated in a safe, clean and clinically appropriate environment, I have instructed NHS Lothian to delay the transfer of patients to the new Edinburgh Children's Hospital. We expect that it will take at least six months for the problem to be resolved, but further work is required to test and validate the proposed solution and estimated timeline.

11. I have also asked that we undertake an external series of checks, led by Health Facilities Scotland and Health Protection Scotland, to ensure that all the relevant technical specifications and standards applicable to the new Edinburgh Children's Hospital are being followed and implemented.

12. Given that it is unclear today what services can be safely moved to the new site, I have instructed that a halt is place on the move in full, pending the outcome of the action at paragraph 11 above, which will then trigger a phased move of services.

13. I will lead on media communications and I will review and approve NHS Lothian's handling plan covering communications to staff, public and patients, before it is released. I have also been clear with NHS Lothian that assurances on critical patient safety areas must be given to SG before any patient moves in.

14. Follow up work has been commissioned by me to audit the full decision and build process to identify how and where this ventilation problem initiated and why it has not been identified until this week. I will continue to keep you updated as this situation develops.

Cabinet Secretary for Health and Sport
4 July 2019

From:	Anderson D (David) (Health) on behalf of McLaughlin C (Christine)
To:	MacDonald D (Daniel); Healy M (Michael); Scottish Government Health Resilience Unit; McLaughlin C (Christine)
Cc:	Low S (Stuart); Roche R (Rowena); Morrison A (Alan)
Subject:	FW: Cab Sec visit to Royal Hospital for Sick Children
Date:	15 July 2019 12:48:38
Attachments:	Briefing - visit to Royal Hospital for Sick Kids.doc
Importance:	High

Adding SG Resilience mailbox, Alan Morrison and Rowena Roche.

David Anderson
PA to Christine McLaughlin, Chief Finance Officer, NHS Scotland, and Director of Health Finance, Corporate Governance and Value
PA to Richard McCallum, Deputy Director - Health Finance and Infrastructure
Room 1E.05
St. Andrew's House
Regent Road
Edinburgh
EH1 3DG
[redacted]

From: MacDonald D (Daniel) [redacted]
Sent: 15 July 2019 12:12
To: McLaughlin C (Christine) [redacted]; Healy M (Michael) [redacted]
Subject: FW: Cab Sec visit to Royal Hospital for Sick Children
Importance: High

Christine / Michael

Please see attached a draft brief for the Cab Sec for her visit to the RHSC in Edinburgh which is not yet confirmed, but is likely to be Thursday. She will be meeting the staff and we understand this is to be a low key affair.

Apologies if I am wrong, but I understand you are both leading on this re the resilience committee so wanted to make you aware of the brief and see if there was anything that needed to be added, in particular around the media this morning re the flooding issues?

Kind regards

Daniel

Daniel MacDonald
Workforce Adviser / Programme Director
Health Workforce, Leadership and Service Reform Directorate
Ground Floor Rear
St Andrews House
Regent Road
Edinburgh, EH1 3DG

Tel: [redacted]

From: MacDonald D (Daniel)
Sent: 15 July 2019 11:28
To: Low S (Stuart) [redacted]
Cc: Carmichael A (Alison) [redacted]; Murray D (Diane) [redacted]; Birch J (Jason) [redacted]; Aitken L (Louise) [redacted]; Johnstone M (Mark) [redacted]; Ives J (Josephine) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Now with attachement!

Daniel MacDonald
Workforce Adviser / Programme Director
Health Workforce, Leadership and Service Reform Directorate
Ground Floor Rear
St Andrews House
Regent Road
Edinburgh, EH1 3DG
Tel: [redacted]

From: MacDonald D (Daniel)
Sent: 15 July 2019 11:22
To: Low S (Stuart) [redacted]
Cc: Carmichael A (Alison) [redacted]; Murray D (Diane) [redacted]; Birch J (Jason) [redacted]; Aitken L (Louise) [redacted]; Johnstone M (Mark) [redacted]; Ives J (Josephine) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children
Importance: High

Dear all

With thanks to Alison, attached is the first outline of the brief for the Cab Sec visit to the RHSC. I have spoken to her office and Thursday afternoon is likely but won't be confirmed until later today. I am also making contact with NHS Lothian to get an update on the media over the weekend for adding in (unless anyone already has briefing on this?).

Comments by COP today as need to get this to Cab Sec office tomorrow.

Regards

Daniel
Daniel MacDonald
Workforce Adviser / Programme Director
Health Workforce, Leadership and Service Reform Directorate

Ground Floor Rear
St Andrews House
Regent Road
Edinburgh, EH1 3DG
Tel: [redacted]

From: Low S (Stuart) [redacted]
Sent: 12 July 2019 13:22
To: MacDonald D (Daniel) [redacted]
Cc: Carmichael A (Alison) [redacted]; Murray D (Diane) [redacted]; Lea-Ross S (Stephen) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Daniel
Please see background information attached - Please advise should you require any additional material.

Kind regards
Stuart

From: Murray D (Diane) [redacted]
Sent: 12 July 2019 11:19
To: Lea-Ross S (Stephen) [redacted]; MacDonald D (Daniel) [redacted]; Low S (Stuart) [redacted]; Carmichael A (Alison) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Thank you Stephen,

CNOD will provide input as required but also happy to provide support to Alison as required.

Regards

Diane

From: Lea-Ross S (Stephen) [redacted]
Sent: 12 July 2019 11:17
To: Murray D (Diane) [redacted]; MacDonald D (Daniel) [redacted]; Low S (Stuart) [redacted]; Carmichael A (Alison) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Many thanks Diane, copying in Alison Carmichael – the Employee Experience team will lead on co-ordination of the briefing pack

Regards
Steve

From: Murray D (Diane) [redacted]
Sent: 12 July 2019 11:15
To: MacDonald D (Daniel) [redacted]; Low S (Stuart) [redacted]
Cc: Lea-Ross S (Stephen) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Hi Daniel,

Stuart will send you the background briefing and the staff Q&A comms to support the development of the briefing for the cab sec visit.

No confirmation of date as yet but likely to be Thursday or Friday.

Regards

Diane

From: MacDonald D (Daniel) [redacted]
Sent: 12 July 2019 10:51
To: Murray D (Diane) [redacted]
Cc: Lea-Ross S (Stephen) [redacted]
Subject: RE: Cab Sec visit to Royal Hospital for Sick Children

Diane

Just to confirm if someone can send me what briefing there already is and I can get one of my team to look at it and put in into the visit format, and add in anything relevant.

Do we have a confirmed date for the visit?

Daniel

Daniel MacDonald
Workforce Adviser / Programme Director
Health Workforce, Leadership and Service Reform Directorate
Ground Floor Rear
St Andrews House
Regent Road
Edinburgh, EH1 3DG
Tel: [redacted]

From: Murray D (Diane) [redacted]
Sent: 12 July 2019 10:09
To: MacDonald D (Daniel) [redacted]
Subject: FW: Cab Sec visit to Royal Hospital for Sick Children

Hi Daniel,

Sean has asked me to contact you regards this as he will be off on leave.

As Director for people we assume that Shirley will want to run point on this one. We will need someone to lead the organisation of the visit and development/co-ordination of briefing.

Happy to chat through.

You can get me on my mobile [redacted].

Regards

Diane

From: Murray D (Diane)
Sent: 12 July 2019 10:00
To: Neill S (Sean) [redacted]; Ives J (Josephine) [redacted]; Johnstone M (Mark) [redacted]; Birch J (Jason) [redacted]
Cc: Aitken L (Louise) [redacted]; Hart S (Suzanne) [redacted]
Subject: Cab Sec visit to Royal Hospital for Sick Children

Hi All,

At the meeting yesterday Cab Sec advised that she will visit the Royal Hospital for Sick Children towards the end of next week. The meeting is to have discussions with staff affected by the delay in moving to the new site, she may also wish to chat to some patients.

CMO has agreed to support the visit.

Comms require briefing for same. In Shirley's absence, Sean, given the staff requirements of the visit I take it you will want to run point on this one. Jo and Mark we will also need input to the briefing from our clinical and policy areas.

The suggestion is that she visits outpatients, ITU (if possible dependant on patient needs at the time) and a ward area. The visit will be supported by our comms team and will be a social media only visit.

The briefing will be required early next week to allow Cab Sec to clear.

Sean I have tried to call this morning it would be good to have a quick catch up. You can get me on [redacted].

Regards

Diane

BRIEFING FOR CABINET SECRETARY FOR HEALTH AND SPORT

Visit to Royal Hospital for Sick Children

Date and time of engagement	tbc
Where	Royal Hospital for Sick Children 9 Sciennes Road Edinburgh EH9 1LF
Who	Visit to outpatients, ITU (if possible dependant on patient needs at the time) and a ward area.
What	Social media visit only
Why	To meet staff and patients
Likely themes	Delay to transfer to new Edinburgh Children's Hospital - operational impact and support for patients and staff
Official Support	Catherine Calderwood, CMO, Comms
Briefing Content	Annex A: Background and key issues Annex B: Q&A

Annex A

Postponed Hospital Moves Royal Hospital for Children and Young People, CAMHS and Department of Clinical Neurosciences

- In order to ensure that patients are being treated in a safe, clean and clinically appropriate environment, I instructed NHS Lothian to delay the transfer of patients to the new Edinburgh Children's Hospital.

- I have asked for an external series of checks, led by Health Facilities Scotland and Health Protection Scotland, to ensure that all the relevant technical specifications and standards applicable to the new Edinburgh Children's Hospital are being followed and implemented.

- The delay has been caused by an problem with the ventilation in Paediatric Critical Care which came to light in final checks. Further work is required to test and validate the proposed solution and estimated timeline including if might be possible for some services unaffected by the ventilation issue to move in the shorter term.

- I know this will be disappointing for staff and we are doing everything we can to support you and to move to the new site as soon as possible. I will write to all staff to update them on the situation and thank them for their ongoing patience.

Operational Impact and Support provided to Patients

- The dedicated helpline set up by NHS 24 has received 55 patient calls as at 11th July. All of these calls were appointment related. The helpline will remain in place and NHS 24 are providing daily updates on activity levels.

- NHS Lothian have been contacting patients by telephone for those who have appointments in July and issuing letters to patients who have scheduled appointments from August onwards. NHS Lothian are also providing daily update reports on the patient contact position. The tables below show total numbers of patient appointments (for the month of July) and those who have been contacted across affected areas:

Department	Total Patient Appts - July	Total Number of Patients Contacted (as at 10 July)
Paediatric	1744	1645
DCN	680	139

Department	Total Radiology Appts - July	Total Number of Patients Contacted (as at 10 July)

Paediatric	301	206
DCN	392	348

- Dedicated redirection staff are on the new site to redirect any self-presenters who might attend. Two patients have self-presented to date and NHS Lothian are keeping this situation under review over the coming week with a view that redirecting staff can be returned to work on the existing site as soon as possible.

- A Q&A for NHS Lothian staff has been cleared by the Scottish Government and published by NHS Lothian on their staff intranet site.

External Checks by Health Facilities Scotland (HFS) & Health Protection Scotland (HPS)

- HFS and HPS are working on site compliance with technical specifications and standards. HFS/HPS are also currently engaging with third party experts to assist in delivering this work. Ventilation, drainage issues and issues that directly impact on the DCN have been prioritised. The plan for delivery of this work is expected by 15 July.

KPMG Audit of Governance

- KPMG should be on site from Monday 15th July. Timescales for the completion of this work should also be known by then and emphasis has been placed on having this work completed as quickly as possible.

Engagement with Clinical professionals

- Regular communications are being maintained with the RCPCH and the RCN to keep them updated on progress. No expressions of concern have been made to RCPCH by its members and the organisation remains supportive of actions taken to ensure patient safety.

Annex B

Q&A

Pay Protection

I was due to go on to pay protection following the move to the new hospital. As this has been postponed, what will happen?

You will continue to be paid as you would normally and your pay protection will not commence until the move to the new hospital happens. As the effective date of pay protection will be delayed the reference period will be recalculated to ensure that any protection is reflective of the hours worked and paid.

Overtime Payments

I was due to work overtime to assist with the move and made alternative family/social arrangements to accommodate this, will I still get paid?

Any planned and agreed overtime, which had been approved to assist with the move will be honoured.

Car Parking

I was allocated a parking permit at the new hospital, what are my options, now that the move has been postponed?

Staff were due to collect permits from Tuesday 8th July, therefore it is unlikely that you will have done so. If, however you have received your permit please can you let your supervisors or line manager know and they will make arrangements to ensure that you are not charged for the permit and that your permit is returned to the Facilities team.

Additional Travel time/Additional costs

I have arranged childcare closer to the new hospital which will impact on my travel time. Are there any arrangements to acknowledge this?

Managers are being advised to support staff, and allow an element of flexibility in start and finish times to accommodate this change.

I am incurring additional transport costs due to my altered childcare, will these be paid?

Any additional costs incurred in travelling will be reimbursed.

I purchased a bus pass in anticipation of the move and on the understanding that it would be reimbursed as part of my entitlement to be reimbursed for excess travel costs associated with the move. What will happen now?

You will be reimbursed in this interim period for any excess costs in line with excess travel guidance. Your full 4 years excess travel entitlement will not be affected by this and will commence from the date of the actual move to the new hospital.

Annual Leave

I postponed taking annual leave until after the move to the new hospital, will my leave still be honoured?

Yes all leave will be honoured.

Staffing

New members of staff are due to take up post in the coming weeks, what arrangements have been put in place to advise of change of base location?

Managers are currently reviewing when individuals are due to start and advising them where to report.

I was due to take up a promoted post following the move, will I still get paid at my new banding?

Your increased salary will apply as planned but there may be a delay in commencing your new duties pending the move. This should be discussed with your manager.

Next Steps

Is there a new date for the move?

We are currently revisiting the plans for the move and once further information is available on these revised plans information will be communicated to staff.

How do I find out what's happening in general about the move? How do I stay up-to-date?

Your main point of contact should be your line manager and you should ask them any questions you have in the first instance. They may be able to give you an answer right away. If they can't, they will either find out for you or direct you to the person who can tell you.

Updates will also be posted on NHS Lothian intranet news and cascaded via departmental managers.

Patient/Relative Communication
I am being asked questions by patients/relatives as to what is happening, how should I respond?

You should acknowledge the uncertainty for patients and relatives but be careful not to respond based on your assumptions or opinions on what will happen. You can say that patients and relatives will be updated as soon as plans are available All patients with appointments in the new building are being contacted directly by the teams responsible for their care with details of new appointments. Every effort will be made to give them a new appointment at the same date and

time as their original appointment. **For appointment information you can contact the dedicated helpline on 0800 028 2816, 8am-10pm Mon-Fri and 9am-5pm Sat & Sun.**

Media Enquiries
If I am contacted directly by the media, what should I do?

All media enquiries should always be directed to the NHS Lothian Communications team. The media do know this so it should not come a surprise. They can email lothian.media@nhs.net or call 0131 465 5644.

Support for Staff
If you have any other questions or concerns

You can discuss your concerns with your line manager in the first instance, or you can contact HR Enquiries on 0131 536 (6)1130 option 3 or by email to HR.Enquiries@nhslothian.scot.nhs.uk. Your trade union or professional organisation representative is also available for advice and support.

From:	Henderson C (Calum)
To:	Cabinet Secretary for Health and Sport
Cc:	McQueen F (Fiona); Murray D (Diane); DG Health & Social Care; Henderson C (Calum); Aitken L (Louise); Hutchison D (David)
Subject:	HIS Inspection of Sick Kids
Date:	07 October 2019 11:24:04
Attachments:	Letter to HIS Chair - Cabinet Secretary.docx F20190028659.doc

PS/ Cabinet Secretary or Health and Sport

Purpose

To provide an update on the proposed inspection by HIS on the current Sick Kids Site.

Priority

Immediate

Background

In a Parliamentary debate on 18 September 2019, Miles Briggs asked the Cabinet Secretary instruct HIS to undertake an urgent inspection of the existing site to investigate concerns. The Cabinet Secretary confirmed that this would be the case .

During the visit at both Royal Hospital Sick Children and the Department of Clinical Neurosciences, clinicians raised concerns regarding the appropriateness and timing of an urgent inspection and report from Health Improvement Scotland (HIS).

Officials were made aware that HIS have possibly been preparing for an unannounced visit to the site given that it is still functioning and therefore would be due for an inspection.

Recommendations

The Cabinet Secretary write to the Chair of Health improvement Scotland under powers of the National Health Service (Scotland) Act 1978 to ask that any inspection of the existing site take account the current situation with regards to the halt of the move to the Royal Hospital for Children and Young People.

Conclusion

The Cabinet Secretary is asked –

(a) to confirm whether she is content with the proposed action
(b) if so, to use the draft letters attached as a basis to write to both the Chair of Health Improvement Scotland and Miles Briggs MSP.

Cabinet Secretary for Health and Sport
Jeane Freeman MSP

Scottish Government
Riaghaltas na h-Alba
gov.scot

[redacted]

Carole Wilkinson
Chair
Health Improvement Scotland
Gyle Square
1 South Gyle Crescent,
Edinburgh
EH12 9EB

October 2019

Dear Carole,

You will be aware that Miles Briggs (Lothian) (Con) asked in a parliamentary debate that I instruct HIS to undertake an urgent inspection to investigate the concerns that the said member highlighted to me. I confirmed that I would do exactly that and that I looked forward to receiving Mr Briggs's letter on the concerns that have been raised.

I understand that HIS may have been preparing for an unannounced visit to the site given that it is still in use and therefore would be due for a re-inspection.

In line with the powers vested in Scottish Ministers in Section 10M (2) of the National Health Service (Scotland) Act 1978. I would like to specify that any inspection to be undertaken of the Royal Hospital for Sick Children in NHS Lothian should be undertaken for the purposes of identifying what immediate steps require to be taken to ensure the safety and cleanliness of the environment for the children and the young people undergoing care within the premises.

In doing so I would ask that Healthcare Improvement Scotland pay particular attention to the difficult situation that the staff find themselves in, having to change well developed plans for the delivery of care in a new environment. I would ask the inspection team to understand the sensitivities and pressures the clinicians face and to work with them to identify what is needed to maintain high levels of quality and safety until the children and young people can be moved to the new facility in autumn 2020.

I would expect any requirements or recommendations to be given urgent priority by NHS Lothian, and I would like to receive your report at the earliest convenience.

Regards

Jeane Freeman

Cabinet Secretary for Health and Sport
Jeane Freeman MSP

Scottish Government
Riaghaltas na h-Alba
gov.scot

[redacted]

Mr Miles Briggs MSP
The Scottish Parliament
EDINBURGH
EH99 1SP

Our ref: 2019/0028659
October 2019

Mr Briggs

Thank you for your letter dated 24 September.

Following the debate, I met with Staff at both Royal Hospital Sick Children and the Department of Clinical Neurosciences where clinicians raised concerns regarding the appropriateness and timing of an urgent inspection and report from Health Improvement Scotland (HIS). I am committed to ensuring that the involvement of HIS is supportive and addresses concerns effectively and appropriately. My officials are currently working with HIS to establish what support can be provided to both sites to allow them to plan for providing quality care over the winter months and until migration to the new site is complete.

You also asked for a break-down of all inspections that, following the concerns that have emerged at the Queen Elizabeth University Hospital and the new Sick Kids' in Edinburgh, are taking place, or will take place, into any other NHS hospital new build projects that have opened since 2007 or are currently under construction. All HIS inspections are unannounced and the Board does not share information regarding upcoming inspections on NHS Sites.

The Annex A provides details of inspections of the Royal Hospital for Sick Children since 2007.

I want to reiterate my commitment to ensuring NHS Lothian are supported to deliver on quality services whilst maintaining patient safety at the forefront.

Jeane Freeman

ANNEX A

HAI Inspections within NHS Lothian's Royal Hospital for Sick Children since 2007*

Date	No of Requirements**	No of recommendations***
15 June 2011	4	3
11 July 2012	3	3
6 August 2013	2	4
2 December 2015	5	2
18 September 2018	4	2

* To note, HAI Inspections commenced in September 2009

** A requirement sets out what action is required from an NHS board to comply with the standards published by Healthcare Improvement Scotland or its predecessors. These are the standards which the patient has the right to expect. A requirement means the hospital or service has not met the standards and the HEI is concerned about the impact this has on patients using the hospital or service. The HEI expects that all requirements are addressed and the necessary improvements are made within the stated timescales.

*** A recommendations relates to national guidance and best practice which the HEI considers a hospital or service should follow to improve standards of care.

NHS National Services Scotland

Scottish Health Technical Memorandum 03-01

Ventilation for healthcare premises
Part A – Design and validation

Health Facilities Scotland
Engineering and Environment

February 2014

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Preface

About Scottish Health Technical Memoranda

Engineering Scottish Health Technical Memoranda (SHTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of Scottish Health Technical Memorandum guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle.

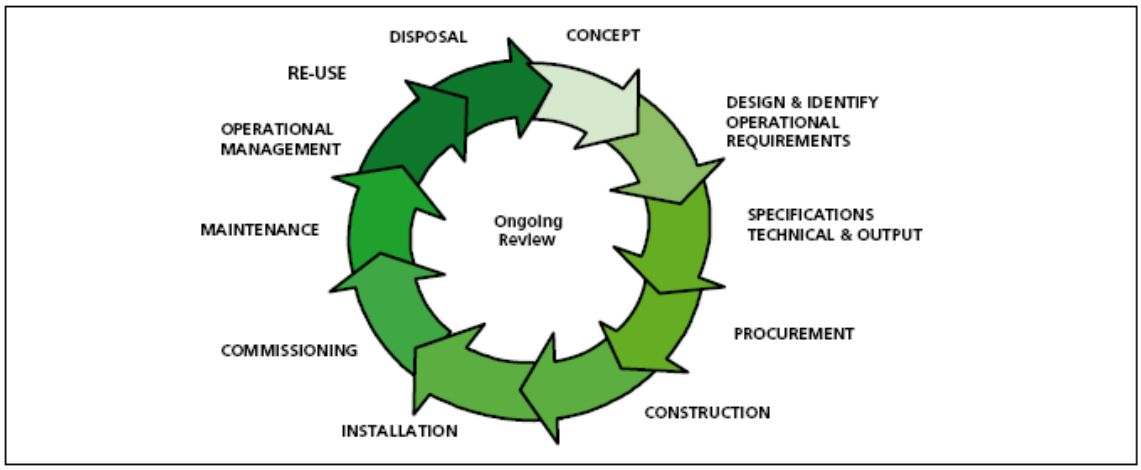
Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Engineering Scottish Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to repeat unnecessarily international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Scottish Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of eight subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.



Healthcare building lifecycle

Structure of the Scottish Health Technical Memorandum suite

The series of engineering-specific guidance contains a suite of eight core subjects:

Scottish Health Technical Memorandum 00: Policies and principles (applicable to all Scottish Health Technical Memoranda in this series).

Scottish Health Technical Memorandum 01: Decontamination.

Scottish Health Technical Memorandum 02: Medical gases.

Scottish Health Technical Memorandum 03: Heating and ventilation systems.

Scottish Health Technical Memorandum 04: Water systems.

Scottish Health Technical Memorandum 05: Reserved for future use.

Scottish Health Technical Memorandum 06: Electrical services.

Scottish Health Technical Memorandum 07: Environment and sustainability.

Scottish Health Technical Memorandum 08: Specialist services.

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Scottish Health Technical Memorandum 06-02 Part A will represent: Electrical Services – Electrical safety guidance for low voltage systems.

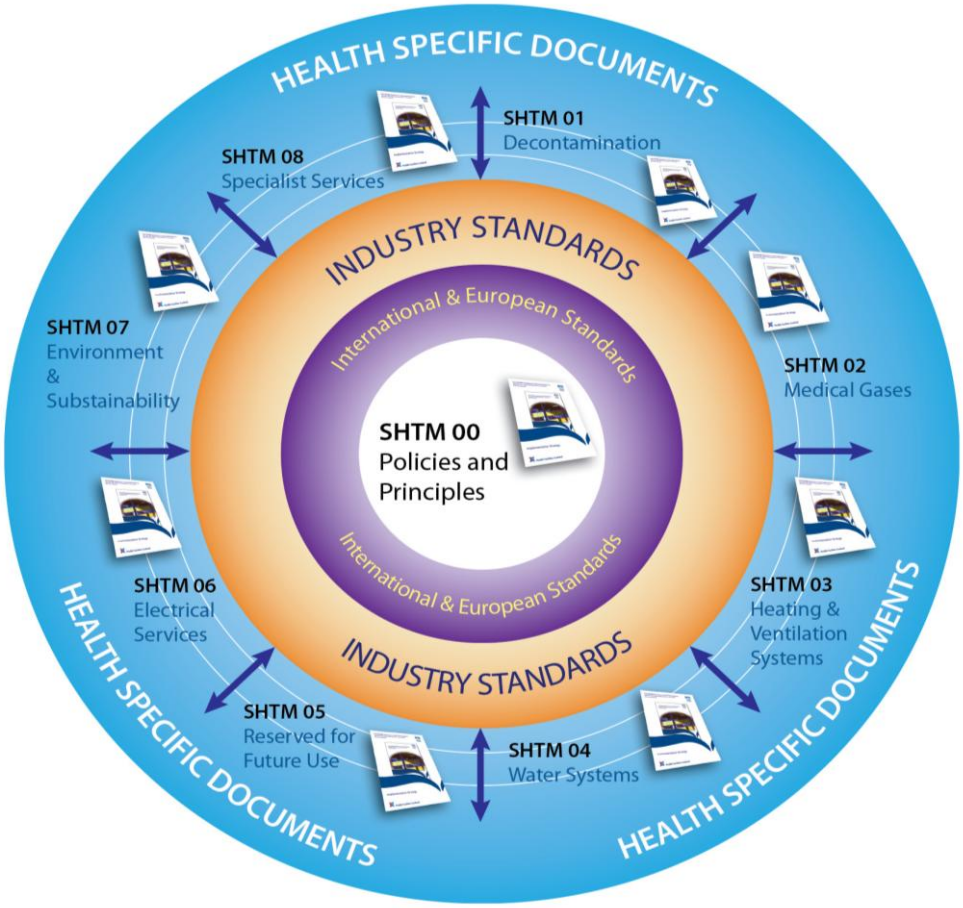
In a similar way Scottish Health Technical Memorandum 07-02 will simply represent:

Environment and Sustainability – EnCO_2de.

All Scottish Health Technical Memoranda are supported by the initial document Scottish Health Technical Memorandum 00 which embraces the management

and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.



Engineering guidance

1. Introduction

1.1 Ventilation is used extensively in healthcare premises or primary patient treatment in operating departments, high dependency units and isolation facilities. It is also installed to ensure compliance with quality assurance of processed items in pharmacy and sterile supply departments and to protect staff from harmful organisms and toxic substances, for example, in laboratories.

1.2 This edition of Scottish Health Technical Memorandum 03 'Ventilation in healthcare premises' is published in two sections. It is equally applicable to both new and existing sites. It gives comprehensive advice and guidance to healthcare management, design engineers, estate managers and operations managers on the legal requirements, design implications, maintenance and operation of general and specialised ventilation in all types of healthcare premises.

1.3 Current statutory legislation requires both 'management' and 'staff' to be aware of their collective responsibility.

1.4 'Ventilation' is also provided in healthcare premises for the comfort of the occupants of buildings. More specialised ventilation will also provide comfort but its prime function will be to control closely the environment and air movement of the space that it serves in order to contain, control and reduce hazards to patients and staff from airborne contaminants, dust and harmful micro-organisms.

1.5 Ventilation systems in themselves present little danger to patients or staff. However, they do possess the ability to transmit hazards arising from other sources to large numbers of people. The danger may not become apparent until many patients and staff have been affected.

1.6 The sophistication of ventilation systems in healthcare premises is increasing. Patients and staff have a right to expect that it will be designed, installed, operated and maintained to standards that will enable it to fulfil its desired functions reliably and safely.

1.7 The Health and Safety at Work etc Act 1974 (HSW Act 1974) is the core legislation that applies to ventilation installations and these installations are intended to prevent contamination, control closely the environment, dilute contaminants or contain hazards. Their very presence indicates that risks to health have been identified.

Statutory requirements

1.8 The Control of Substances Hazardous to Health (COSHH) regulations place upon management an obligation to ensure that suitable measures are in place to protect their staff and others affected by the work activity. These methods may include both safe systems of work and the provision of a specialised

ventilation system. In laboratories the requirements are often met by the provision of fume cupboards and safety cabinets.

1.9 The existing requirements to provide ventilation, implicit under HSW Act 1974 and COSHH, have been made explicit by the Management of Health and Safety at Work Regulations 1999, the Workplace (Health, Safety and Welfare) Regulations 1992 and the Provision and Use of Work Equipment Regulations 1998, all issued as a result of European Directives.

1.10 Where specialised ventilation plant is provided as part of the protection measures there is a statutory requirement that it be correctly designed, installed, commissioned, operated and maintained. The local exhaust ventilation (LEV) section of the COSHH regulations requires that the plant be inspected and tested at least every 14 months by an independent organisation and that management maintain comprehensive records of its performance, repair and maintenance.

1.11 Certain substances have Occupational Exposure Limits (OEL) set out in Guidance Note EH 40 published annually by the Health and Safety Executive. If special ventilation systems are provided in order to achieve these standards they will be subject to the COSHH regulations as above.

1.12 All ventilation systems should conform to the principles set out in the Approved Code of Practice and guidance document entitled “Legionnaires’ disease: the control of *Legionella* bacteria in water systems” (commonly known as ‘L8’) published by the Health and Safety Executive and Scottish Health Technical Memorandum SHTM 04-01: The control of *Legionella*, hygiene, “safe” hot water, cold water and drinking water systems.

1.13 Special ventilation plants installed in laboratories dealing with research, development or testing, whether involving drugs, animals or genetically modified organisms, may be subject to particular legislation with regard to their operation in addition to that mentioned above. Further information is given by the Health and Safety Executive Health Services Advisory Committee in:

- safe working and prevention of infection in clinical laboratories;
- safe working and prevention of infection in clinical laboratories: model rules for staff and visitors;
- safe working and prevention of infection in clinical laboratories in the mortuary and post-mortem room.

1.14 Plants installed in units manufacturing medicinal products to the standards set out in the current European Guide to Good Manufacturing Practice may also be subject to particular legislation with regard to their operation in addition to that mentioned above.

1.15 Records should be kept of equipment design and commissioning information. The Health and Safety Executive, Medicines Inspectorate and other interested bodies have a statutory right to inspect them at any time. All records should be kept for at least five years.

1.16 The fire regulations require that if ventilation ductwork penetrates the fabric of a building it should be designed and installed so as to contain the spread of fire. (for further information refer to Firecode Series SHTMs 81, 83 and 85)

1.17 Increased health risks to patients will occur if the more specialised ventilation systems installed to supply high quality air to operating departments do not achieve and maintain the required standards. The link between post-operative infection and theatre air quality has been well established. Plants serving conventional operating departments, for instance, will be required to ensure the separation of areas within the suite by maintaining a specific direction of air flow between rooms, even when doors are opened. They will also maintain the selected operating department environmental conditions regardless of changes in the outside air conditions or activities within the space. In addition ultra-clean operating ventilation systems that are designed to provide an effectively particle-free zone around the patient while the operation is in progress, have been shown to reduce significantly post-operative infection in patients undergoing deep wound surgery. Their use for other forms of surgery may well be required.

1.18 Ventilation systems that can be shown to be inappropriate, inadequate or ineffective and that give rise to proven failures can result in a civil suit by the patient against the operators.

1.19 If the plant has been installed to dilute, extract or contain harmful substances (the definition of which now includes microorganisms) its failure may expose people to unacceptable levels of hazard. Proven failures can give rise to a civil suit against the designers and operators by the individuals who have been affected. This would be in addition to the actions brought as a result of breaching the statutory requirements.

1.20 There is a statutory requirement to provide ventilation in all enclosed workspaces. It may be provided by either natural or mechanical means. The following are some of the factors that determine the ventilation requirements of a workspace:

- human habitation (minimum fresh air requirement);
- the activities of the department, that is, extraction of odours, aerosols, gases, vapours, fumes and dust – some of which may be toxic, infectious, corrosive, flammable, or otherwise hazardous (see Control of Substances Hazardous to Health (COSHH) regulations;
- dilution and control of airborne pathogenic material;
- thermal comfort;
- the removal of heat generated by equipment (e.g. catering, wash-up, sterilising areas, electrical switch rooms, uninterruptible power supply (UPS) cupboards and some laboratory areas);
- the reduction of the effects of solar heat gains where other forms of reducing the solar effect is not available or practical, i.e. solar blinds;
- the reduction of excessive moisture levels to prevent condensation (for

example Hydrotherapy pools);

- combustion requirements for fuel burning appliances (see BS5376, BS5410 and BS5440);
- 'make-up' supply air where local exhaust ventilation (LEV) etc., is installed.

Mechanical ventilation systems are expensive in terms of capital and running costs, and planning solutions should be sought which take advantage of natural ventilation either where the use of the area in question is not critical to airflow patterns or pressures, or where backup systems are available when natural ventilation cannot be achieved.

1.21 When new ventilation systems are accepted for use, full information as to their designed mode of operation together with recommended maintenance procedures should be provided as part of the handover procedure.

Requirement	Reason	Application
Statutory	Health and Safety at Work etc Act	Operating department Laboratories Pharmacy
	COSHH regulations	Areas containing identified biological or chemical hazards Areas containing oxygen displacing gases
	Local Exhaust Ventilation (LEV)	Enclosed work-spaces Workshops
Functional	Comfort	Situations where the quality of the environment for staff and patients is critical to their general performance and well-being
Clinical	Post-operative infection reduction	Operating suites used for general surgery, casualty, obstetrics/gynaecological and maternity procedures
	Reduction of deep wound sepsis	Ultra-clean operating suites for transplant, deep wound surgery, hip replacement, bone grafting and bone marrow transplant procedures
	Isolation from contact with bio hazards	Isolation units for patients who present a biological, chemical or radiation hazard to others. Isolation units for patients with a reduced immune system

Table 1: Reasons for providing ventilation

Functional overview – Terms in use

1.22 The terms 'ventilation' and 'air-conditioning' are often incorrectly used to describe the same equipment. A general explanation of the terms is given below.

Ventilation

1.23 Ventilation is a means of removing and replacing the air in a space. In its simplest form this may be achieved by opening windows and doors. Mechanical ventilation systems provide a more controllable method. Basic systems consist of a fan and either collection, (extraction) or distribution (supply) ductwork. More complex systems may include the ability to heat and filter the air passing through them. Ventilating equipment may be required in order to remove smells, dilute contaminants and ensure that a supply of 'fresh' air enters a space.

Air-conditioning and mechanical cooling

1.24 Air-conditioning is the ability to heat, cool, dehumidify and filter air. For full air-conditioning, humidification may also be provided. This means that the climate within a space being supplied by an air-conditioning plant can be maintained at a specific level regardless of changes in the outside air conditions or the activities within the space. Mechanical cooling may be provided where close control of 'comfort conditions' within a space is required but humidity control is not needed.

Special ventilation

1.25 In healthcare premises, certain activities will necessitate the provision of ventilation equipment with additional special features in order to achieve and maintain specific conditions. These may be needed in order to assist with the treatment of patients or maintain the health and safety of staff. The precise reason for providing special ventilation will depend upon the intended application. The list below indicates some of the more typical reasons:

- to remove, contain or dilute specific contaminants and fumes;
- to ensure the isolation of one space from another;
- to preserve a desired air flow path from a 'clean' to a 'less clean' area;
- to provide control of the cleanliness of a space;
- to provide 'close' control of temperature;
- to provide 'close' control of humidity.

1.26 The following departments will usually have specialised ventilation requirements, either for a single room or throughout a suite of rooms:

- operating department;
- laser surgery unit;
- intensive treatment unit;
- infectious diseases isolation unit;
- manufacturing pharmacy;
- specialised imaging, X-ray and scanning unit;

- pathology containment laboratories;
- mortuary and dissection suite;
- research laboratory;
- sterilising and disinfecting unit (SDU);
- endoscopy unit;
- renal dialysis suite;
- ultrasound facilities;
- audiology room.

1.27 Ventilation may be provided in a wide variety of ways. These will include:

- extensive purpose-built air-conditioning units housed in their own plant rooms;
- proprietary 'packaged' systems often sited outside on a roof or;
- wall-mounted electric fans located at the point of use.

1.28 A fixed volume of air may be supplied, often expressed in terms of the resulting number of air changes per hour (ac/h) within the space being ventilated. It may also be expressed in terms of litres/second/person. Alternatively the volume of air supplied may be varied in order to maintain a specific pressure relationship between the area supplied and other surrounding areas. In some situations a combination of both methods may be adopted.

1.29 Modern plants are fitted with the means to recover energy from the extract air where this can be justified without causing contamination of the incoming supply air.

1.30 Ultra-clean systems use the same basic plant and equipment as standard air-conditioning but are in addition fitted with a terminal device that supplies the air in a unidirectional manner to the working area. Their standard of filtration will be capable of delivering air with a very low particle count to the space that they serve.

Local exhaust ventilation

1.31 Local exhaust ventilation (LEV) is a term used to describe systems installed to prevent hazardous substances from entering the general atmosphere of the room in which they are being used. Their primary function is to protect staff from the effects of their work activity.

1.32 Simple LEV systems comprise a capture hood, extract ductwork and fan. These are used to contain industrial types of hazard such as fumes from welding processes, gas discharges from standby battery banks and dust from woodworking machinery. The vapour given off when large quantities of chemicals are decanted into ready-use containers and fumes from X-ray film processing units are further examples of chemical hazards often controlled by LEV systems.

1.33 In laboratories, pharmaceutical manufacturing facilities and operating suites, LEV systems usually take the form of semi-open fronted cabinets within which the hazardous substance is manipulated. These cabinets either have their own filtered air supply or are fed with air from the room. The air extracted from the cabinet is passed through a high-efficiency filter before being discharged either to the atmosphere or back into the room. Microbiological safety cabinets, laboratory fume cupboards, cytotoxic drug cabinets and fixed or mobile disinfection enclosures are all examples of this type of facility.

1.34 Mortuaries and dissection suites may have LEV systems incorporated within the dissection table, specimen bench and bone saw.

Management action

1.35 The guidance contained in this SHTM should be applied in full to new installations and major refurbishments of existing installations.

1.36 Ventilation will need to be provided:

- as a requirement for patient care;
- in order to fulfil a statutory duty.

1.37 In assessing the need for more specialised ventilation and the standards desired for patient care, managers will need to be guided by their medical colleagues and by information published by Health Facilities Scotland.

1.38 The statutory need for ventilation falls into two categories:

- in the first, the need for specialised ventilation and the standards to be adopted are clearly set out in specific pieces of legislation. An excellent example of this is the current legislation surrounding the manufacture of medicinal products in the European Community. The managers of the departments affected by this type of legislative requirement should be aware of their needs and be able to advise on the standards to be achieved;
- the second type of statutory requirement arises due to the interpretation of both the Health and Safety at Work etc Act and the Control of Substances Hazardous to Health (COSHH) regulations. The person tasked with conducting COSHH assessments will be able to advise as to the need for, and standard of, ventilation in each particular case.

Design and validation process

1.39 It is essential when undertaking the design of a specialised ventilation system that the project be considered as a whole. The process model set out below should ensure that all relevant factors are considered.

Step	Question	Design statement and information required	Comment
1	Why is the system required?	Healthcare applications Statutory elements Non-healthcare applications	
2	What is the required system performance?	Room air flow pattern Air change rate Differential pressures Air quality Room air condition Noise limits	
3	What are the constraints on the distribution system?	Location, Size, Materials Dampers, Access, Insulation Fire considerations Room terminals	
4	What are the minimum requirements for the AHU(s)?	Intake / Discharge positions *Legionella*, Health and Safety Access, Fire, Electrical safety Leaks, Insulation, Cleanliness Filtration, Drainage	
5	What control functions are required?	User control requirements Estates control functions Energy management Environmental conditions Control sequence logic Run, Set back, Off philosophy	
6	How will the system performance be validated?	Validation methodology Instruments used Design information required [*Design air flow rates* *Design air velocities* *Pressure differentials* *Noise levels* *Air quality* *Installation standard*]	
7	The system will only be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.		
8	Handover to client	Basic design information Commissioning results Validation report	

Table 2: Design and Validation process model

Use and function of typical equipment used in ventilation plant

1.40 Typical equipment used in ventilation systems is listed below together with a brief description of both function and use.

General

1.41 The equipment built into the ventilation system and its ductwork should be of a type that will neither cause nor sustain combustion. No materials that could sustain biological activity should be used in the construction or assembly of the system.

Air Intake

1.42 An uncontaminated air supply to the system is essential. In order to achieve this, the air intake will be positioned so that air discharged from extract systems or other dubious sources cannot be drawn in. Exhaust fumes from vehicles can present particular problems. The area surrounding the intake will need to be kept clean and free of vegetation and waste material in order to reduce the possibility of biohazards or fire. The intake itself will be protected by a louvre and mesh screen to prevent rainwater, vermin and insects etc from entering the system.

Damper

1.43 Several types may be fitted:

- automatic dampers fitted immediately behind the air intake and extract louvres. They will automatically close when the system is shut down in order to prevent an uncontrolled circulation of air;
- balancing dampers are fitted into each branch of the air distribution ductwork system so that the design air flow rate can be set during the commissioning process;
- where ductwork passes through a fire compartment wall, ceiling or floor a fire and/or smoke damper may be required;
- plant isolating dampers are fitted so that the main plant can be isolated from its air distribution duct system. They are manually operated and enable cleaning and maintenance of the air-conditioning equipment to be carried out.

Ducting

1.44 The means by which air is conveyed from the intake to its point of use. Ducting is usually constructed of galvanised steel and will normally be insulated to reduce noise and conserve energy. Ducts can also be formed in concrete, brickwork, stainless steel or plastic and may be rigid or flexible.

Fan

1.45 A series of rotating blades that move the air in the direction required. Fans are usually powered by electric motors either directly connected to them or driven through belts and pulleys. A fan may be arranged either to force air into or draw air from a ductwork system.

Attenuator / silencer

1.46 A device that will contain and absorb the noise emitted by a fan. They may be required to reduce disturbance caused by noise breaking out through the air intake and also noise transmitted along the ductwork to the conditioned space.

Filter

1.47 A filter consists of a labyrinth of fibrous material contained in a frame. It is designed to capture and hold particles being carried in the airstream. Because of the size range and number of particles that exist in air no filter can remove them all. The purpose of filtration is to reduce their number and size range to an acceptable level. Filters of progressively higher grades are fitted through the ventilation system:

- primary filters (coarse) are designed to collect the larger particles and are intended to keep the air-conditioning plant clean;
- secondary filters (fine) will remove the staining particles from air and keep the conditioned space visibly clean;
- high efficiency particulate air filters (HEPA/absolute) will remove virtually all particles from air. These may be required in order to reduce contamination in the working area either biologically or in terms of particle count.

Filters may be fitted to extract systems to protect energy recovery devices. They may also be fitted to remove biological, radiation or chemical hazards and if so, are often contained in a 'safe change' facility in order to protect those carrying out maintenance.

Activated carbon filters will reduce odours in extracted or recirculated air.

Heater battery / heater coils

1.48 A series of heater batteries or heating coils with or without fins through which steam or hot water is circulated. Heat is given up to the air passing over the battery thus increasing its temperature. Heating is usually carried out in stages, the final battery being controlled by the end user. Small batteries may be electric.

Humidifier

1.49 A device for increasing the humidity of air by adding moisture. For ventilation in healthcare premises this is normally achieved by releasing 'clean' steam into an air supply duct. The steam will be completely absorbed into the air, increasing its humidity. The level of humidity may be preset or controlled by the end user.

Cooler battery / cooling coil

1.50 A series of finned coils mounted in the air supply duct. Either chilled water or refrigerant is circulated through the coils causing heat to be removed from the air. This will reduce its temperature and may also condense moisture out of the

air. As free moisture in a duct can be a source of contamination the coil will be fitted with an eliminator and drainage system.

Eliminator

1.51 A device for catching and removing water droplets from an air stream. It may form part of a cooling coil or be a separate device.

Drainage system

1.52 A means of removing water from ductwork and disposing of it safely. Typically it will consist of a tray mounted in the duct to catch moisture, a glass water seal trap, continuously falling drainage pipework and an air break in the drain run to prevent waste water returning and contaminating the duct.

Access doors and observation ports

1.53 Doors and removable panels providing access for routine maintenance and cleaning. The doors should be fitted with glazed ports and suitable lighting provided so that the correct operation of devices such as cooling coils, humidifiers and filters can be easily observed without needing to switch off the plant.

Energy recovery

1.54 Many plants are fitted with the means to recover energy from the extract air without causing contamination of the incoming supply air. These devices will be fitted with a drainage system and may incorporate an eliminator. Several types of energy recovery systems are available.

1.55 Precise definitions of ventilation and air-conditioning terms are given in the Chartered Institution of Building Services Engineers (CIBSE) Guide B.

Typical plant

1.56 The layout of a typical plant that conforms to the requirements for healthcare applications is shown in Figure 1 overleaf. It contains most of the equipment described above.

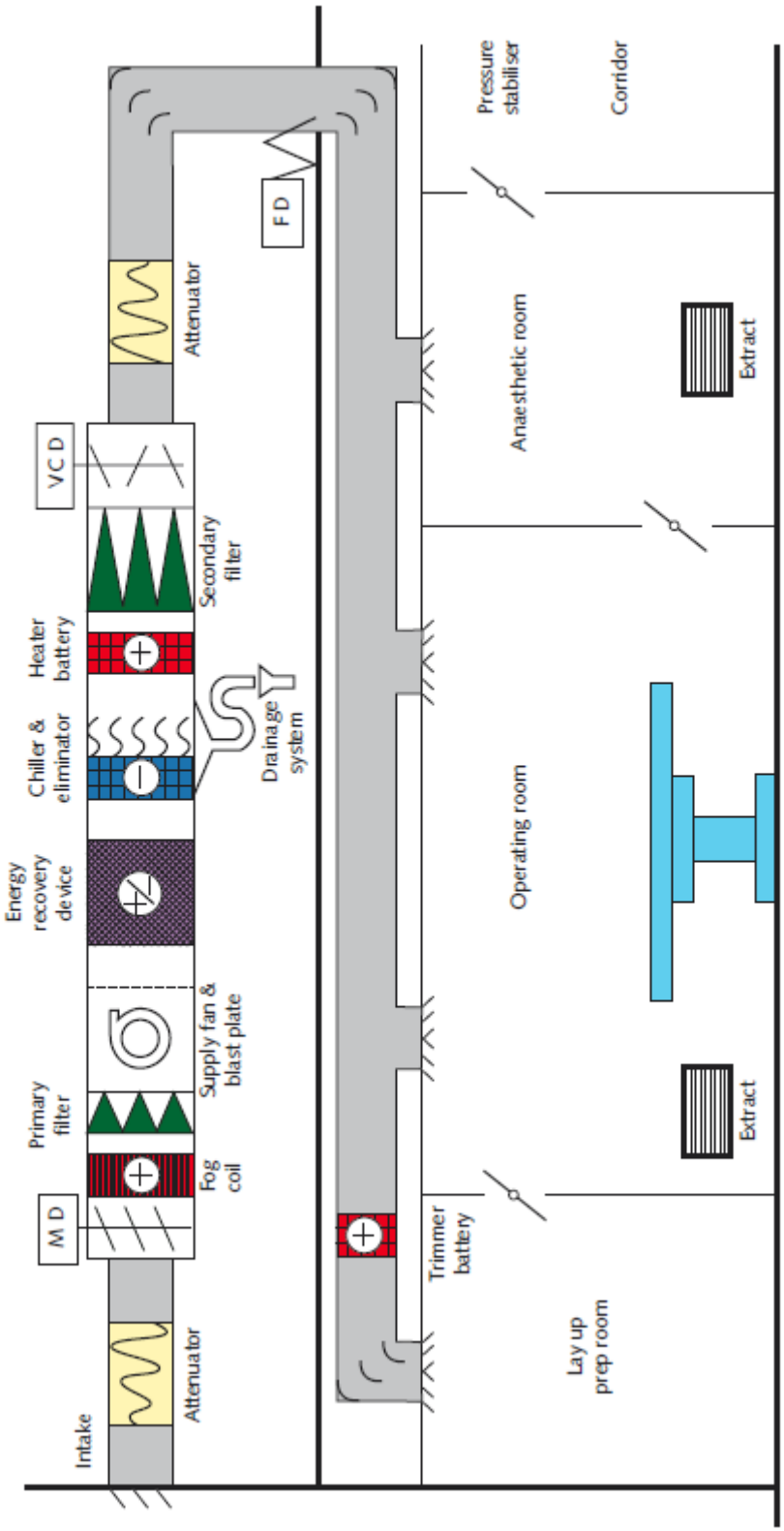


Figure 1: Design and Validation process model

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2. Provision of ventilation in healthcare buildings

2.1 It is acknowledged that planning constraints imposed by the building shape and/or functional relationships of specific areas will invariably result in some measure of deep planning thus reducing the opportunity for natural ventilation. However, ventilation costs can be minimised by ensuring that where practicable, core areas are reserved for rooms that have a functional requirement for mechanical ventilation. Examples are sanitary facilities, dirty utilities and those rooms where clinical or functional requirements have specific environmental needs; and where for reasons of privacy, absence of solar gain etc., windowless accommodation is acceptable. Other spaces appropriate to core areas are those that have only transient occupation and therefore require little or no mechanical ventilation, for example circulation and storage areas.

Natural ventilation

2.2 Natural ventilation is usually created by the effects of wind pressure. It will also occur if there is a temperature difference between the inside and the outside of the building. The thermo-convective effect frequently predominates when the wind speed is low and will be enhanced if there is a difference in height between inlet and outlet openings. Ventilation induced by wind pressures can induce high air change rates through a building provided air is allowed to move freely within the space from the windward to the leeward side.

2.3 As the motivating influences of natural ventilation are variable, it is almost impossible to maintain consistent flow rates and ensure that minimum ventilation rates will be achieved at all times. This variability is normally acceptable for general areas including office accommodation, general wards, staff areas, libraries rooms, dining rooms and similar areas which should, where possible, be provided with opening windows of a design that facilitates natural ventilation.

2.4 Current guidance restricts the amount windows can be opened for safety reasons and as many designs are top-hung, their ability to permit natural ventilation is limited. It may therefore be necessary to provide dedicated ventilation openings in the fabric of the building to allow a sufficient natural flow of air into and out of the space. Paragraph 2.20 also refers.

2.5 In all cases, excessive heat gain, indoor air quality requirements or external noise may limit or preclude the use of natural ventilation.

Extract ventilation systems

2.6 Separate extract ventilation will be required for sanitary facilities, lavage areas, dirty utilities and in rooms where odorous, but non-toxic fumes are likely, in order to ensure air movement into the space. 10 air changes per hour have been found necessary, particularly in geriatric and psychogeriatric accommodation. This will assist with infection control procedures. A single

fan/motor unit can be suitable for individual rooms, but multi-room systems should be provided with duty and standby fans or motors to meet this need.

2.7 Toilets should have an extract ventilation rate as set out in the building regulations. Where WC's are located in shower and bathroom spaces, the ventilation required for the WC will normally be adequate for the whole space.

Supply only ventilation

2.8 Mechanical supply ventilation will be required in areas where it is important to maintain a positive pressure in order to prevent the ingress of less clean air, e.g. in pharmacy aseptic suites, sterile supply packing rooms, operating theatres and their preparation rooms (air change rates are given in Table A1).

Supply and extract ventilation

2.9 Mechanical supply and extract ventilation should be provided in rooms where there is a need to control room pressure in relation to adjacent spaces. Intensive Care Units, (ICU), isolation suites and treatment areas are typical applications.

Mechanical or comfort cooling

2.10 Cooling is very expensive in terms of energy costs and should be provided only where necessary to maintain a comfortable environment for staff and patient, or to ensure satisfactory operation of equipment. The imaging department in particular may require cooling to offset the equipment load.

2.11 Calculations and thermal modelling should be undertaken to ensure that during the summertime, internal temperatures in patient areas do not exceed 28ºC (dry bulb) for more than 50 hours per year taking into account the level of design risk for the application.

2.12 Certain non-patient areas may also require cooling and will typically include some laboratories, central wash-up and other areas that are subject to high equipment heat gains.

2.13 Where deep planning of other continuously occupied spaces, for example offices, is unavoidable, there will also be occasions when acceptable levels of comfort can only be maintained by cooling. Planning solutions of this type however will be exceptional.

2.14 Refrigeration plant should be of sufficient capacity to offset heat gains and maintain areas at a temperature that does not exceed the external design shade temperatures by more than about 3ºC taking into account the level of design risk for the application.

Air-conditioning

2.15 Full air-conditioning is only required in a very small number of areas within healthcare buildings and due to the capital and running cost its inclusion should be kept to a minimum. Paragraphs 3.14 - 3.15 and 4.91 - 4.93 also refer.

2.16 Areas whose functions may warrant the installation of air-conditioning include operating departments, intensive therapy units, manufacturing pharmacies and areas with particularly sensitive equipment.

Specialised ventilation

2.17 Due to the nature and extent of activities carried out in healthcare buildings, there will be a need for a wide range of specialised ventilation systems. The types of system which are generally required in individual departments and typical arrangements are given in Section 7.

2.18 The activities within some departments will require the provision of local exhaust ventilation (LEV). This is a statutory requirement under COSHH wherever the escape of chemicals, toxic fumes, biological material or quantities of dust into the general area would present a hazard to the occupants.

Ventilation for general areas

2.19 Table A1 provides recommended air change rates, temperatures and pressures for general areas that require mechanical ventilation in healthcare buildings.

Use of natural ventilation

2.20 The air tightness of new buildings has improved to the point that infiltration through building leakage can no longer be relied upon to provide sufficient air-flow. Attention must therefore be given to the provision of purpose-made ventilation openings to achieve the necessary flow rates. The air entering the openings may need to be controlled by motorised dampers linked to temperature and / or occupancy sensors in the ventilated space.

2.21 Internal partitions, fire compartment walls and closed doorways can often impede the flow path, and when this happens, the process will be more dependent on single-sided ventilation. Nevertheless, even with this degree of compartmentation, acceptable ventilation may still be achieved without window openings that would prejudice safety, security or comfort.

2.22 Some types of window, for example, vertical sliding, can enhance single sided air change by temperature difference, and these will improve the overall rate of natural ventilation in protected or sheltered areas where the effect of wind pressure is likely to be minimal.

2.23 It is generally considered that natural cross-flow ventilation is able to give reasonable air distribution for a distance of up to 6 metres inwards from the external façade, provided that reasonably clear air paths are maintained. Beyond this distance in areas where clear air paths cannot be maintained and in areas where high minimum air change rates are specified, mechanical ventilation should be provided.

2.24 Further information can be found in SHTM 55 ‘Windows’, BS5925 ‘Code of practice for ventilation principles and designing for natural ventilation’ and

CIBSE Applications Manual AM10: 'Natural ventilation in non-domestic buildings'.

Mixed mode ventilation

2.25 This comprises an assisted form of natural ventilation. Fans are fitted in the purpose made damper-controlled ventilation openings. Alternatively a separate ventilation unit may be installed. In both cases the dampers and fans are controlled under the dictates of temperature and occupancy sensors to ensure a minimum air flow rate while taking advantage of natural ventilation effects when present.

2.26 Where natural or mixed mode ventilation is adopted with complex air paths, the designer should produce an air flow diagram in order to ensure correct provision of air transfer devices. CIBSE Applications Manual AM13: 'Mixed mode ventilation in non-domestic buildings' gives guidance.

Mechanical extract ventilation

2.27 General extract systems can vary in complexity from a single wall-mounted fan to a ducted air system with dual extract fans.

2.28 Replacement air is generally provided by a central supply system (as described below). Unless special precautions are taken, the latter may result in an unacceptable level of draughts occurring in winter, and possible risk of unacceptable levels of noise transmission.

2.29 If individual systems are used, the ventilation can be operated intermittently, provided it continues to run for at least 15 minutes after the room is vacated, as with light switch-operated fans in individual toilets.

2.30 If general exhaust systems are used; it is recommended that filtered and tempered replacement air is provided via a central supply plant to adjoining lobbies or corridors, to prevent the risk of discomfort caused by the ingress of cold air. Fire compartmentation requirements must be maintained.

2.31 Information on specialised extract systems is given in Section 7.

Mechanical supply systems

2.32 Where mechanical supply systems are required, the fresh air should be tempered and filtered before being delivered to the space, to avoid discomfort.

2.33 The air should be heated using a constant or variable temperature source, but generally only to the space air temperature. In most instances, the low-pressure hot water heating (LPHW) should offset any fabric loss, so that setback room temperatures can be maintained during unoccupied periods without the need for the ventilation system to operate.

Balanced ventilation

2.34 Balanced ventilation systems are merely a combination of a supply and extract systems of equal volume; and either a single space or a whole building may be considered to be balanced. A balanced system is necessary in instances where it is essential to maintain consistent air movement within an area, for example, treatment rooms.

Cascade ventilation

2.35 In operating departments it is normal practice to supply air to the operating room, and allow it to pass through less clean areas – corridors, utility rooms etc. (from where it is eventually extracted).

Recirculation systems

2.36 Due to the nature of the use of mechanical ventilation systems within healthcare buildings, there are few opportunities for the application of recirculation air systems. They are however normally used for HEPA filtered clean room applications where the extract air is significantly cleaner than the outside supply. Recirculation is also routinely used in the canopy section of Ultra Clean Operating theatre ventilation systems.

2.37 Where the designer is considering the installation of a recirculation air system, due account must be taken of:

- minimum fresh air supply volume required by the Building (Scotland) Regulations 2004 (currently 20%);
- prevention of contamination of supply air from vitiated air in extract systems;
- prevention of stratification occurring within plenum chambers and mixing boxes which may result in freezing of downstream coils;
- ensuring sufficient velocities through control dampers (ideally 5-6m/s) to provide suitable authority; and good shut-off;
- modulating control of mixing to provide optimum on-plant conditions;
- use of ‘free cooling’ by cycling the dampers to minimum fresh air when the enthalpy of the outside air is above that of the extract air under conditions when cooling is required.

Chilled beams

2.38 The use of chilled beams for the provision of heating, cooling and ventilation is increasingly common in healthcare premises. The use of Active Chilled Beams providing tempered filtered air to a heating / cooling device within the room can provide effective local control of environmental conditions.

2.39 Care should be taken in positioning chilled beams to ensure the avoidance of cold draughts particularly when used in the cooling mode. The control settings should ensure that the external elements of the beam are always above dewpoint.

2.40 Consideration should be given to the ease with which specific types of chilled beam units can be accessed for cleaning having regard to the need to control the infection risk. The impact of maintenance requirements on room availability should also be considered.

Split comfort air-conditioners

2.41 Split comfort air-conditioners, room conditioners or cassette units are used increasingly where there is a small local requirement for cooling for operational purposes. They can provide an effective economic solution to cooling needs, where a central refrigeration system is not practicable.

2.42 The units re-circulate room air so provision for a fresh air make up, either by natural or mechanical means, to the standard required by the Building (Scotland) Regulations must be provided.

2.43 The recirculation of room air presents problems with indoor air quality (IAQ) and may increase the risk of healthcare associated infection (HAI). Split units should not therefore be used in critical patient areas.

2.44 Split units may be used for single room applications or as multiple linked units that can independently provide either heating or cooling, all served by a single outdoor unit. These systems enable good temperature control of a number of rooms with maximum energy efficiency.

2.45 Whether single or multiple systems are used, it is essential that the designer gives due consideration to the source of electrical supply, location of the heat rejection unit, environmental effects to the refrigerant used and drainage provision for the cooling coil condensate.

2.46 The units will require routine maintenance for filter change and cleaning; they should therefore be installed in an accessible position.

Dilution ventilation and clean air flow paths

2.47 Dilution ventilation has in the past been used to control levels of hazardous substances in a space. This approach is no longer considered acceptable. The COSHH Regulations require that known hazardous substances should be substituted by safe alternatives. If this is not possible then they should be controlled at source by the use of closed systems such as anaesthetic gas scavenging units or exhaust protective enclosures such as fume cupboards.

2.48 The exposure of staff to casual spillages of substances such as medical gases in anaesthetic rooms should in the first instance be dealt with by establishing a clean airflow path. Air should be supplied at high level and extracted at low level directly behind the anaesthetic equipment position. The philosophy of establishing a clean air-flow path from the supply point; to the staff; on to the patient and out via a low level extract would also apply in recovery rooms and maternity delivery rooms including labour, delivery, recovery & post partum (LDRP) Rooms. A suitable air change rate will provide dilution ventilation as an additional safeguard; see Table A1, Table A2 and Note c.

2.49 In operating theatres the patient will be on a closed breathing circuit in a room with a high air change rate. Under these circumstances the dilution effect would be considered sufficient to control any casual exposure to anaesthetic gases.

Mechanical ventilation systems

System selection

2.50 Natural ventilation is always the preferred solution for a space, provided that the quantity and quality of air required, and the consistency of control of ventilation to suit the requirements of the space, are achievable with this method. If this is not the case, a mechanical ventilation system will be required.

Choice of central/local plant

2.51 Mechanical ventilation is expensive to operate, and as such, should be controlled to operate when the space being served requires to be ventilated. In addition, loads on refrigeration plant are rarely constant owing to changes in solar gain, occupancy and use of heat-generating equipment and lights, therefore control of temperature is critical.

2.53 If the ventilation loads throughout a department or building are in phase, or are not significant, a central plant with single zone control can be adopted. However, this is rarely the case, and elsewhere, the condition or quantity of supply air to different areas or zones of the building must be varied accordingly. This can be done by providing either individual plants to each zone, or separate zone terminal control. Where there is a high density of rooms with similar ventilation requirements in an area of a building or department, it is usually economical to combine them into a central system.

2.54 In large buildings, a choice between a single distribution system and multiple smaller systems may arise. Large distribution systems and their plant can have the advantage of lower operating costs, but require more space for vertical shafts and horizontal distribution. In general, very long runs of ducting should be avoided to prevent undue heat losses or gains, excessive leakage, and difficulties in balancing during commissioning. As the pressure losses in the long runs will be greater and a higher initial static pressure will be required, this will lead to a more expensive class of ductwork. Multiple smaller distribution systems may be more expensive in capital and operating costs but they avoid long runs, large ducts and vertical shafts, and this may reduce overall building costs. They also provide a more robust service as the failure of an individual system does not prevent the use of the rest of the building.

Zoning of the building

2.55 The efficiency and effectiveness of any ventilation or air-conditioning installation depends largely on the zoning and control of the installation. The factors to consider when determining the zoning of a ventilation system for a building or department are:

- periods of occupancy;

- fresh air/ventilation requirements;
- smoke control.

2.56 Where the ventilation system is not merely tempering the air, but also providing the heating and/or cooling requirements, the following additional factors will need to be considered:

- internal or peripheral location;
- orientation of windows;
- variation in internal loads;
- level of control required.

2.57 For single zone plant in staff areas, local control (with a run-on timer if required) is recommended, as this can be turned off when the space is not in use, thus saving both thermal and electrical energy. Most supply and extract systems, conversely, are required to operate continuously while the department is occupied, thus some form of time or use control is necessary.

2.58 The control of individual plant items is covered in Section 4, with examples of typical control strategies in Section 6. For control of particular specialised ventilation and air-conditioning systems refer to Section 7 of this document.

2.59 On very rare occasions a duplicate standby air handling plant may be justified. If installed it must be provided with a gas-tight damper at its junction with the supply distribution duct, so that no back-flow can occur. Standby plants can become sources of contamination if warm moist air is allowed to dwell within them. Their design and control system must ensure that this cannot happen.

Specific requirements for hospital departments

2.60 Specific requirements for individual spaces and departments are included in the Health Building Notes (HBNs) and Activity Database (ADB) A-Sheets, or Scottish Health Planning Notes (SHPNs).

3. Assessment of service requirement

Selection of design criteria

External design conditions

3.1 The most accurate data that is available for the summer and winter conditions at the site should be used. The Metrological office can supply data for the United Kingdom.

3.2 Healthcare mechanical ventilation systems will normally be 'full fresh air'.

3.3 Local adjustments such as for height above sea level, exposure factor, or other climate peculiarities, should be made as appropriate.

Internal design conditions

3.4 The design conditions selected within patient areas must strike a balance between the comfort requirements of staff and patients, who often have very different levels of clothing and activity.

3.5 Recommendations for the dry resultant temperature and humidity of individual spaces are shown on Activity Database (ADB) A-Sheets. Table A1 gives a summary.

Minimum fresh air requirements

3.6 For most applications involving human occupancy, the dilution of body odours is the critical factor in determining ventilation requirements. Where natural ventilation or mechanical full fresh-air systems are used, all ventilation air will be fresh.

3.7 Where odour dilution is the overriding factor, it is recommended that 10 litres/second/person should be taken as the minimum ventilation rate.

3.8 Smoking is not permitted in healthcare premises. If permitted for example in residential care, it will be confined to designated areas. It therefore follows that these areas will contain a high percentage of smokers so the ventilation rate would be at least 36 litres/second/person for these applications (CIBSE Guide A; Table 1.10 refers).

3.9 In non-standard applications such as laboratories, aseptic suites, operating departments, etc., the particular requirements for each area should be considered independently in order to determine the overriding minimum requirement for ventilation.

Limiting supply air conditions

3.10 For most applications in healthcare buildings, it is the temperature differential between the supply and room air, rather than the actual temperature of the

supply air which is the critical factor. The maximum recommended supply-to-room air temperature differential is:

summer cooling: - 7K

winter heating: + 10K

3.11 It is also necessary to keep supply air humidity below 70% during winter in order to minimise risks associated with condensation.

Air purity

3.12 In healthcare premises, the standard of filtration will depend on the activities within the occupied spaces. With the exception of special areas, (for example manufacturing pharmacies), the requirement for aerobiological needs is not stringent and filtration is only required to:

- maintain hygienic conditions for the health and welfare of occupants, or for processes such as food preparation;
- protect finishes, fabrics and furnishings; to reduce redecoration costs;
- protect equipment either within the supply air system; that is, to prevent blocking of coils, or in the space itself to prevent dust collection.

3.13 Given that almost all viable particles will originate from the occupants of a space and not from the incoming air, dilution is the more important factor aerobiologically. Therefore, for general areas a G4 filter will be suitable. More critical areas will require a F7 filter. HEPA filters will only be required in Ultra Clean systems.

Humidity control requirements

3.14 Providing humidification is expensive in terms of plant, running costs and maintenance, and therefore its use should be restricted to where it is necessary for physiological or operational reasons.

3.15 Humidification was originally required for some healthcare applications, e.g. operating theatres, in order to control the risk associated with the use of flammable anaesthetic gases. The use of such gases has now ceased. Humidification is therefore no longer required unless there is a very specific application requirement.

Maximum noise levels

3.16 Noise will be generated in an air distribution system by the fan, ductwork fittings, dampers and grilles. The specified maximum noise level will depend on the activities within the occupied spaces.

3.17 The overall noise levels should not exceed the values given in Scottish Health Technical Memorandum 08-01: ‘Acoustics’, although general requirements are given in Table 3.

3.18 Attenuation should be incorporated into the ductwork system or plant arrangement as necessary to reduce noise from fans and plant items in order to achieve the acceptable limits within the rooms at the design air flows.

3.19 Plant noise should not be greater than 80dB(A) within the plant room from the fans, coolers, heaters, humidifiers etc. when starting up or running, and should be reduced to lower noise levels where the plant is near to departments sensitive to noise.

3.20 Attention must be given to the reduction of tonal components. High tonal components from air diffusers etc. can seriously disturb concentration over longer periods even when the overall noise level is low. Broadband noise causes less annoyance. Reference should be made to SHTM 08-01: 'Acoustics'.

3.21 The designer requires knowledge of the total hospital layout and operational policies, to assign acceptance magnitudes to all the possible noise sources, in order to arrive at the correct rating.

Room	Overall noise level - NR	Ventilation plant commissioning - NR	Ventilation plant design - NR
Operating department	50 (55)	45	40
Ward areas	33	30	30
Sanitary facilities	45	40	35
Industrial areas	50	45	40
Circulation areas	50	45	40

Table 3: Interior noise level

3.22 In Table 3, above, the overall noise level takes account of all internal and external noise sources. The commissioning noise level is the level measured with a sound level meter in the unoccupied room, taking account of the external noise together with the noise generated by the ventilation system. When occupied and in use, this commissioning level will constitute a continuous background noise which will allow the overall noise level to be achieved. The ventilation plant design noise level is that generated by the plant alone with no other noise source being considered. The levels suggested make recognised allowance for the ingress of environmental noise that must be considered in the overall design, that is, in specifying the attenuation of walls, partitions, ceilings, etc.

3.23 The recommended criterion is measured as the "A" weighted sound pressure level expressed in decibels, which should not be exceeded for more than 10% of the time.

3.24 The designer must also consider noise escaping to the external environment and this must not be unacceptable to occupants of adjacent buildings.

Calculation of building loads

Air infiltration

3.25 Air infiltration occurs due to a complex combination of wind pressure, thermal effects, location relative to other features and the construction standard of the building. The infiltration rate is governed by the size and number of openings in the building envelope and the complexity of internal air paths.

3.26 CIBSE Guide A (2006) Section 4 provides information and formulae for the calculation of air infiltration and natural ventilation of buildings. In all cases the requirements of the appropriate section of the Building (Scotland) Regulations must be met.

Summertime temperatures

3.27 The calculation method for determining the summertime temperature is described CIBSE Guide A (2006) Section 5. However, it is very important to select the time of day and time of year of peak loadings for the calculations. These will be dependent on the orientation and proportion of solar to total heat gain. In establishing outside design values, the design risk having regard to the function and occupancy of the building should be considered.

3.28 Where calculations indicate that internal temperatures will frequently exceed the selected design external shade temperature by more than 3K for a period that exceeds the building design risk, methods of reducing temperature rise should be implemented. Options include: - reducing solar and casual gains, the use of chilled beams or ceilings, increasing ventilation rates or providing mechanical cooling. In some situations it may be possible to alter the thermal mass of the structure to 'move' the peak temperature event time so that it occurs outside of the occupancy period. Calculations and thermal modelling should be undertaken to ensure that during the summertime internal temperatures in patient areas do not exceed 28°C dry bulb for more than 50 hours per year. It has been found that there is a relationship between preferred indoor temperatures and mean outside temperature. Fig A2 in CIBSE Guide A indicates this relationship.

Peak heating load

3.29 Peak heating local calculations are necessary on all mechanical supply systems to establish the size of heater batteries and subsequently the central plant.

3.30 Where ventilation systems provide tempered air to spaces that have supplementary LPHW to offset the building fabric losses, the plant heating load should be calculated based on the external winter design temperature, the design internal air temperature, and the calculated total air volume (including a suitable allowance for leakage).

3.31 Where the ventilation system is the only means of heating a space, an increase in load equivalent to the calculated fabric heat losses from the space should be added to the ventilation load. A check of supply temperature difference should

be made. If it exceeds 10K the ventilation supply volume should be increased to suit.

Condensation risk

3.32 A check should be made to ensure that the selected air condition will not lead to surface condensation on low-temperature elements of the ventilated space.

3.33 Where there are local sources of moisture that would require excessive levels of ventilation to avoid condensation, the designer should consider the capture and removal of moisture at the source of the evaporation via an exhaust hood or similar device.

3.34 In intermittently heated buildings, it is necessary to consider the condensation risk at night setback conditions as well as during normal operation. Calculation methods for this assessment are given in CIBSE Guide A.

Peak cooling load

3.35 In addition to the base data of airflow rates and temperatures, when calculating cooling loads, the designer must take into account:

- solar cooling loads;
- surface conduction cooling loads;
- internal gain cooling loads;
- cooling loads due to high-level humidity control;
- method of control of internal conditions;
- fluctuations in internal temperatures.

3.36 When the peak internal loads have been assessed and a suitable allowance made for non-coincidence, the supply temperature can be calculated.

3.37 Once the lowest required supply temperature of the air handling unit has been established, and an allowance made for temperature rise through the fan and ductwork (usually 1K for low pressure systems), the off-plant enthalpy can be established from a psychrometric chart or table.

3.38 The cooling loads for all plants on the chilled water system should be calculated at each of the individual peak times in order to establish accurately the required (diversified) capacity of the chiller.

Annual energy consumption

3.39 Annual energy consumptions of heating-only ventilation systems are simple to calculate based on supply-to-external air temperature rise, and frequency of occurrence of external temperatures as given in CIBSE Guide A.

3.40 Minimum air volumes are usually fixed by the room loads or fresh air requirements. However, the designer may increase airflow to some rooms or

zones in order to balance loads, as detailed in the following paragraphs on "Calculation of plant requirements."

3.41 The method of zoning and control can significantly influence energy consumption.

3.42 The nature of air-conditioning operation, comprising cooling and reheating for humidity or zonal temperature control, makes prediction of energy consumption very complex. It is imperative that these calculations are performed to ensure optimum energy efficiency.

3.43 The concept of load and plant operation charts is outlined in the CIBSE Guide A. The method requires the designer to establish the minimum and maximum loads on all zones across the range of external temperatures between winter and summer design conditions. Once the load chart is complete, the plant chart converts the loads to supply temperatures, which are then superimposed on external air temperatures.

3.44 When all temperatures for all zones are plotted on the plant operation chart, set points and resetting schedules can be established. From this information, the outputs of individual heaters, coolers and humidifiers can be established at any given external temperature. When those loads are computed against annual frequency of occurrence of external temperatures as given in CIBSE Guide A, the annual energy consumption of individual elements, and thus the air-conditioning system, can be established.

3.45 In order to prevent surface condensation occurring, it is necessary to provide sufficient ventilation to maintain the maximum and ambient dew-point temperature below the lowest surface temperature, the coldest usually being the glazing. Paragraphs 3.33 and 3.34 also refer.

Calculation of plant requirements

Air supply volumes

3.46 The minimum air supply volume for a room is determined by the greatest of these three criteria:

- the minimum fresh-air requirement;
- the minimum supply volume for the room load as determined by the maximum heating or cooling supply temperature differential;
- the desired/required air change rate.

Plant sizing

3.47 Once the design airflow has been established the cross-sectional area of the air-handling unit can be calculated based on a maximum coil face velocity of 2.0 m/s.

3.48 In order to establish the length of the air-handling unit, it will be necessary to refer to manufacturers' literature, ensuring all necessary access panels and components are included as detailed in Section 4.

3.49 The fan duty should be calculated by adding the resistances of all elements that contribute to the pressure drop of the index circuit.

3.50 The main elements that must be considered are:

- inlet or discharge louvres;
- plant entry and discharge;
- attenuators;
- components within the air-handling unit;
- duct-mounted heaters and filters (including a dust allowance);
- ductwork distribution;
- ductwork fittings, including: fire dampers, volume control dampers, bends and sets, tees, changes of section;
- air terminal device;
- discharge velocity.

3.51 Where packaged air-handling units are installed, the fan pressure drop is usually quoted as external plant resistance, and thus the designer does not need to calculate the resistances of individual plant items. The designer should, however, ensure that an allowance has been made for filter clogging; and confirm whether the fan pressure quoted is fan total or static pressure.

3.52 Resistances of ductwork and fittings may be obtained from the CIBSE Guide A. However, the designer should exercise some care when using tabulated pressure loss information for fittings that are relatively close together.

3.53 Upon completion of the resistance calculation exercise, the designer should make allowances for calculation and construction tolerances as indicated in Table 4.

Criteria	Low pressure systems	Medium/high pressure systems
Volume flow rate margin for leaking and balancing requirements	+5%	+5%
Total pressure loss margin A. for increase in volume flow rate (above)	+5%	+5%
B. for uncertainties in calculation	+5%	+10%
Combined total pressure loss margin	+10%	+15%

Table 4: Typical fan volume and pressure margins

Plantroom size and location

3.54 The ventilation plant and associated equipment should be positioned to give maximum reduction of noise and vibration transmitted to sensitive departments; while at the same time, achieve an economic solution for the distribution of services.

3.55 It is not recommended that noise and vibration generating plant be housed either directly above or below sensitive areas (for example, operating or anaesthetic rooms) unless there is no alternative, in which case, additional care and attention must be given to the control measures.

3.56 The plant must also be located so that it is remote from possible sources of contamination, heat gains and adverse weather conditions. The design should ensure that wind speed and direction have a minimal effect on plant throughput.

3.57 Safe access to and around plant is essential to facilitate inspection, routine maintenance, repair and plant replacement.

Provision of primary services

3.58 Where more than one air-handling plant requires cooling, remote central cooling plants with piped chilled water are preferred. In the case of a single plant, a multi-stage direct-expansion cooling coil with refrigerant piped from an adjacent compressor/condensing plant could be considered. If this option is selected, a refrigerant gas detector mounted in the base of the duct and an alarm system audible to the end-user will also need to be provided (as dictated by COSHH Regulations).

3.59 Clean dry steam is preferred for humidification, provided that the boiler water treatment does not render the steam unusable for direct humidification.

3.60 If a suitable supply of steam cannot be obtained from the steam main, a steam generator should be provided locally, or a self-generating humidifier installed. Electric humidifiers require considerable electrical loads and if a gas supply can be derived, this would be preferable. The location of a local steam generator is critical if condensate is to drain back into it.

Inlet and discharge sizing and location

3.61 Air intakes and discharge points should preferably be located at high level, to minimise the risks of noise nuisance to surrounding buildings, contamination and vandalism.

3.62 Intakes and discharges should be designed and located so that wind speed and direction have a minimal effect on the plant throughput.

3.63 Helicopter landing pads in the vicinity of ventilation intakes and discharges can result in large short-term pressure changes. This can cause pressure surges in supply systems and reverse airflows in extracts. Exhaust fumes from the helicopter may also be drawn into intakes. For general information, refer to Health Building Note (HBN) 15-03 – Hospital helipads.

3.64 Intake points should also be situated away from cooling towers, boiler flues, vents from oil storage tanks, fume cupboards and other discharges of contaminated air, vapours and gases, and places where vehicle exhaust gases may be drawn in.

3.65 Where intakes have necessarily to be sited at or near ground level, the area around them should be paved or concreted to prevent soil or vegetation being drawn in. They should also be caged or located within a compound to prevent rubbish being left in the vicinity. The likely proximity of vehicle exhausts should also be taken into account when determining the protected area around the intake.

3.66 The discharge from an extract system must be located so that vitiated air cannot be drawn back into the supply air intake or any other fresh-air inlet. Ideally, the extract discharge will be located on a different face of the building from the supply intake(s). In any event, there must be a minimum separation of 4 metres between them, with the discharge mounted at a higher level than the intake.

3.67 Discharges from LEV systems should preferably be vertical and usually not less than 3m above roof level. They should not be fitted with a cowl that could cause the discharge to be deflected downwards.

3.68 Each intake and discharge point should be fitted with corrosion-resistant weatherproof louvres or cowls to protect the system from driving rain. Louvres should be sized based on a maximum face velocity of 2 m/s in order to prevent excessive noise generation and pressure loss.

3.69 The inside of the louvres should be fitted with a mesh of not less than 6mm and not more than 12mm to prevent leaves being drawn in and infestation by vermin.

3.70 The duct behind louvres should be self-draining. If this is not practicable, it should be tanked and provided with a drainage system.

3.71 Cleaning access must be provided either from the outside via hinged louvres or by access doors in the plenum behind the louvre. Where a common plenum is provided, cleaning access should be via a walk-in door.

Heat rejection devices

3.72 The design conditions given in Section 2 make no allowance for the elevated temperatures that can occur on the roof of buildings. Refrigeration condensers should, if practicable, be shaded from direct solar radiation, or the design adjusted to take account of the gain.

3.73 Air-cooled condensers must always be the first choice for heat rejection from any refrigeration plant. Evaporative cooling systems must not be used in healthcare premises.

3.74 Reference should be made to Scottish Health Technical Memorandum 04-01: 'The Control of *Legionella*, hygiene, 'Safe' hot water, cold water and drinking

water systems, Part A: Design, Installation and Testing, and Part B: Operational Management, published by Health Facilities Scotland, 2011.

4. Air handling unit design and specification guidance

General requirements

Location and access

4.1 Air-handling units should be located in an accessible area secured from unauthorised entry. Siting units in ceiling voids above occupied spaces is not appropriate.

4.2 Units located on roofs must have a safe means of access together with suitable precautions to prevent personnel or equipment falling or being blown off during maintenance activities.

4.3 Units located at ground level should be secured within a locked compound to prevent unauthorised access. Measures should be taken to exclude vehicles from the vicinity to ensure that exhaust fumes will not be drawn into intakes.

4.4 Units may have a working life of approximately 20 years. It can be anticipated that over this period there will be a need to access every element within the unit for deep cleaning. It is also quite possible that the main fan and individual heater and chiller batteries will need replacement. Suitably positioned service connection joints and adequate spacing should permit these items to be withdrawn without the need to dismantle other installed plant or equipment. Batteries significantly wider than 1 metre should be split to permit withdrawal from both sides.

4.5 It is essential that air-handling units are positioned so that all parts are easily and safely accessible for routine inspection and service. If a unit is located against a wall or backs onto another unit then access to all parts must be available from the front. Units greater than 1 metre wide should preferably have access from both sides or access doors large enough to permit the full and safe entry of maintenance personnel.

4.6 Water may be used during routine cleaning or spilt when maintenance is being undertaken. The area around the unit should be tanked to prevent water penetration to adjacent areas and adequately drained.

4.7 Fire precautions should be incorporated in accordance with Firecode. Guidance is available in BS5588: Part 9 and Sections 5 and 6 of this document.

4.8 Combustion equipment must not be located in a fire compartment that houses air-handling equipment.

Technical requirements

4.9 The basic technical requirements of the whole of the ventilation system should meet the relevant clauses of the Model Engineering Specification. It should be noted that the Specification contains a menu of clauses that cover a wide range

of applications, so it is important to select only those that are relevant to the specific application.

Note 1: At the time of writing, Model Engineering Specification C04 was listed for revision in order to bring it into line with the revised standards as set out in this Scottish Health Technical Memorandum. Where conflicts in specification arise, the Scottish Health Technical Memorandum takes precedence.

4.10 It is essential that the main plant/ductwork is located far enough above the floor to permit the correct installation of drainage systems for cooling coils, humidifiers and heat recovery systems. Easy access for maintenance of drainage systems and their associated pipework must be provided.

4.11 Organic materials or substances that can support the growth of microorganisms must not be used in the construction of the plant or its distribution system. The water fittings and materials directory lists suitable materials for sealants and gaskets.

4.12 The plant and its distribution system must not contain any material or substance that could cause or support combustion.

4.13 Plants should have a high standard of air-tightness. The double-skin method of construction with insulation sandwiched between two metal faces is recommended. The panels may be available in a variety of colours at no additional cost. This can aid identification by colour coding of units in a plant room (for example green for general ventilation; blue for theatres; red for laboratories and isolation facilities; grey for extract etc).

4.14 The inside of the plant should be as smooth as possible. Channels, rolled angles or formed sections that could trap or hold moisture should be kept to a minimum. If stiffeners are required, they should be fitted externally. If internal bracing has to be fitted it must be of a design that will not trap or hold moisture.

4.15 Airflow across air treatment components such as filters, heat exchangers and humidifiers will be influenced by the pattern of the approaching airstream. If unsatisfactory conditions are created, the performance of the component will be reduced.

4.16 Access to items that require routine service such as filters, frost batteries and chiller batteries should be via hinged doors. The doors should be large enough (for example 500mm minimum) to allow easy access. Items requiring infrequent access such as attenuators may be via bolted-on, lift-off panels. All doors and panels should be close-fitting and without leaks.

4.17 Care should be taken during installation to ensure that electrical and mechanical services are not installed in positions that will reduce or impede access.

4.18 It can be difficult to turn off AHUs in order to inspect filters and drainage trays. Viewing ports and internal illumination will therefore facilitate routine inspection of such items. Viewing ports should be at a convenient height so that temporary ladders are not required. Internal illumination should be provided by

fittings to at least IP55 rating. Fittings should be positioned so that they provide both illumination for inspection and task lighting. All of the lights in a unit should be operated by a single switch.

4.19 Access to AHUs and items in the distribution system such as filters or heater / chiller batteries should be via fixed ladders and platforms or pulpit-style moveable steps. The installation of distribution ductwork and other electrical or mechanical services should provide sufficient clearance to allow the pulpit steps to be easily wheeled into position.

AHU drainage system

4.20 All items of plant that could produce moisture must be provided with a drainage system. The system will comprise a drip tray, glass trap, air break and associated drainage pipework.

4.21 The drip-tray should be constructed of a corrosion-resistant material (stainless steel is preferred) and be so arranged that it will completely drain. To prevent 'pooling', it is essential that the drain connection should not have an upstand; and that a slope of approximately 1 in 20 in all directions should be incorporated to the drain outlet position. The tray must be completely accessible or, for smaller units, easily removable for inspection and cleaning.

4.22 Each drip tray should be provided with its own drain trap. The drain trap should be of the clear (borosilicate) glass type. This permits the colour of the water seal to be observed thus giving an early indication of corrosion, biological activity or contamination within the duct. The trap should have a means for filling and incorporate couplings to facilitate removal for cleaning. It should be located in an easily visible position where it will not be subject to casual knocks. The pipework connecting it to the drainage tray should have a continuous fall of not less that 1 in 20.

4.23 Traps fitted to plant located outside or in unheated plant rooms may need to be trace-heated in winter. The trace-heating must not raise the temperature of water in the trap above 5°C.

4.24 Water from each trap must discharge via a clear air gap of at least 15mm above the unrestricted spill-over level of either an open tundish connected to a foul drainage stack via a second trap, or a floor gully (or channel). A support should be provided to ensure that the air gap cannot be reduced. More than one drain trap may discharge into the tundish providing each has its own air break.

4.25 Drainage pipework may be thermoplastic, copper or stainless steel. Glass should not be used. The pipework should be a minimum diameter of 22mm and a fall of at least 1 in 60 in the direction of flow. It should be well supported and located so as not to inhibit access to the AHU.

Layout of air handling unit

4.26 The AHU should be arranged so that the majority of items are under positive pressure. Any item of plant requiring a drain should be on the positive pressure side of the fan. A recommended layout is given in schematic from in Figure 3.

4.27 A separate extract unit will generally be required for the area served by each supply unit.

4.28 An energy recovery system will normally be fitted between the supply and extract units.

Provision of dampers

4.29 Fire- or smoke-actuated dampers shall be provided at the locations required by Firecode. (See Paragraphs 5.17 - 5.21).

4.30 Motorised low-leakage shut-off dampers should be located immediately behind the intake and discharge of each supply and extract system respectively. They should be of the opposed-blade type, opening through a full 90° and must close automatically in the event of power failure or plant shutdown to prevent any reversal of the system airflow.

4.31 The quality of motorised dampers is critical. They should be rigid, with square connections fitted with end and edge seals of a flexible material and with minimal play in linkages. The leakage on shut-off should be less than 2%.

4.32 A manually operated isolating damper should be installed between the main AHU and its distribution system to enable the unit to be isolated when cleaning is in progress.

4.33 Good practice will require the fitting of a main volume control damper so that the design airflow rate can be set at commissioning. The damper should be lockable in any position. If it will also be used for plant isolation, it should be capable of being reset to give the design airflow without the need for re-measurement.

4.34 Internal plant isolating dampers or provision for the fitting of shut-off plates between items within a unit are not required.

Vibration

4.35 Vibration from a remote plantroom can be transmitted by the structure of the building, may be regenerated and may sometimes be magnified many times. Units should be selected to have the minimum vibration generation and installed on suitable anti-vibration mounts. Pipe and ductwork should incorporate anti-vibration couplings, preferably in two planes at right angles, as close to the vibration source as possible. Consideration should be given to the use of anti-vibration pipe hangers and supports.

Sequence of components

4.36 The following arrangement of plant components is typical although in many instances not all elements will be required:

- fresh air intake;
- motorised isolation damper;

- frost / fog coil;
- pre-filter;
- energy-recovery device;
- attenuator;
- fan;
- blast plate;
- attenuator;
- chiller battery;
- eliminator;
- heater battery;
- humidifier;
- final filter;
- isolation / volume control damper.

Note 2: Attenuators may be located in the intake and discharge duct if they are of a suitable type (See Paragraphs 4.159 - 4.162)

There may be instances where the above arrangement is not appropriate and the plant arrangement should be planned accordingly.

Fans

General requirements

4.37 The fan should be selected for good efficiency and minimum noise level, but the overriding factor should be the selection of a fan characteristic such that the air quantity is not greatly affected by system pressure changes due to filters becoming dirty or external wind effects.

Acceptable types

4.38 Fans can be of the axial, centrifugal, cross-flow, mixed-flow or propeller type, depending upon the requirements of the system.

4.39 Where used, centrifugal fans should preferably be of the backward-blade type. Alternatively, where noise levels are more critical and pressure requirements are lower, forward-curved blade fans are acceptable. For high-power applications, aerofoil-blade fans may be appropriate.

Selection

4.40 Generally, large ventilation systems will use centrifugal fans due to their efficiency, non-overloading characteristics, and developed pressures.

4.41 Forward curved centrifugal fans can overload if allowed to handle more air than they are designed for.

4.42 Alternatively, it may be appropriate to use mixed flow fans in high-pressure systems.

4.43 Axial flow or propeller fans are generally only used in local through-the-wall systems, or systems with very low pressure requirements.

4.44 Cross-flow fans have very low operating efficiencies, and thus their use is restricted to applications such as fan coil units.

Location and connection

4.45 Fans are normally positioned to 'blow through' the central plant so that the cooling coil and humidifier drains will be under positive pressure.

4.46 The fan performance figures given by manufacturers in their catalogue data are based on tests carried out under ideal conditions, which include long uniform ducts on the fan inlet/outlet. These standard test connections are unlikely to occur in practice, the designer should therefore ensure as far as is practical that the fan performance will not be significantly de-rated by the system. This objective can be approached by ensuring that the fan inlet flow conditions comprise uniform axial flow velocities with low levels of turbulence.

4.47 Where the outlet duct is larger than the fan discharge connections, there should be a gradual transition, with a following section of straight duct, having a length equivalent to three duct diameters.

4.48 The design of the fan intake connection must be carefully considered to avoid swirl in the airstream. When the air spins in the same direction as the impeller, the performance and power consumption of the fan are reduced. When the air spins in the opposite direction to the impeller the power consumption and noise will increase with hardly any pressure increase. Airstream swirl is usually induced by large variations across the fan intake caused by the air passing round a tight bend immediately before the intake.

4.49 Where a centrifugal fan is located with an open intake, the clear distance between the suction opening and the nearest wall should be not less than half the diameter of the inlet. If two fans with free inlets are positioned within the same chamber, their adjacent suction openings should be at least 1 diameter apart.

4.50 Airtight flexible joints should be provided at fan inlet and outlet connections. They should be equal in cross-section to the points of connection and be neither longer than 200mm nor shorter than 100mm.

4.51 For centrifugal fans, a diffuser screen / blast plate should be fitted immediately downstream of their discharge.

Supply fan drive arrangements

4.52 Where the fan drive is via a motor-driven belt and pulley, it should be external to the air stream. This arrangement has the following advantages:

- the fire risk is reduced;
- the drive is visible so it is simple to check that the belt is still there;
- particles shed from the drive belt are outside of the air stream;
- if the belt slips, the "burning rubber smell" is not transmitted down into occupied areas of the premises;
- noise generated by the motor and drive will not be transmitted along the ductwork;
- waste heat is excluded from the system;
- the drive may be through a vee or toothed belt and pulley. The latter have the advantage of eliminating belt squeal on start up and have a longer service life. They are particularly suitable where the fan drive motor is fitted with a soft start and should be located external to the air stream.

4.53 The drive train should be easily visible without the need to remove access covers. Protecting the drive train with a mesh guard is the preferred option. For weatherproof units designed to be located outside, the fan drive will be external to the duct but enclosed. It should be easily visible through a viewing port with internal illumination and access via a lockable hinged door.

4.54 For direct-coupled fan and motor units, the motor should be out of the air stream.

4.55 For induction drive 'plug' motor arrangements (where the motor is fitted within the fan and is integral to it) and in line axial fans with a pod motor; the fan / motor combination may be within the air stream provided the motor windings are protected from over temperature by a thermister and lockout relay.

Extract fan drive arrangements

4.56 The preferred method where the fan drive is via a motor driven belt and pulley arrangement will be to locate it external to the air stream.

4.57 The fan drive and motor may be located inside the duct within the air stream provided the motor windings are protected from over-temperature by a thermister and lockout. The drive train should be easily visible through a viewing port, have internal illumination and access via a lockable hinged door.

4.58 Where the system air is explosive, aggressive or has high moisture content, the extract fan motor must be located outside the air stream. This is generally achieved with axial fans by using a bifurcated unit.

Control

4.59 Fans in healthcare applications are normally either single or two-speed. Where there is a requirement for two-speed operation, this is generally via a local user control (for example, in a hood extract system to provide a boost facility) or via a time schedule for energy saving during unoccupied periods.

4.60 Normally only a single motor is required with a standby motor available for fitting as necessary or fitted but not belted. Twin, run and standby motors - with the standby being jockeyed around - are not required.

4.61 Where there is a specified requirement for standby fans, the system should incorporate an automatic changeover facility activated via an airflow sensor. Fault indication should be provided.

4.62 The control of fans in terms of start-up and run is increasingly being vested in computer software. Inverter-drive, variable-speed, soft-start systems are becoming a standard approach. It should be remembered that most healthcare applications require known amounts of air to be delivered while the system is in use. Constant volume systems that deliver specified air-change rates are therefore the norm. Duct- or room-pressure-controlled, variable-speed systems have a very limited application in healthcare.

4.63 It is necessary to ensure that - should the computer control system or its software develop a fault - then the fan can be switched to a direct-start, fixed-speed, manual operation. This is particularly important for critical care systems serving operating suites, high-dependency care units of any type, patient isolation facilities, laboratories and pharmaceutical production suites. Off-site software support is no substitute for the ability of on site staff to override the automatic control and keep the system operating in an emergency. Under these circumstances actions that may shorten the life of the plant are considered of secondary importance to that of preserving the health and safety of patients and staff.

Heater batteries / heater coils

General requirements

4.64 Frost batteries are installed to protect the downstream filters from low-temperature, high-humidity intake air conditions. As they handle unfiltered air they should be constructed of plain tubing without fins and be as near to the outside as possible to minimise condensation during cold weather. Access for cleaning will need to be provided to both sides of the coil.

4.65 Where steam coils are used for a frost battery, they may be constructed using spiral-finned copper tube. As they will be prone to fouling the tube layout and spacing should permit easy access for regular cleaning.

4.66 Main and branch heater-batteries should be constructed of solid-drawn copper-tube coils with copper fins, generally connected in parallel.

4.67 Where there is a wet heating system in the areas served, the main heater-battery should be sized for the ventilation requirements only, and not for the fabric loss.

4.68 Access for cleaning must be provided to both sides of all frost batteries and heater-batteries.

Acceptable types

4.69 Electric, water or steam heater-batteries may be considered. However, electric heater-batteries are expensive to operate and where there are alternatives, their use should be restricted to low-power use (for example trimming control).

4.70 Where steam-supplied heater-batteries are used, their control, venting and trapping systems should be designed so that a vacuum cannot occur within the coil. The condensate drainage arrangements should not allow pressure to build in the main resulting in a back-up of condensate in the coil.

Location

4.71 Where possible, wet-trimmer heater-batteries should be located in plant areas.

4.72 Where it is necessary to locate heater-batteries in false ceilings etc, consideration should be given to the use of electric heaters. If this is not practicable, drip-trays should be installed under both the battery and the control valve assembly to protect the ceiling. A moisture sensor and alarm should be fitted in the tray. In any event, to facilitate maintenance access, they should be located above corridors or other non-critical areas and never above patient occupied spaces.

4.73 Auxiliary fan coil units should not be installed in the ceiling above an occupied space. They should be accessible for routine maintenance and cleaning without the need to cause significant disruption to the operation of the department that they serve.

Control

4.74 LPHW frost coils should be controlled by an off-coil temperature sensor operating a motorised valve to provide a minimum plant “on temperature” of between 2°C and 5°C. The off-coil temperature of the frost coil is generally sensed by a serpentine thermostat downstream of the coil or upstream of the next plant item. This thermostat will shut the fan down if any part of the air stream is below the minimum set-point.

4.75 Steam-supplied frost coils should be fitted with an on/off control operated by a temperature sensor mounted upstream of the battery. These are normally set to open the control valve fully when the outside temperature drops to +1°C. This will ensure that there is no standing condensate in the base of the coil.

4.76 The main heater-battery should be controlled in the same manner under the dictates of either an off-coil temperature sensor, or a room temperature sensor, depending on the plant configuration and method of control. Trimmer heater-

batteries are generally controlled by one or more averaging temperature sensors within the room or rooms in the zone.

4.77 Heater-battery control valves should drive to a closed position on system shutdown or fan failure. The control system should then automatically set to provide frost protection.

Cooling coils

General requirements

4.78 Cooling coils will need to be decontaminated periodically. They must have good access both up and downstream. Hinged access doors with viewing ports and illumination inside the duct should be provided both sides of the coil.

4.79 An eliminator will be required downstream of all cooling coils. The eliminator may take the form of an extension of the coil fins or be a separate device. If a separate device it should be removable as a unit to permit cleaning of the coil face.

4.81 4.80 All cooling coils must be fitted with their own independent drainage system as specified above. A baffle or similar device must be provided in the drip tray to prevent air bypassing the coil. The tray should be large enough to capture the moisture from the eliminator, bends and headers. Where coils are greater than 1m high, intermediate drip-trays will be required.

4.82 Condensate traps manufactured from Borosilicate Glass will allow easy visual inspection and incorporate a self-cleaning smooth non-porous internal surface, complying with ISO 3585 and BS2589 Part 1.

Selection

4.83 Cooling coils supplied with chilled water are the preferred option. For small loads or where chilled water is not available, direct expansion coils may be used.

4.84 Care must be taken in selection to minimise electrolytic action resulting from condensation on the airside. Coils constructed from copper tubes with copper fins extended on the downstream side in the form of an eliminator and electro-tinned after manufacture are preferred. Aluminium fins should only be used if vinyl-coated.

4.85 All parts of the coil and its associated ductwork in contact with moisture must be manufactured from corrosion-resistant materials. Pressed steel coil headers, even if treated, have been shown to be prone to corrosion over time and should not be used. Steel mounting frames and casings present similar problems hence stainless steel is preferred.

Location

4.86 Microorganisms that multiply in moisture cannot be avoided when the coil is dehumidifying. However, locating the final filter downstream of the coils will reduce the risk of infection.

4.87 Cooling coils in AHUs should be located upstream of the final filter.

4.88 Where any cooling coil has to be located above a ceiling, drip-trays should be installed under both the coil and the control valve assembly to protect the ceiling. A moisture sensor and alarm should be fitted in the tray. To facilitate maintenance access, they should be located above corridors or other non-critical areas and never above patient occupied spaces.

Control

4.89 There are two basic methods of control for cooling coils:

- off-coil control – used in multi-zone systems or single-zone systems where close humidity control is required, to provide a constant maximum off-plant condition which satisfies the temperature and high humidity requirements of the zone with the highest load;
- sequential control – used in single-zone systems, or multi-zone systems with averaging sensors where close control is not required. A room or duct temperature sensor controls the cooling coil and heater battery in sequence to maintain constant room conditions.

4.90 The advantage of off-coil control is that accurate humidity control can be provided without relying on humidity sensors, which are prone to inaccuracy and drift. Off-coil control is however, expensive to operate in terms of energy consumption, due to the fact that there is no feedback of room loads, and thus at low loads and in systems where there are large zonal variations, significant over-cooling and reheating will occur.

4.91 On systems with two-speed operating, it is usual to isolate the cooling coil upon selection of low speed. In addition, on system shutdown, low airflow or fan failure, the cooling coil must be isolated.

Humidifiers

Design need

4.92 Humidification was originally required for some healthcare applications in order to control the risk associated with the use of flammable anaesthetic gases. The use of such gases has now ceased. Humidification is therefore no longer required unless there is a very specific application requirement.

4.93 Operating-theatre AHUs do not generally require humidifiers but provision for their retrofitting in terms of space provision and a capped drainage system should be provided.

4.94 Where humidification is required, it will be subject to the specific requirements set out below. These are intended to ensure that the unit will operate safely and not become a source of contamination.

General requirements

4.95 The most important requirement for a humidifier is to create complete mixing of the steam with the air. The manufacturers' instructions should be followed regarding minimum distances which should be allowed before bends or other components. This is particularly important with respect to a filter mounted downstream. If it becomes saturated by the humidifier, organisms can grow through the filter and be released into the duct. These may then be carried on the airstream into an occupied space.

4.96 The section of ductwork containing the humidifier may need to be periodically decontaminated. Hinged access doors with viewing ports and internal illumination should be provided. A label warning that the device emits live steam and should be isolated prior to opening should be affixed to the access door.

4.97 All parts of the humidifier and its associated ductwork in contact with moisture must be manufactured from corrosion-resistant materials. Stainless steel is preferred.

4.98 The electrodes of self-generating electrode-boiler type humidifiers should be stainless steel.

4.99 All humidifiers must be fitted with their own independent drainage systems as detailed in Paragraphs 4.20 - 4.25 or 4.72 and 4.87.

4.100 For self- and locally-generated steam humidifiers, the cleanliness of the water supply is essential for their safe operation. Provision should be made for draining down supply pipework and break tanks for periodic disinfection and cleaning during periods when they are not required in service.

4.101 The addition of treatment chemicals for continuous control of water quality for humidifier/air handling units should be avoided. Consideration could be given to installing a UV system to control microbiological growth. Given the limitations of UV systems, however, this will require filtration to high quality to ensure the effectiveness of exposure of organisms to the UV irradiation. As with all water treatment systems the unit should be of proven efficacy and incorporate UV monitors so that any loss of transmission can be detected.

Acceptable types

4.102 Only steam-injection manifold-type humidifiers are considered suitable for use in health building air-conditioning systems. Water humidifiers of any type should not be used.

4.103 Steam may be derived from the central steam supply provided that it does not contain any treatment carry-over, or generated locally either within or adjacent to the humidifier.

4.104 The introduction of steam should be by an appliance specially designed to discharge dry steam into the air-conditioning system without objectionable noise or carry-over of moisture.

4.105 During the design stage, consideration should be given to the proposed methods for the regular cleansing of the humidifier(s) and their components.

Selection

4.106 The number and length of steam-injection manifolds to be used is dependent on various factors such as duct cross-sectional area, air velocity, dry-bulb temperature and manifold design. Guidance from the manufacturer should be followed closely.

4.107 A mains steam humidifier can be noisy and will be difficult to control if it is operated at an excessive steam pressure. It should be sized for an operating pressure of approximately 1 bar. The pipework supplying it should be provided with a dirt pocket, pressure reducing valve and steam trap installed as close as practicable to the humidifier, so that the steam condition at entry is as dry as possible. A temperature switch on the condensate line (or equivalent design provision by the humidifier manufacturer) should be incorporated to prevent 'spitting' on start-up.

4.108 Most operational problems with mains steam humidifiers arise because of back-pressure in the condensate discharge line which will result in flooding into the duct. Unless the condensate from the device can be discharged and collected at atmospheric pressure, it should be discharged directly to drain.

4.109 A local steam generator, where used, must be fed with potable quality water. Additional water treatment to the standard set out above may be required. If the humidifier is unused for a period exceeding 48 hours, it must automatically drain its water content, including that contained in the supply pipework, right back to the running main and leave itself empty.

4.110 Some steam generators are of a type that requires regular cleaning and descaling. The design must allow for them to be installed such that they can be physically isolated from the air duct in order to prevent contamination of the supply by cleaning agents while this is taking place.

Location

4.111 Careful siting of the humidifier injection manifold is required to prevent the steam impinging onto the side(s) of the duct, condensing and generating excess moisture.

Control

4.112 Accurate humidity control can only be provided on single-zone systems, or multi-zone systems with zonal humidifiers. In the above systems, humidity sensors control the humidifier for low-level humidity control, and override the temperature controls to open the cooling coil valve for high-limit humidity control.

4.113 Multi-zone systems are more usually controlled by a minimum humidity sensor located in the supply duct(s) following the last heater-battery.

4.114 Overriding controls separate from the normal plant humidistat should be installed. Their purpose is to prevent excessive condensation in the conditioned space when starting up. A time delay should be incorporated into the humidifier control system such that the humidifier does not start until 30 minutes after the ventilation/plant start-up. In addition, a high-limit humidistat should be installed to limit the output of the humidifier so that the saturation in the duct does not exceed 70%. This humidistat is to control the added moisture. It is not necessary to install a de-humidifier to reduce the humidity of the incoming air if it already exceeds 70%. The humidifier control system should ensure that the humidifier is switched off when the fan is not running.

4.115 On systems with two-speed operating, it is usual to isolate the humidifier upon selection of low speed. In addition, on system shutdown, low airflow or fan failure, the humidifier should be isolated.

Filtration

General requirements

4.116 The purpose of filtration is to reduce the level of airborne contamination in an air stream. It is generally carried out in stages.

4.117 Filters must be securely housed and sealed in well-fitting frames that minimise air by pass. Air by pass significantly reduces filter efficiency, the higher the filter grade the greater the effect. Mounting frames should be designed so that the air flow pushes the filter into its housing to help minimise air bypass. Mounting frames that withdraw so that the filter can be changed without having to reach into the unit are preferred.

4.118 Neither the filter media, nor any material used in the construction of the filters, should be capable of sustaining combustion. The filter media should be such that particles of it do not detach and become carried away by the airflow.

4.119 Filters need to be readily accessible for replacement so a hinged access door should be provided. The upstream side of the filter should be visible for inspection through a viewing port with internal illumination.

4.120 All filters should be provided with a means of visually checking the differential pressure across them. Direct-reading dial-type gauges marked with clean and dirty sectors are preferred.

4.121 A complete spare set of filters must be provided at handover.

Definition of filter terms

4.122 Particulate air filters are divided into four categories:

- general ventilation filters grades G1 to G4;

- fine filters grades F5 to F9;
- high efficiency particulate filters (HEPA) graded H10 to H14;
- ultra-low particulate air filters (ULPA) graded U15 to U17.

4.123 General filters are graded in terms of their 'Synthetic dust weight 'Arrestance'. This represents the percentage of a test dust captured by a filter. 'Arrestance' provides a good indication of a filter's ability to remove the larger, heavier particles found in outdoor air. These are of a size to block finned batteries and large enough to settle out in the air distribution system.

BS EN 779 grade (Eurovent grade)	% Arrestance	Notes and typical healthcare application
G1 - (EU1)	< 65	Metal mesh grease filter
G2 - (EU2)	65 to < 80	Coarse primary filter
G3 - (EU3)	80 to < 90	Primary air intake; return air; energy recovery device protection
G4 - (EU4)	> 90	General purpose tempered air supply

Table 4: General Filters

4.124 Fine filters are graded in terms of their 'Atmospheric dust spot Efficiency'. This is a measure of the filter's ability to remove the very fine staining particles found in outdoor air. It will indicate how 'visibly' clean a filter will keep a ventilated space. The staining particles are approximately the same size as most common bacteria so it is also a rough measure of the filter's ability to remove microorganisms.

BS EN 779 grade (Eurovent grade)	% Efficiency	Notes and typical healthcare applications
F5 - (EU5)	40 to 60	General purpose panel / bag filter
F6 - (EU6)	60 to < 80	Basic grade bag filter
F7 - (EU7)	80 to < 90	Medium grade bag or pleated paper Conventional operating theatre supply air
F8 - (EU8)	90 to < 95	High grade bag or pleated paper
F9 - (EU9)	> 95	Basic HEPA filter – Level 8 clean rooms

Table 5: Fine Filters

4.125 High efficiency filters (HEPA and ULPA) are graded in terms of their ability to capture their 'Most Penetrating Particle Size' (MPPS). High-efficiency filters self-select the particle that they are least able to trap, hence the MPPS. They are then tested against that size of particle. These filters are designed to provide very high-efficiency filtration of particles in the sub-micron size range.

BS EN 1822 grade (Eurovent grade)	% Efficiency @ MPPS	Notes and typical healthcare application
H10 - (EU10)	85	Ultra-clean theatre terminal
H11 - (EU11)	95	
H12 - (EU12)	99.5	
H13 - (EU13)	99.95	
H14 - (EU14)	99.995	Pharmacy aseptic suite Category 3 room extract
U15 – U17	-	Not generally used in healthcare

Table 6: High Efficiency (HEPA) Particulate Filters

Selection primary filters

4.126 All filters should be of the dry type. Panel filters are cheap and disposable with relatively low dust-holding capacity. They are generally used as pre-filters to eliminate large particles that would otherwise clog or cause damage to the fan and finned heating and cooling batteries. Stainless steel frames that hold disposable pre-cut filter pads are preferred.

4.127 General ventilation supply plant should incorporate primary air filters of grade G3, sized for a maximum face velocity of 2.0 m/s. Additional coarse pre-filters may be justified where the intake air is exceptionally polluted. They are sometimes fitted as a temporary measure when building work is being carried out in the vicinity of the air intake.

Secondary filters

4.128 Where a higher standard of filtration is required, secondary bag or pleated paper panel filters would be used. Rigid frame filters incorporating pleated paper elements are preferred over bag filters for critical care applications such as operating theatres.

4.129 In urban or other areas of high atmospheric pollution, a higher standard of filtration may be justified to reduce the level of staining to internal finishes.

Extract air filters

4.130 Extract filtration will generally only be required where heat-recovery devices are installed. There are a very limited number of specialised applications (microbiological safety cabinets and similar LEV systems) where contaminated air is required to be filtered prior to discharge to atmosphere. If it is safe for staff to work in a room without wearing respiratory protective equipment, it is safe to discharge the room air to atmosphere without filtration.

Return-air filters

4.131 They are used to reduce the load on HEPA filters in recirculating applications such as Ultra Clean operating suite ventilation canopies and pharmacy aseptic suites.

High-efficiency filters – HEPA and ULPA

4.132 HEPA filters are expensive so their use should be kept to a minimum. Applications requiring HEPA filters include the air supply to aseptic suites in manufacturing pharmacies, the discharges from microbiological safety cabinets and isolation facilities.

4.133 If used, HEPA filters should be of the replaceable panel type with leak-proof seals. They should be installed in a manner that permits on-site validation of the filter and its housing. This may involve the release of a Dispersed Oil Particle (DOP) challenge smoke through an injection point upstream of the filter and a measurement of the DOP penetration across the downstream face. Alternatively a particle-counting method may be used.

4.134 HEPA filters are sometimes fitted in extract systems to capture hazardous substances or organisms. Design provision must be made for the subsequent safe handling of contaminated filters by maintenance staff. This may be achieved by:

- sealing the hazardous substance into the filter before it is removed;
- providing a system to fumigate the filter to kill any organisms;
- housing it in a ”safe change” unit that permits the filter to be ejected into a bag and sealed without staff having to come into direct contact with it.

4.135 In view of the costs and problems associated with placing HEPA filters in extracts, it is recommended that a full risk assessment be carried out at the design stage. This should include defining the true need for HEPA filters in an extract; validation of its performance at installation; the method of safely changing a contaminated filter; and its subsequent disposal.

4.136 ULPA filters are very expensive and are designed to remove particles below a size that are either surgically or aerobiologically significant. There would have to be exceptional circumstances in order to justify their use in healthcare ventilation systems.

Activated carbon filters

4.137 Activated carbon filters are able to remove gases and vapours from an air stream and are graded according to the range of substances they can remove. They are not normally fitted in air-conditioning supply systems.

4.138 They are occasionally fitted retrospectively because the main air intake has been poorly sited and is drawing in traffic fumes. Where used they must be protected by a particulate air filter.

4.139 Activated carbon filters are more commonly used in specialised fume extraction systems when the location of the discharge means that dilution cannot be relied upon to disperse noxious fumes.

Location

4.140 The primary filter should be positioned on the inlet side of the supply fan, downstream of the frost coil. The secondary filter, when fitted, should be on the positive-pressure side of the fan. This will prevent air being drawn into the system after the filter and capture any particles shed by items of equipment within the AHU.

4.141 The filter installation must be arranged to provide easy access to filter media for cleaning, removal or replacement, with side or front withdrawal as required.

Control

4.142 Differential-pressure transducers should be provided to monitor and alarm remotely on excessive filter pressure drop. In critical areas dirty-filter indication lights should be provided at the point-of-use.

Energy-recovery

General requirements

4.143 Energy recovery will normally be fitted to all healthcare ventilation systems. It may be omitted only where it would clearly be uneconomic. Where the economic case is marginal, space should be allowed for the retrofitting of an energy recovery system.

4.144 For systems in healthcare premises, a plate heat exchanger or 'run-around coil' system is suitable. Thermal wheels may be used providing they are fitted with a purge sector. The small amounts of air leakage across those devices are not considered significant. Other systems such as heat pumps or heat pipes are also suitable. Selection should be based on relative locations of the supply and extract units, ease of maintenance and practicality. Cleaning access will be required to both sides of any energy-recovery device.

4.145 The following are the minimum energy transfer efficiencies required for devices handling equal air volumes:

- run-around coil – 45%;
- plate heat exchanger – 50%;
- thermal wheel – 65%;
- any other energy-recovery device – 50%.

4.146 If a plate heat exchanger is chosen, the plates should be constructed of metal. Plastic should not be used for internal bypass dampers and drive gears.

4.147 Whichever energy-recovery device is chosen the extract side will need to be protected by a G3 filter and provided with a drainage system as described in Paragraphs 4.20 - 4.25, to remove condensate.

Location

4.148 Energy-recovery devices should be located downstream of the frost battery and pre-filter, prior to the cooling coil or main heater battery on the supply side.

Control

4.149 It is essential to consider the control of both the energy recovery device and the frost battery when assessing the economics of recovery, as all energy provided by the frost battery will directly reduce the heat exchange of the recovery device. To this end, the off-coil setting of the frost coil should be the minimum possible to protect the primary filter (for example +2°C).

4.150 The energy-recovery device should be controlled in sequence with the main heater battery, and should incorporate a control to prevent the transfer of unwanted heat when the air-on condition rises above the required plant set point.

4.151 In instances where the plant is cooling the air, it may be possible to remove heat from the supply air at high ambient conditions, under the dictates of enthalpy sensors in the intake and extract ducts.

Attenuation

General requirements

4.152 Noise will be generated in an air distribution system by the fan, plant items and airflow. The ductwork is a very effective transmitter of this noise hence there is generally a need to limit the noise transmission to meet the requirements of the building. This normally involves the provision of sound attenuation treatment as part of the overall ductwork system design.

4.153 A thorough assessment of the design should be made to assess the noise impact. This should take into account the following primary factors:

- fan- and plant-noise generation;
- air-flow generated noise in ductwork fittings and dampers;
- noise generated at grilles, diffusers and other terminals;
- noise break-in and break-out of ductwork;
- cross-talk and similar interference;
- the noise limitations for the building and surrounding areas;
- external noise generation.

4.154 A method of assessment of these factors and the sound attenuation requirements of ductwork systems is given in CIBSE Guide B.

4.155 The fan is usually the main source of system noise. The sound power that it generates varies as the square of the fan pressure, and thus to limit the fan noise level the system resistance should be kept as low as economically

possible. As a general rule the selected fan should operate close to its point of maximum efficiency to minimise its noise generation. Where there is disturbance to the airflow at the fan inlet, the manufacturer's stated fan noise levels should be increased by up to 5 dB(A). More precise guidance on this aspect may be available from the manufacturers.

4.156 Fans radiate noise through both the inlet and outlet connections and it may be necessary to provide attenuation to limit the noise from both of these connections. It is always preferable and more economic to control noise and vibration at source, or as close to source as possible. It should be noted that attenuators offer a resistance to airflow. The resistance must be included in the fan and ductwork calculations.

4.157 Provided care is taken in the design and construction of low-pressure systems to avoid significant noise generation in the ductwork, attenuation should only be needed to absorb fan noise.

4.158 Noise breakout from all equipment housed in the plantroom must be taken into consideration if control is to be satisfactory. Any ductwork within the plantroom after the silencer should be acoustically insulated to prevent noise break-in or the silencer relocated at the point of entry or exit of ductwork to and from the plant room.

4.159 There is no complete means of control over external noise generation from such as road traffic, aircraft, factory and community noise. Consideration must be given to this at the design and planning stage.

Acceptable types and location

4.160 The noise levels produced by ventilation and other plant should be reduced by either lining the inside of the duct with sound-absorbing material or fitting bespoke attenuator units.

4.161 In supply systems, sound-absorbing material should not be applied to the inside surface of a duct system downstream of the final filter, owing to the risk of mechanical damage and the subsequent dispersal of the media into the ventilation system.

4.162 In supply and extract systems, sound-absorbing material must not be applied to the inside of a duct within 1 metre of a fire damper. The material should be non-particle-shedding and fire-resistant (further guidance can be found in SHTM Firecode suite of documents). Where sound-absorbing material is applied in a section of duct that will be routinely exposed during maintenance activities it should be protected from mechanical damage.

4.163 Bespoke attenuator units with a sound-absorbing infill suitable for the quality of air being handled and protected by a perforated sheet metal casing are the preferred option for critical systems. Absorption of moisture, dirt and corrosive substances into the 'in-fill' and the release of fibrous particles into the airstream should be prevented by the use of a membrane. The membrane material should have a declared service life of at least 25 years. If these conditions can be met then the attenuator may be located in the supply ductwork downstream

of the final filter. When so located, cleaning access should be provided at both ends of the attenuator unit.

5. Air distribution system

Air distribution arrangements

Ductwork distribution systems

5.1 Ductwork systems for ventilating and air-conditioning applications are referred to by their velocity or pressure category, that is, as low, medium or high velocity (or pressure) systems. Heating & Ventilating Contractors Association (HVCA) limits are up to 10 m/s or 1,000 Pa; 20 m/s or 1,750 Pa: and 40 m/s or 3,250 Pa in the case of conventional low, medium and high pressure systems respectively. High-pressure systems are disappearing because of the constraints of the Building Regulations but existing systems may sometimes need to be altered or extended.

5.2 For normal applications in healthcare buildings, low velocity systems are recommended. The use of higher velocities than those recommended is not likely to be economical. Future trends are likely to be towards even lower optimum duct velocities; however, velocities below 2 m/s are unlikely to be justified.

5.3 The site will often dictate the main routing of ductwork systems, but in general, the design should seek to make the layout as symmetrical as possible; that is, the pressure loss in each branch should be as nearly equal as possible. This will aid regulation and may reduce the number and variety of duct fittings that are needed.

5.4 Main distribution ductwork should not be routed above sleeping areas. Where there is no alternative route, additional acoustic insulation will be required.

5.5 Where auxiliary cooling units, fans, filters or trimming devices are installed in the distribution system, they must be independently supported and fitted with a suitable drainage system where appropriate. If they are a source of vibration they should be linked to the distribution ductwork via flexible connections.

5.6 The fan of a Local Exhaust Ventilation (LEV) system provided under the COSHH Regulations should be located outside of the building so that all of the ductwork within the building is under negative pressure. Where the fan has to be within the building it should be located as close as practicable to the outside with an absolute minimum run of discharge ductwork within the building. The discharge ductwork within the building will be under positive pressure so it must not be penetrated by test holes or inspection hatches.

Ductwork materials and construction

5.7 The choice of duct material should take account of the nature of the air or gas being conveyed and the environment in which the duct will be placed.

5.8 Galvanised-sheet-steel is generally suitable and most economical for normal ventilating and air-conditioning applications. Its inherent mechanical strength

renders it resistant to casual damage both during the construction phase and throughout its service life when mechanical and electrical services around it are altered. It also readily withstands the impacts sustained when rotary equipment is used to for internal cleaning.

5.9 In instances where moisture levels and/or corrosive elements in the air being conveyed are very high, aluminium, stainless steel, PVC or GRP (glass-reinforced plastic) ducts should be used. Stainless or black steel are the only suitable materials for high-temperature ductwork.

5.10 In inherently wet areas, such as the base of fresh air inlet ducts and some extract systems, the ductwork may require draining to prevent a build-up of standing water. The layout of the drains should be as specified in Paragraphs 4.20 - 4.25.

5.11 Where builderwork plenum chambers or ducts are used, these may be constructed of various materials. However all such ducts must be rendered and sealed to prevent dust shedding. A greater allowance may need to be made for leakage.

5.12 Galvanised, black and stainless steel ductwork should be manufactured and installed to the current HVCA specification for sheet metal ductwork DW144, but excluding the use of bolt-through supports.

5.13 GRP and PVC ductwork should be manufactured and installed to the current HVCA specification for plastic ductwork DW154.

5.14 Where phenolic-board ductwork is considered, care should be taken to ensure that it is fabricated to a quality standard and installed strictly in accordance with the manufacturers' instructions. Its pressure rating and degree of support should be suitable for the application and ducts should be fitted with mechanical protection where required. Designers should be fully conversant with installation techniques and Installers should be experienced having received training in the techniques required and certified to this effect by the manufacturers. Due consideration should be given to the impact on ductwork pressures created by the closing of dampers. Phenolic-board ducting should not be installed in plant rooms or any other areas where it could be vulnerable to impact damage. Internal cleaning using mechanical (rotary) means is also liable to cause damage to the integrity of surfaces.

5.15 Flexible ductwork is unsuitable for air distribution in healthcare applications. It should only be used to make the final connection to a terminal (See Paragraphs 5.54 and 5.55).

5.16 The inside of the ductwork should be free from structural projections and as smooth as possible. Flanged, gasketed joints are preferred.

Fire aspects, damper types and locations

5.17 It is essential that all relevant fire aspects of ducting systems are agreed with the fire officer before the design is finalised.

5.18 Ductwork must be fire-stopped where it penetrates fire compartment walls, floors and enclosures, cavity barriers and sub-compartment walls or enclosures, and provided with weatherproof collars where roofs or external walls are penetrated.

5.19 Fire/smoke dampers shall be provided at the locations required by SHTM Firecode. The fire-damper mounting frame must be securely attached to the building fabric. Where a fire-damper is not mounted directly in a fire compartment wall, it must be correctly supported and the ductwork between it and the firewall must posses the same fire rating as the firewall that it penetrates. The fire-rated portion of ductwork must not be penetrated by test holes or inspection hatches. All fire/smoke dampers shall be capable of remote re-setting via the Building and Energy Management System (BEMS) or equivalent, after periodic testing procedures.

5.20 An access hatch shall be provided adjacent to each fire damper so that its correct operation can be directly observed.

5.21 Smoke-diverting dampers must be provided on recirculation air systems to divert automatically any smoke-contaminated return air to the outside of the building in the event of a fire; and arranged so that the normally open smoke-diverting damper on the return-air branch to the input unit closes and all the return air is exhausted through the extract fan. Guidance is available in SHTM 81 and BS5588: Part 9.

Duct sections

5.22 Ducting is generally available in rectangular, circular and flat oval sections, although other sections may be made for special situations.

5.23 Rectangular ducting is most common on low-pressure systems, for the following reasons:

- it can readily be adapted to fit into the space available;
- fittings are cheaper than those for circular or flat oval ductwork;
- it can readily be joined to such component items as heating and cooling coils, and filters.

5.24 When sizing ductwork, the designer should take into account:

- both installation and operating costs;
- space limitations imposed by the structure and other services;
- operating noise levels;
- requirements of regulation at the commissioning stage.

5.25 For overall economy and performance, the aspect ratio should be close to 1:1, since high aspect ratios increase the pressure loss, heat gains or losses and overall cost (for example, changing the aspect ratio from 1:1 to 1:4 can typically

increase the installed cost of the ductwork by 40% and add 25% to the heat gains or losses).

5.26 Rectangular ducting should not be the first choice for high pressure systems, and should be avoided in systems operating at high negative pressures, because the strengthening of the flat sides and the sealing requirements necessary to make rectangular ducts suitable for these high pressures are costly.

5.27 Circular ducting is preferable for high-pressure systems, and for systems operating at high negative pressures. In the case of the latter, additional stiffening rings may be necessary. Machine-formed spirally-wound ducting and a standard range of pressed and fabricated fittings can sometimes make circular ducting more economical, particularly in low pressure systems having a relatively low proportion of fittings.

5.28 Flat oval ducting provides an alternative to circular ducting, principally where there is a limitation on one of the dimensions in the space available for the duct run.

5.29 Other sections may be used, such as triangular sections to pass through roof trusses. Such sections present difficulties in the provision of fittings, and connections to standard plant items, and are likely to be more expensive than traditional sections.

Standard ductwork fittings

5.30 All fittings should conform to current HVCA specification DW144. Wherever possible, long radius bends, large radius main branches, not more than 45° angle sub-branches and long-taper transformations should be used.

5.31 Fittings should be arranged with vanes in sub-branches connected directly to grilles and diffusers, and turning vanes in square bends (when used). When vanes are used, additional cleaning access will be required.

5.32 The number of duct fittings should be kept to a minimum and there should be a conscious attempt to achieve some standardisation of types and sizes. Increasing the number and variety of fittings in a system can markedly raise its overall cost.

5.33 Bad design in relation to air flow can lead to vibration of flat duct surfaces, increases duct-generated noise and pressure loss, unpredictable behaviour in branch fittings and terminals, and adverse effects on the performance of installed plant items (such as trimmer batteries).

Branches

5.34 There are many designs of branches and junctions in use. The important features are that the flow should be divided (or combined) with the minimum interference and disturbance. Changes in duct sizes should not be made at the branch but a short distance downstream (or upstream). A good dividing branch

design cannot be effective if the flow entering the branch is not uniform across the section.

Changes of section

5.35 The expansion of a duct section should be formed with sides having a total included angle of no more than 30°, and preferably less than 20°. If the angle of expansion is greater, the flow is not likely to remain attached to the walls of the duct and large eddies will be formed with flow reversal at the walls. This leads not only to a high-pressure loss, but also to non-uniform velocity pattern at the outlet. Where there is insufficient space for a gentle expansion and a greater angle is necessary, internal splitters should be used.

5.36 A contraction in a duct section is less critical, but the total included angle of the taper should not exceed 40° (or 20° where the contraction is made on one side of the duct only)

5.37 The most economical way to change the section of a rectangular duct is to restrict the change of duct size to one side only. If the calculated reduction or increase to the side dimension is 50mm or less, it is usually not economical to change the size at the position. The minimum size of a rectangular duct should usually be 150mm x 100mm.

Other fittings

5.38 As a general rule, fittings should avoid abrupt changes in direction and also sharp edges that cause the flow to separate and form eddies, thus limiting pressure loss and causing noise generation. If the fitting leads to the flow preferentially attaching to one side of the outlet, then a significant length of straight downstream duct is necessary before the next branch or fitting; this length should be greater than five equivalent diameters.

Thermal insulation

5.39 Thermal insulation is applied to ductwork to reduce heat exchange, and to prevent condensation.

5.40 In a duct system, the air temperature changes can be significant, especially when passing through untreated space, and these have the effect of reducing the heating or cooling capacity of the air and of increasing the energy input to the system. The heat transmission to and from the surrounding space can be reduced by effective insulation of the ducts. Extract ductwork conveying air from which heat recovery will be derived should be thermally insulated to the same standard as with associated supply ventilation ductwork.

5.41 Condensation can arise in ductwork systems conveying cooled air and, apart from creating conditions conducive to corrosion of ductwork, condensation affects the heat and vapour-resisting properties of insulating materials themselves which may induce further condensation.

5.42 In normal circumstances, the insulation thickness for heat resistance is sufficient to prevent surface condensation, but in extreme conditions the

insulation thickness for vapour resistance may be greater than that for heat resistance. When cold ducts pass through areas of high dew-point, carefully selected vapour barriers should be applied externally to the insulation.

Noise generation within the ductwork

5.43 Noise is generated in ductwork at sharp edges, by tie rods, damper blades, duct obstructions and sharp bends etc. This air-flow-generated noise becomes an important factor if it is about the same or greater level than the upstream noise level. (Air-flow-generated noise is often referred to as “regenerated noise”).

5.44 The noise level generated by airflow in ductwork is very sensitive to the velocity. The sound power of this noise is approximately proportional to the sixth power of the velocity; that is, a doubling of the duct velocity will increase the sound power by a factor of 64. The duct velocities should therefore be kept as low as possible. In general, duct fittings that have lower pressure loss factors in similar flow conditions will generate less noise.

5.45 Ductwork serving quiet areas should not be routed through noisy areas where noise break-in can occur and increase the noise level in the ductwork.

5.46 Grille, register and louvre noise should be kept to the minimum by selecting types having low noise-producing characteristics, without high tonal noise, and should be fitted with acoustically treated external inlet and outlet louvres.

5.47 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where individual room confidentiality is required. They will normally be of the ‘through-the-ceiling, ‘up-and-over’ type and may include a fire damper if required.

Volume control damper locations

5.48 Manually operated balancing dampers are needed generally:

- in the main duct downstream of the fan;
- in branches of zone ducts;
- in sub-branch ducts serving four or more terminals;
- at terminals not covered by the previous item.

5.49 Dampers integral with terminals should only be used for final trimming of air volumes, otherwise noise and air distribution problems may ensue.

5.50 Dampers in rectangular ducts should be single-bladed when the longer side is up to 450mm but be of the opposed-blade multi-leaf type above this size. In circular ducts, iris-type dampers are recommended. Dampers must be accessible, incorporate a position indicator and means of locking in the commissioned position. Dampers should be located as far away as possible from adjacent branches or plant items.

Cleaning and access door locations

5.51 Cleaning and access doors are required to facilitate access to plant items and ductwork components for inspection, maintenance, cleaning and replacement, and must be of sufficient size to permit safe access for the required functions. Consideration should also be given to the number of doors to be provided. Older installations may be deficient in the provision of access doors and consideration will be necessary to have these incorporated in the course of any refurbishment in the accommodation served.

5.52 Recommended locations for access doors are given in the current HVCA specification DW144 and are generally provided to give access to:

- every regulating damper;
- every fire and motorised damper;
- filter (to facilitate filter withdrawal);
- both sides of cooling/heating coils;
- humidifiers;
- fans; and
- motors and impellers.

5.53 Care should be taken when siting access doors to ensure that no other services to be installed will prevent reasonable access.

Flexible ducting

5.54 Flexible ductwork may be used for final connections to grilles and diffusers provided it is constructed to meet the fire precautions recommended in BS8313. It must not pass through fire compartment walls, floors or enclosures of sub-compartment walls or enclosures, or through cavity barriers.

5.55 Flexible ducting will cause a significant frictional loss and may be difficult to clean and should never be used in lieu of a bend. Where installed it should take the most direct route and be as short as possible, never exceeding 1 metre in length.

Diffuser and grille selection and sizing

5.56 The effectiveness of all ventilation and air-conditioning systems depends on the methods by which air is introduced to, and vitiated air is removed from, the space. The usual results of poor air-terminal selection and/or positioning are: draughts, stagnation, poor air quality, large temperature gradients and excessive noise.

5.57 Air can be supplied to a space in a number of ways, although any device can be broadly placed into one of two categories: that producing a diffused supply, or that producing a perpendicular jet. Diffusers may be radial or linear, and normally utilise the Coanda effect (that is, adhesion of the air stream to an adjacent surface), to reduce the risk of excessive room-air movement. A

perpendicular jet is formed by discharging air through grilles, louvres or nozzles, which are generally adjustable.

5.58 Air-flow patterns produced by both types of terminal are dependent to a large extent on the presence of the Coanda effect.

5.59 Supply air terminals can be incorporated into any room surface, for example, floors, walls (high or low level), desktop etc.

5.60 As they operate on the jet principle, the use of sidewall and linear grilles is restricted to areas where air change rates are low, that is, less than 10 per hour. Perforated rectangular diffusers can provide acceptable conditions within the occupied zone at up to 15 air changes per hour. In areas where a higher air change rate is required, square or circular ceiling mounted diffusers should be used.

5.61 The performance of supply air terminal devices is provided, based on three criteria: throw, spread and drop.

- **throw** is defined as perpendicular or parallel distance from the terminal to the point at which the air velocity is 0.5 m/s isovel;
- **spread** is defined as the width of the 0.5 m/s isovel; and
- **drop** is defined as the vertical distance from the centre line of the terminal to the bottom edge of the 0.25 m/s isovel.

5.62 It is necessary to consider each of these parameters in both summer and winter conditions to ensure satisfactory operation of the air-terminal device, as warm jets behave very differently from cold jets.

5.63 A warm jet tends to rise until it attaches itself to a horizontal surface, while a cold jet falls. Care must be taken to ensure that this does not lead to unacceptable temperature gradients in winter or excessive air velocities in the occupied zone in summer.

5.64 In order to ensure satisfactory air movement within a space, it is necessary to consider interaction between air movement from adjacent terminals, and ceiling mounted fixtures (light fittings etc), as well as interaction between air movement and room surfaces.

5.65 If the supply and extract terminals are too close, short-circuiting may occur, while if they are too far apart, stagnant zones may be formed. Where two opposing air streams meet, the individual velocities must not be greater than 0.25 m/s.

5.66 Supply and extract grilles and diffusers should be fitted with opposed-blade dampers for fine balancing purposes.

5.67 Further guidance on the selection of grilles and diffusers is given in the CIBSE Guide B.

5.68 In operating theatres, the supply terminals must be able to produce a down-flow movement of air in the operating zone 1 metre above floor level. Ceiling mounted diffusers with fixed directional vanes that provide a downward turbulent airflow are the preferred option. Plenum boxes fitted with perforated screens to produce a parallel downward flow are also acceptable. Nozzles or jets of any type are not acceptable. Sidewall-mounted linear diffusers that utilise the Coanda effect to send air across the ceiling and 'drop' it into the operating zone are also not suitable. However linear ceiling mounted diffusers that provide a direct downward airflow around the operating zone may be used.

Transfer grille - size and location

5.69 Air-transfer grilles in walls, partitions or doors form an integral part of the building's air distribution system. Modern doorsets have very low leakage rates so cannot be relied upon to permit even quite small airflows. Failure to make adequate provision for air to move from room to room will result in excessive pressure differentials and 'door whistle'.

5.70 Transfer grilles are required in locations where there is a significant imbalance between the supply and extract rates in a room. They will relieve any pressure differentials that may affect the operation of the spaces and/or the ventilation system and permit airflow in a known direction. However, transfer grilles are vulnerable to damage and, in many instances, as long as the equivalent free area is provided, they can be substituted with undercut door.

5.71 Care needs to be taken to ensure that the positioning of transfer grilles does not interfere with the fire or smoke integrity of the building. In general, the air-transfer grilles should not be installed within fire-resisting boundaries, although if this is unavoidable, they should be fitted with fire- or smoke-dampers.

5.72 Where installed, transfer grilles should be of the non-vision type, sized for a maximum face velocity of 1.5 m/s.

5.73 In photographic dark rooms, lightproof transfer grilles will be required.

5.74 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where individual room confidentiality is required. (See also Paragraphs 5.43 - 5.47).

Pressure stabilisers - size and location

5.75 Pressure stabilisers are required in lieu of air-transfer grilles in areas where it is necessary to maintain pressure differentials between adjacent rooms to prevent reversal of airflows for example, in operating suites, isolation facilities and clean rooms. (See also Paragraphs 7.24 - 7.28).

5.76 Fire precautions for pressure stabilisers are the same as for transfer grilles. For sizing criteria, refer to Paragraph 7.23

5.77 Pressure stabilisers should be of the balanced-blade type, with the facility to make fine adjustment of the pressure setting. They should be silent in

operation and give a seal as tight as practicable when closed. The materials of construction and method of assembly should allow for cleaning and disinfection.

5.78 Pressure stabilisers should be installed in a visible location so that their operation can be readily observed.

5.79 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where confidentiality is required. In these cases, the pressure stabiliser and cross-talk attenuator should be mounted in a short length of ductwork within the ceiling void.

5.80 Pressure stabilisers may need to be fitted with a stand-off baffle on their discharge side to prevent a sight line in situations where a laser will be used. Baffles may also be required to preserve privacy or prevent discharge air causing draughts or disturbing the air distribution pattern in the adjoining room. They are also useful in low-level locations to prevent the airflow path being obstructed by portable equipment.

6. Automatic controls

6.1 Various options for control of single and multi-zone air-conditioning systems are given in CIBSE Guide B.

General requirements

6.2 The basic requirements for an automatic control system are as follows:

- facilities to start, set-back and stop the plant;
- facilities to control the volumetric air-flow;
- facilities to control the system or room pressure;
- temperature control and indication;
- humidity control and indication;
- devices to monitor and indicate the plant's operating state;
- alarms to indicate plant failure, low air-flow, and filter state.

The control functions actually provided will depend on the purpose of the ventilation system.

6.3 There will also be a need to determine the control strategy in the event of a fire either within the zone being served or within an adjoining zone.

6.4 The designer should consider whether it is necessary for the supply and extract fans to be interlocked, either so that the supply fan will not operate unless air-flow is established within the extract system, or vice-versa depending on the required pressures within the rooms being served.

6.5 The sequence switching of units in order to prevent transient reverse airflows will be particularly important in laboratory and pharmacy areas that also contain fume cupboards, safety cabinets and other LEV systems.

6.6 Alarms should be provided to show 'filter fault' and 'low air-flow'. The "filter fault" alarm should be initiated by a predetermined increase of pressure differentials across the filter. The 'low air-flow' alarm should be initiated when the supply air quantity falls to 80% of the design value.

Objectives of control system

6.7 The primary objective of ventilation plant control system is to maintain the space served within the required environmental control limits, at the appropriate times, regardless of external conditions or internal loads and with the minimum energy consumption.

6.8 Often, it is not possible to predict accurately building load variation at the design stage, and thus optimum set points cannot be assessed. Information provided by monitoring the operation of the plant via a Building and Energy Management

System (BEMS) will enable optimum set points to be established and energy consumption reduced. Control of most systems will be via a BEMS. This will enable the operating conditions and control tolerances to be set and monitored. The BEMS may also be set to log the actual energy consumed by the system together with that recovered by the energy-recovery device. This will provide a useful check on overall operating efficiency and provide evidence that energy targets are being achieved.

6.9 BEMS incorporating self-adaptive control algorithms that automatically adjust the set-point to the suit the usage and load are preferred. The provision of movement sensors within the controlled space in order to determine the actual occupancy will facilitate this process.

6.10 The failure of specialised ventilation systems can have grave consequences for the delivery of healthcare. Control systems should therefore be simple, robust and reliable.

6.11 Computer-software-driven control systems are becoming the norm in building services. However, it should be remembered that healthcare ventilation systems need to be available to operate outside of normal working periods when software support is not available. Should the software fail, it will be left to site staff, who may have little knowledge of the control algorithms to restart the ventilation system. It is therefore essential to ensure that a simple means of re-starting critical systems in the event of a software failure is provided (see also Paragraphs 4.62 - 4.63)

Location of controls

6.12 Whether within the plant, duct or room, sensors should be located to provide accurate measurement of the condition of the air being monitored.

6.13 Sensors and control items such as control valves should be located close to the element being sensed or plant item being controlled, in order to minimise time lags within the system which may create over-shoot of conditions beyond the design envelope and result in additional energy consumption.

6.14 There are practical advantages in locating all control valves for an air-handling unit in a bank (at a convenient height) at one end of the unit. (This will not normally result in an undue additional control lag.)

6.15 Some applications require intermittent mechanical ventilation, frequently at a high air-change rate, (for example, in bathrooms and treatment rooms.) Local controls to facilitate this mode of operation should be placed in a prominent position to encourage economical use.

6.16 Local controls that enable the user to select more than one mode of operation should be clearly labelled to identify the particular mode selected. Where the system allows different room pressures to be selected then a direct-reading pressure gauge should be fitted within the eye line of the users to provide an independent confirmation of the resultant mode of operation. A clear

description of the selectable modes of operation should be mounted adjacent to the control switch.

Fire aspects

6.17 A fire control panel should be mounted at the entrance of the area that the ventilation serves. The panel should have restricted access for the fire officer and include independent on/off controls and indication of the supply and extract systems.

6.18 In certain critical care departments it is preferable to maintain the supply ventilation in case of a fire within the area. For example, in an operating department, while undergoing surgery, the patient cannot always be easily moved without significant risk. In the event of a fire in a staff or support area of the department, or adjoining zone, the continued supply of air to a theatre will maintain it at a positive pressure and protect the patient and staff from the effects of smoke. This will allow time for the patient to be stabilised so that he/she can be safely evacuated if necessary. A similar situation occurs for patients in ITU and other critical care units. In all of these cases the ventilation to the critical area should continue to operate unless the AHU starts to draw in smoke. For these departments, a notice should be affixed to the fire control panel drawing attention for the need to liaise with departmental staff before switching off fan units.

6.19 All supply AHUs should have a smoke sensor mounted in the main supply duct immediately downstream of the AHU. In the event of a fire in the AHU or smoke being drawn into the system from an outside source, it should cause the supply air fire damper to close and shut down the AHU.

Time switching

6.20 Facilities to start, set-back and stop the plant should be provided in the plantroom. Remote start and set-back control and indication, if required, should be provided at a manned staff location, for example, at the reception or staff base or, in theatres, within the Surgeon's Panel.

6.21 Many ventilation systems may be completely shut down when the area served is not in active use. Alternatively, where there is a need to maintain a background condition, the ventilation output can be reduced by "setting back" the system. This will significantly reduce energy consumption and extend the life of filters and other system components.

Start-up control

6.22 The plant's start control should contain a control logic that will start the plant in the sequence set out in the following algorithms, Figures 2 - 5

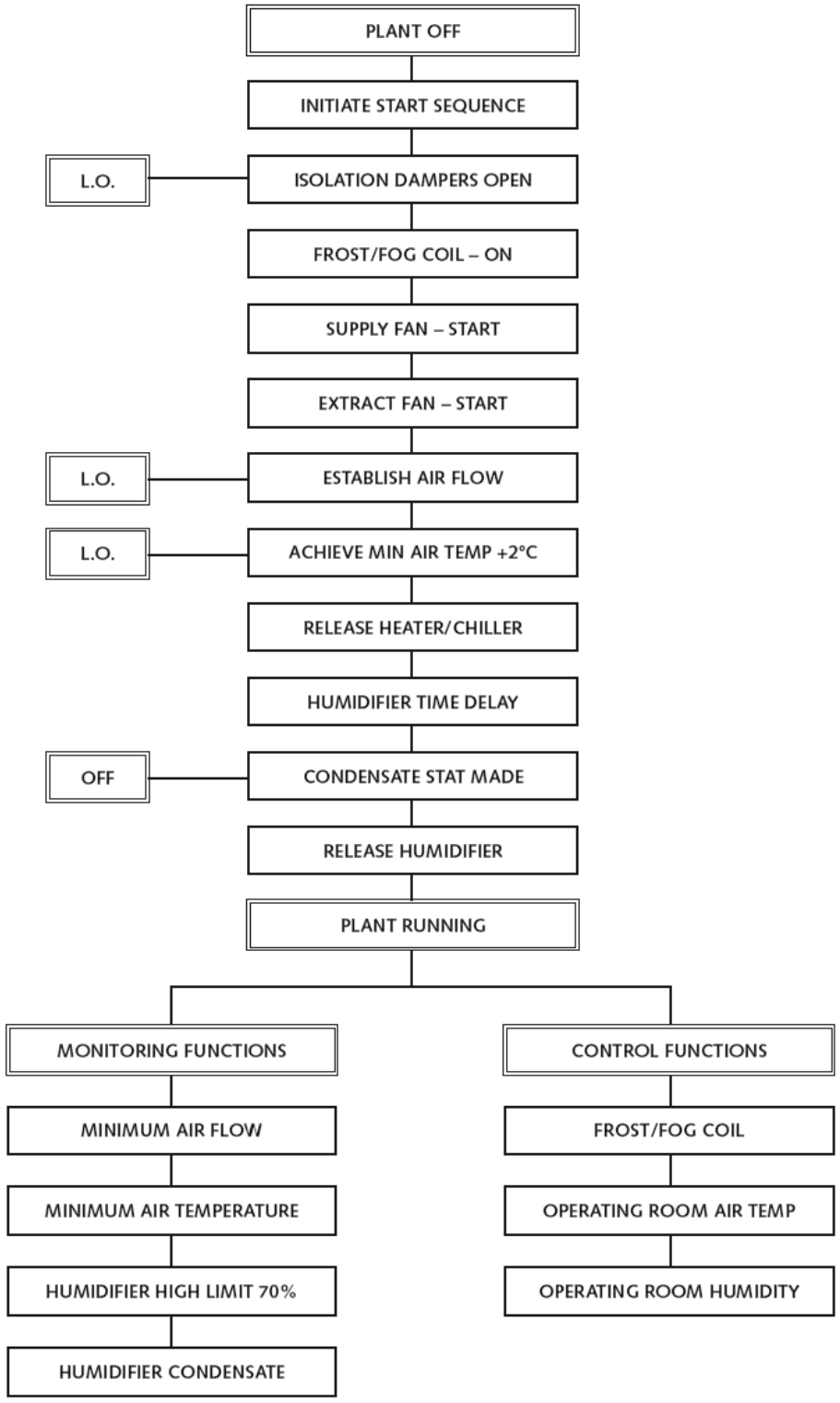


Figure 2: Typical plant control algorithm – normal start-up sequence

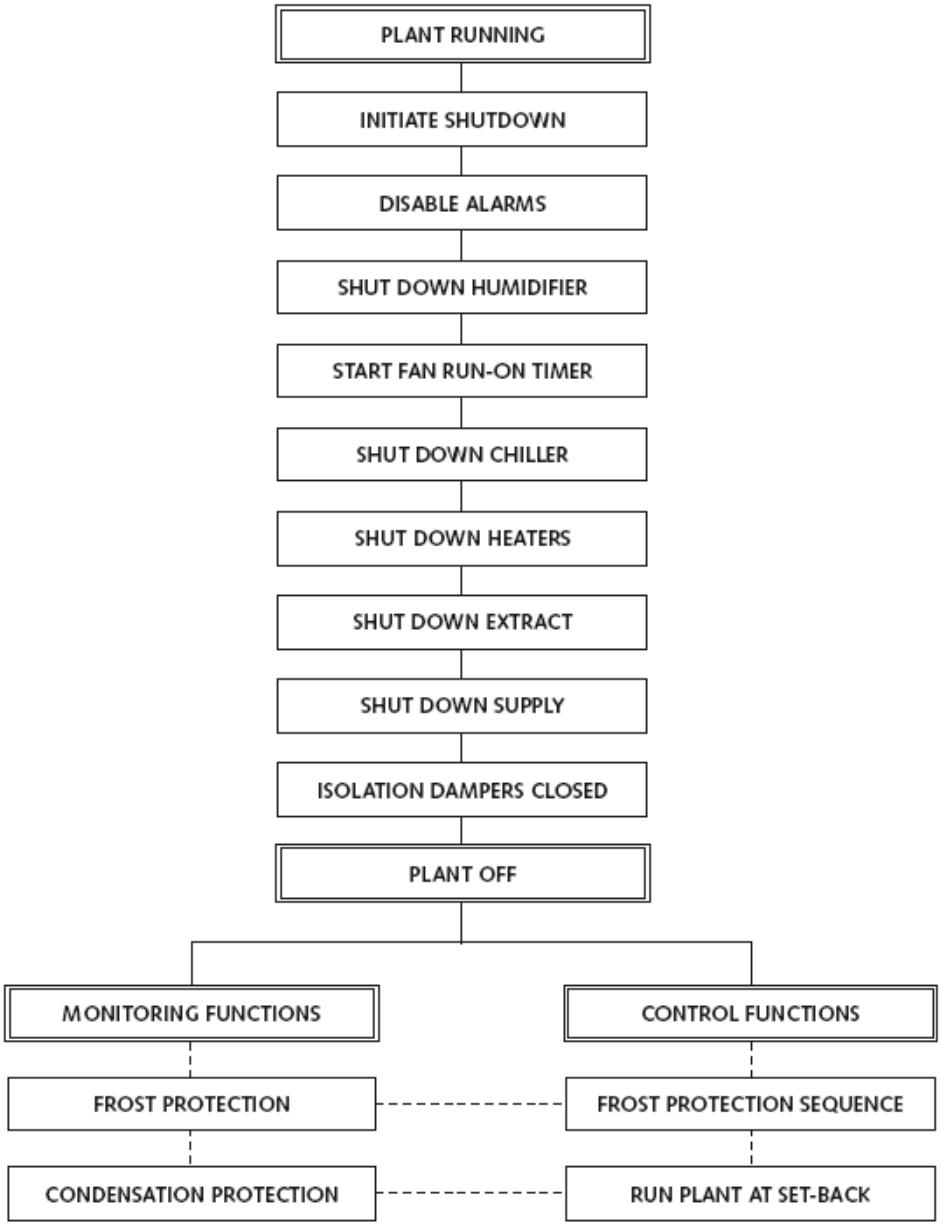


Figure 3: Plant control algorithm – normal shutdown sequence

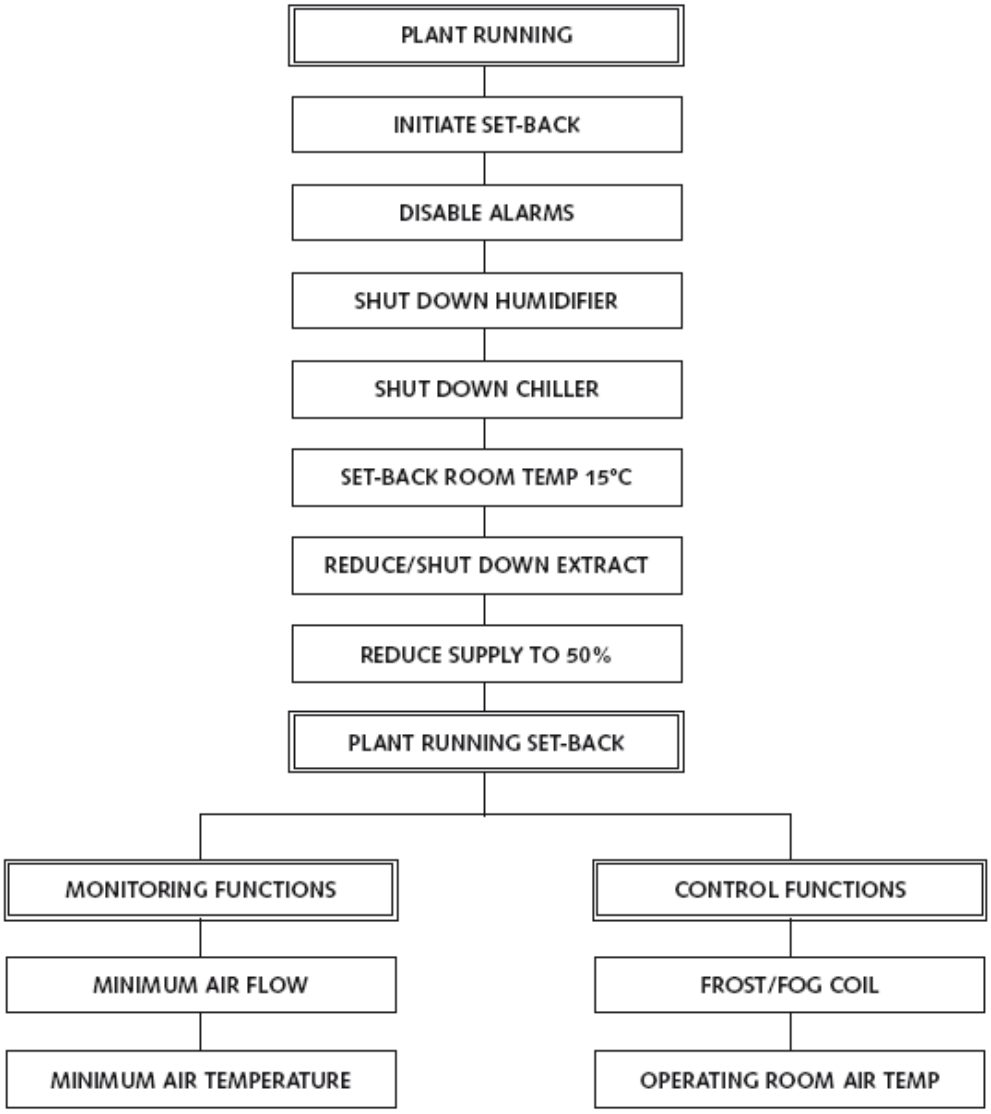


Figure 4: Plant control algorithm – set back sequence

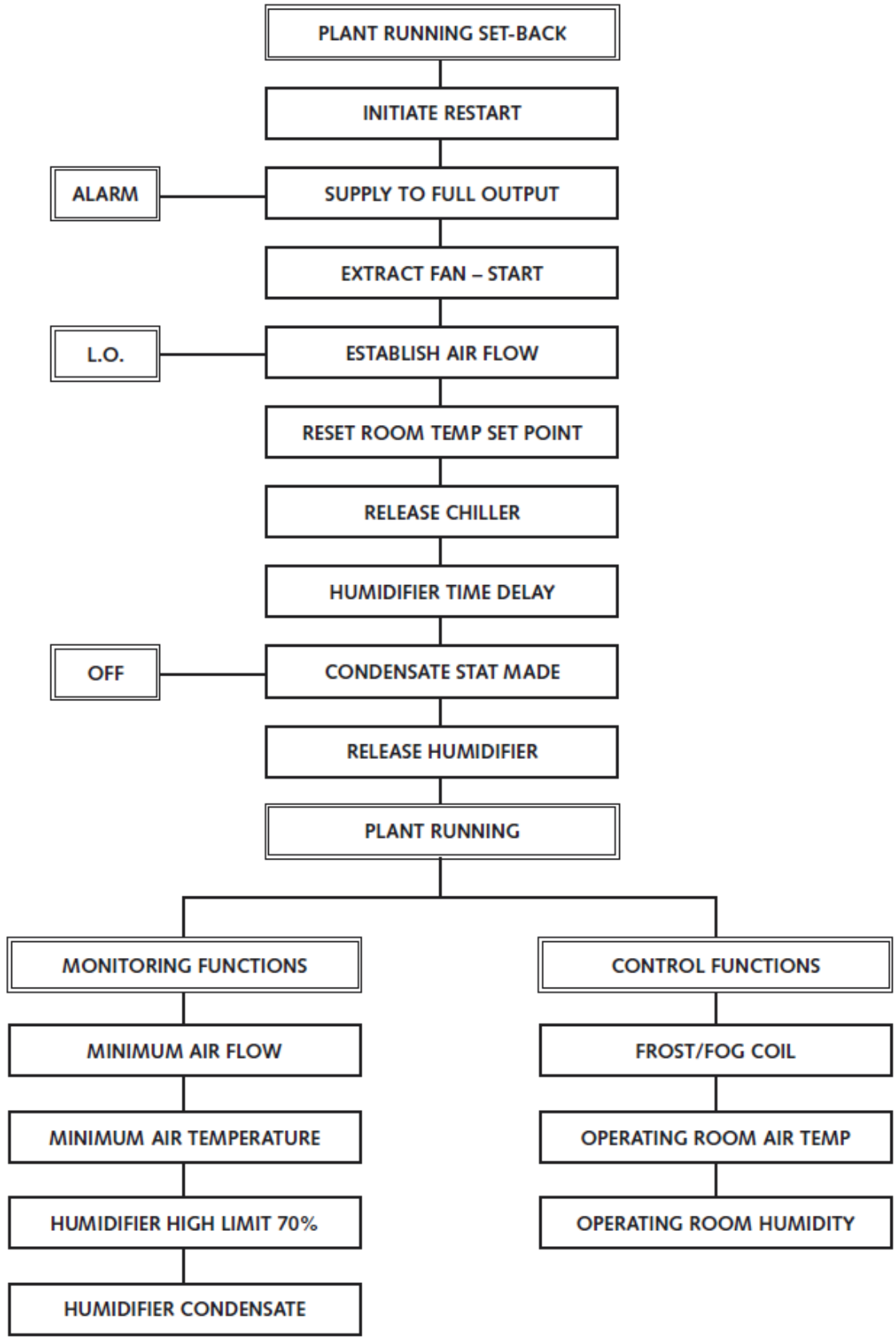


Figure 5: Plant control algorithm – restart from set-back

Set-back control

6.23 Where variable speed controls are installed, the setback facility for each plant should depress the control temperature to around 15°C; exclude any humidification and cooling from the system; and reduce the supply and extract air volumes to around 50%. The extract fan can also be turned off as long as the desired direction of air movement from clean to less clean will be maintained (See also Figures 2 - 5).

Use control

6.24 The installation of movement detectors allows for “use control” of ventilation systems. A simple control logic that reduces the system to a “set-back” condition if there has been no movement detected in the space for, say, 30 minutes and that switches the system “off” if no movement is detected for one hour is recommended for many applications, including operating suites.

6.25 A variation on this can be provided by linking ventilation controls to lighting. For example, in an operating theatre, the system may be off outside of working hours, could run at set-back when the general lighting was switched on and increase to full speed when the operating lamp is switched on. As with movement detection, a 30-minute run-on should be provided at each stage when the lights are turned off.

6.26 Either of the above control strategies may be refined by linking to the BEMS to provide a control logic related to normal working hours and associated ‘real-time’ movement within the zone being controlled. This should result in significant energy savings.

Environmental control

Temperature control methods and application

General

6.27 All control valves must fail safe, that is, close in the event of power or air-flow failure, with the exception of the fog/frost battery control valve, which should open upon power or airflow failure.

6.28 Control valves should be located in an accessible position. Isolation valves should be provided to enable the control valve to be removed for service without the need to drain-down the system.

6.29 Care should be taken to ensure that the installation of control valves and their associated pipework do not obstruct access to the AHU inspection doors and hatches.

Room temperature control

6.30 The limits for room temperature set point are generally between 16°C and 25°C depending on the particular application, and in some specialised instances (for

example, operating departments) are adjustable within a predetermined range by the user.

6.31 The selection of temperature set point for each room or zone may be by a control facility in the room / zone, or remotely at the control panel or BEMS. Where the control device is mounted within the room / zone and adjustable by the user, it should be marked either 'raise' and 'lower' or '+' and '-'. It should control within a specified temperature range to suit the user requirement with a control tolerance of ±1K. All other control set-points should be selectable either on the control panel or at the BEMS interface.

6.32 Where local control is provided, an indication of temperature will be required locally, or at a staff base (if appropriate), using an analogue or digital indicator. The indicator should be large enough to be read from the normal working position (for example, at the operating table in a theatre). This may be mounted in a supervisory or, 'surgeon's' control panel, with the signal repeated on the main system control panel or BEMS. It is important that this indicator displays the actual measured temperature and not the selected temperature.

6.33 Where the supply and extraction systems are designed for ventilation only and there is a wet heating system to provide background heating, care must be taken to avoid one system trying to heat the space while the other system is trying to cool the area.

Frost battery control

6.34 Steam-supplied frost batteries must be operated as on/off devices with their sensor mounted upstream of the battery. This will give 'open loop' control. A set point of +1°C is recommended.

6.35 Low pressure hot water (LPHW)-supplied frost batteries should be controlled using the proportional mode. Their sensor should be located downstream of the battery to give 'closed loop' control. A set point of between 2°C and 5°C is recommended.

6.36 If the temperature downstream of the frost battery, as sensed by a serpentine thermostat, falls below the required set point over any part of the coil, the plant must automatically shut down in order to prevent damage to the other batteries. The serpentine thermostat must not be in direct contact with the coil.

Off-plant control

6.37 The control logic must prevent the chiller and pre-heater being on at the same time.

Humidity control methods and application

6.38 In order to prevent excessive condensation when starting up from a total plant shut-down, a time delay should be incorporated into the control system such that the humidifier does not start until 30 minutes after the ventilation plant starts up.

6.39 Irrespective of the method of control, a high-limit humidistat should be installed to ensure that when the humidifier operates, the condition of the air in the duct does not exceed 70% saturated, particularly during plant start-up.

6.40 With certain types of steam humidifiers, it may be necessary to install a thermostat in the condensate line from the humidifier's steam supply, to ensure that the steam at the control valve is as dry as possible before it is injected into the air supply.

6.41 The humidifier and cooling-coil control must be interlocked so that they cannot be on at the same time.

6.42 The humidifier control system should ensure that it is switched off with the fan. It is preferable to design the control system so that the humidifier is isolated for an adequate time before the fan is turned off so as to purge humid air from the system.

6.43 All control valves must fail safe (that is, close in the event of power failure) and the humidifier must be interlocked with the low airflow switch.

Multi-zone control methods and application.

6.44 Close control of all air-conditioning parameters may be difficult to achieve with multi-zone systems, since each zone will in theory require a re-heater and humidifier to give total control of humidity if that is what is required. In reality such close control is rarely required in practice. It is therefore usual with multi-zone systems to provide control of zonal temperature only, with humidity control where fitted being based on average conditions within all zones, or minimum conditions within one zone.

6.45 Where there is a requirement for close control of air-conditioning parameters in a number of zones (e.g. an operating department) separate plants should be provided for each zone in order to avoid the need for expensive over-cooling and reheating of individual zones.

6.46 Most multi-zone systems within healthcare premises are controlled based on off-coil control within the central plant, with trimmer heater batteries on individual zones.

Alarms and indication

6.47 Supply and extract systems should include indicator lamps on the control panels to confirm the operational status of each system. Where the usage is on a regular daily pattern, time control with a user-operated timed manual over-ride should be provided.

6.48 Where a system is provided for a particular space, the indicator should be in, or immediately adjacent to, that space and local controls should be provided with labels clearly defining their function (eg. isolation suites.)

6.49 The 'plant failure' and 'low air-flow' alarms should be initiated by a paddle switch or other device located in the main air supply duct. This should operate when

the air quantity fails to reach or falls to around 80% of the design value and will give indication of fan failure, damper closed, access door left open, or any other eventuality that could cause a reduction of air quantity. Monitoring the current drawn by the fan motor is not a substitute for a sensing device that is directly affected by the air-flow.

6.50 The 'filter fault alarm' should be initiated by a predetermined increase of pressure differential across the filters, thereby indicating a dirty filter.

6.51 Direct-reading gauges or manometers should be installed across filters to give maintenance staff an indication of their condition.

6.52 Visual indication should be provided at a manned staff location (for example, the reception or staff base) and on the main control panel and BEMS to show 'plant failure' and 'low air flow'.

BEMS

6.53 Control of most systems will be via a Building Energy Management System (BEMS). This will enable the operating conditions and control tolerances to be set and monitored. The BEMS may also be set to log the actual energy consumed by the system and recovered by the energy recovery system. This will provide a useful check on the overall operating efficiency and provide evidence that energy targets are being achieved.

7. Specialised ventilation systems

7.1 This section contains design information for a range of healthcare ventilation applications.

7.2 The following departments will require a degree of specialised ventilation.

- the Operating department;
  - treatment rooms;
  - endoscopy, day case and minimum invasive suites;
  - cardiology and operative imaging suites;
  - conventional operating theatres;
  - Ultra-clean ventilation (UCV) operating theatres;
  - barn theatres;
  - recovery and ancillary areas.
- Obstetrics;
  - maternity theatres;
  - birthing rooms;
  - LDRP Rooms;
  - SCBU.
- critical areas and high-dependency units of any type;
- Isolation facilities;
  - infectious diseases units;
  - bone marrow and other transplant units;
  - chemotherapy and oncology units.
- Sterile Supply and Decontamination Units;
  - wash rooms;
  - inspection and packing rooms;
  - sterile pack stores.
- the Pharmacy departments;
  - aseptic suites;
  - extemporaneous preparation areas;
  - radio pharmacies.
- the Pathology department;
  - laboratories;
  - cat 3 and 4 rooms.

- the Mortuary and Post mortem suite;
  - mortuaries;
  - post-mortem rooms;
  - specimen stores.
- Hydrotherapy units;
- Burns units;
  - burns theatres;
  - treatment rooms;
  - isolation rooms;
  - tissue banks.
- Emerging specialties;
  - gene therapy units;
  - stem-cell laboratories.
- Infrastructure;
  - plant rooms housing combustion equipment;
  - welding facilities;
  - wood working workshops;
  - electric vehicle charging areas.

7.3 Design information for many of these applications is given in Appendix 1 Table A1, Appendix 2 and in the following Chapters within this section.

7.4 It is not possible within this existing document to give definitive guidance for every healthcare specific ventilation application. Additional detailed guidance may be issued in due course in the form of supplements.

General information

7.5 The section on operating theatres is the most extensive and contains much information that is common to other applications. Each theatre suite should have its own dedicated air-handling unit and extract fan. Where no specific guidance is given the principles set out below should be followed:

- the foregoing sections of the document contain general information on healthcare-specific aspects of ventilation system design and specification;
- a set of standard solutions for the design of general operating theatre suites to conform to past and new standards is given in new standard layouts Nos 1, 3, 5 and 7 and those for UCV theatres in new standard layouts Nos 2, 4, 6 and 8 within Appendix 3;
- the CIBSE Guides A & B contain basic information on ventilation design that can be applied to most applications;

- where a British or European standard exists that is specific to the application (for example, a clean room) it should be used as the basis of the design requirement;
- air should always move from clean to less-clean areas. A hierarchy of room cleanliness is given in Table A2;
- differential pressure will prevent contamination between areas when doors are closed. Information on air leakage through closed doors and hatches for a range of differential pressures is given in Table A3;
- the flow of air will prevent contamination between areas when doors are open. Information on air leakage through open doors and hatches for a range of differential pressures is given in Table A4;
- if anaesthetic gases are used, 15 air changes per hour will be required;
- a methodology for calculating a design solution for a non-standard suite of operating rooms is given in Appendix 4. This may be adapted as necessary to suit other less complex applications where air is required to cascade from clean to less clean areas.

7.6 The supply of air to a room has four main functions:

- to dilute airborne contamination;
- to control air movement within such that the transfer of airborne contaminants from less clean to cleaner areas is minimized;
- to control the temperature and if necessary the humidity of the space;
- to assist the removal of and dilute waste gases where used.

7.7 Because of the complexities of controlling air-movement patterns, much design effort will be required for this aspect. It is important that the design makes the best possible use of the air available, as excessive supply airflows for the control of air movement should not be used. The amount of air supplied will be determined by the number of doors and desired air-change rate.

7.8 There are four routes whereby airborne contaminants may appear in a room:-

- through the supply air;
- shed directly by the room occupants;
- arising as a result of the work activities;
- transferred from adjacent spaces.

7.9 Particles entering with the supply air can be controlled by the selection of suitable filter grades.

7.10 Particles shed directly by the room occupants can be controlled by:

- restricting access to essential persons only;
- the choice of the occupants' clothing;

- the room's air-change rate.

7.11 Particles arising as a result of the work activity can be controlled by:

- enclosing, semi-enclosing or otherwise controlling the work-based source;
- the room air-change rate.

7.12 The transfer of particles from adjacent spaces can be controlled by:

- differential pressure;
- air-flow paths.

7.13 Air change rates are given in Table A1. These figures have been found to give sufficient dilution of airborne contaminants, provided the mixing of room air is reasonably uniform.

7.14 A downward-displacement turbulent air distribution is generally preferred. The supply and extract diffusers should be positioned to ensure that all parts of the room are actively ventilated and that where necessary the staff will be in a clean air-flow path. (See Section 5 for additional guidance on supply terminals).

7.15 Horizontal-flow room-air distribution with or without a Coanda effect can be a source of draughts and difficult to set up correctly. Its use should be confined to non-critical areas.

Air movement control

7.16 The design of the system should seek to minimise the movement of contaminated air from less clean to cleaner areas. Transfer grilles enable air to pass in either direction between rooms of equal class and pressure. Pressure stabilisers operate in one direction only; they allow excess air to be directed to the area desired and assist in maintaining room pressure differentials. When closed they prevent significant reverse air-flow.

7.17 The relative locations of supply and extract terminals and their design air-volume rates will determine the basic airflow between adjacent spaces. Transfer grilles and pressure stabilisers will permit and control the flow of air between spaces ensuring a flow from the clean to less clean areas. Failure to provide such devices will lead to uncontrolled air flows when personnel move between rooms. They may also result in doors being held partially open by air pressure

Temperature and humidity control

7.18 To achieve the required room conditions, supply flow rates are calculated conventionally, taking account of all heat and moisture gains and losses, and of maximum permissible temperature differences between the room and supply air. In most applications the base heating load will be provided by a heating system. In critical systems the room or suite being considered will be within the heated building envelope so the ventilation will be sized to suit the casual gains or losses.

7.19 Temperature differences of up to 10K for winter heating and 7K for summer cooling must not be exceeded.

7.20 It is acceptable for the humidity to swing uncontrolled between 35% and 70% saturation.

Removal and dilution of waste anaesthetic gases

7.21 Anaesthetic gases are subject to occupational exposure limits. Waste anaesthetic gas must be contained and removed by a suitable gas-scavenging system. Some leakage from the anaesthetic equipment and the patient's breathing circuit will occur with all systems, particularly during connection and disconnection; and from the interface with the patient. The air movement scheme should ensure that this leakage is diluted and removed from the room. Anaesthetic agents are heavier than air so placing the supply terminal at high level with an extract at low level, adjacent to the anaesthetic gas terminal units will ensure that staff are in a clean air-flow path.

7.22 In LDRP and delivery rooms the use of anaesthetic gas is controlled on demand by the patient. This may result in significant leakage which, in order to reduce staff exposure, will need to be controlled by establishing a clean airflow path. A supply at high level at the foot-end of the bed with extract at low level at the head-end will provide such a path.

Fire aspects

7.23 When considering the overall airflow movement, careful thought needs to be given to the operation of the ventilation system, to limit smoke spread in the event of a fire.

Door protection

7.24 Air should flow from the cleaner to the less clean areas as shown in Table A2. There are several factors that affect the likelihood of a reverse air- flow through doorways:

- when a person passes through a doorway, both the passage of the person and the movement of the door flap cause a transfer of air between the areas separated by the door;
- when a door is left open there is a transfer of air between the two areas separated by the doorway. This is caused by air turbulence, but is greatly increased by any temperature differential between the areas (a 1.4m wide doorway may allow the transfer of 0.19 m^3/s of air in each direction when there is no temperature difference, but when the temperature differential increases to say 2K, the volume transferred may increase to 0.24 m^3/s).

7.25 Two methods of door protection are used in order to reduce the likelihood of contamination of clean area by a reverse air-flow from a less clean area:

- closed door protection – a pressure differential is created across a closed door so that any air leakage is from the clean to the less clean area.

Table A3 gives details of closed door leakage rates for a range of differential pressures;

- open door protection – the pressure differential drops (See Table A5) and is effectively replaced by a flow of air through the doorway from the clean to the less clean area. The flow of air needs to be sufficiently large to ensure that significant reverse airflow cannot occur and will be related to the relative cleanliness of the areas being considered. Table A4 gives air-flow rates for open door protection related to door / opening size and classification of the adjoining areas.

7.26 Pressure stabilisers enable the room differential pressure to be set when the doors are shut, thus providing closed-door protection. When a door is opened the stabilisers will close, forcing air to be directed through the doorway thus providing open-door protection.

7.27 The recommended air-flow rates to achieve this are given in Table A3. Provided that the dilution criteria in Table A1 are met, the occasional small back-flows created (when two doors are opened simultaneously; or when there is a high temperature difference across an open door) will have little effect on the overall air cleanliness of the affected room.

7.28 In applications where it is critical to maintain a specific airflow and /or pressure regime (for example isolation rooms) all windows in the zone should be locked shut or sealed. Trickle vents, if fitted, will also need to be sealed.

Systems design

7.29 The design of the ventilation system for an area depends on the overall configuration of the department. Where the department is served by more than one AHU, the control of the units may need to be interlocked so that reverse air-flow patterns do not occur.

7.30 Dual-duct high velocity systems have advantages, but are noisy, costly and may give rise to unacceptable values of humidity. Single-duct, low velocity/pressure systems are preferred.

7.31 Extract grilles should be sited and balanced to promote air movement in the desired direction.

7.0 (a) Operating department ventilation systems

7.32 The information given in this section relates to general operating suites. It will be applicable to other types of theatre suite such as maternity, burns, cardiac, etc. The standard values given may need to be adjusted to reflect non-standard room sizes, pressure regimes and air change rates.

7.33 A method of obtaining a design solution for non-standard theatres is given in Appendix 4.

7.34 Additional information for Ultra-clean ventilation (UCV) theatres is given in Section 7.0 (b).

General

7.35 The supply of air to an operating room has four main functions:

- to dilute airborne contamination;
- to control air movement within the suite such that the transfer of airborne contaminants from less clean to cleaner areas is minimized;
- to control the temperature and if necessary the humidity of the space;
- to assist the removal of, and dilute, waste anaesthetic gases.

7.36 Because of the complexities of controlling air-movement patterns, much design effort will be required for this aspect. It is important that the design makes the best possible use of the air available, as excessive supply airflows for the control of air movement should not be used. The amount of air supplied to the operating room will be determined by the number of doors and desired air-change rate.

7.37 The detailed considerations upon which the supply air-flow rate is based are as follows.

Dilution of airborne bacterial contaminants

7.38 There are four routes that airborne contaminants may appear in an operating room:

- through the supply air;
- shed by operating staff;
- produced by the surgical activities;
- transferred from adjacent spaces.

7.39 Supply flow rates for the main rooms of the operating suite are given in Appendix 3. For the other areas where room sizes and activities vary from site to site, air-change rates are given in Table A1. These figures have been found to give sufficient dilution of airborne bacterial contaminants, provided the mixing of room air is reasonably uniform.

7.40 A downward-displacement air distribution is preferred; it may be either turbulent or laminar flow. For turbulent flow the supply-air diffusers should be positioned either in the centre of each quadrant of the ceiling or along a line between the centres of each quadrant. This should ensure that all parts of the room are actively ventilated and that there will be adequate air movement at the operating table. Laminar flow would be provided by a perforated plenum terminal centred above the operating table. (See Section 5 for additional guidance on supply terminals).

7.41 Suspended articulated equipment is usually fitted in theatres. These require significant structural steelwork in the ceiling void to cater for the loads imposed by the resulting bending moments. It is important to ensure that the void is

deep enough to accommodate both the steelwork and the ventilation ducts. The location of the steelwork must not prevent a suitable layout of the ventilation ductwork and correct positioning of the supply air terminals. It needs to be recognised that the correct ventilation of an operating theatre plays a significant part in controlling healthcare acquired infections and is not subordinate to the desire to make equipment easy to move.

7.42 Horizontal flow distribution with or without a Coanda effect can be difficult to set up correctly and are unlikely to be as effective in Theatre applications. It should not be used in new installations. However space constraints may force its retention or replacement when refurbishing existing installations. Where fitted, the supply grilles will require a means of directional adjustment.

7.43 For general operating theatres, the air supply would be filtered in the AHU. Terminal HEPA filters are not generally required.

Control of air movement within the suite

7.44 The design of the system should seek to minimise the movement of contaminated air from less clean to cleaner areas. Transfer grilles enable air to pass in either direction between rooms of equal class and pressure. In older designs suitably dimensioned door undercuts were often used in lieu of transfer grilles. Pressure stabilisers operate in one direction only; they allow excess air to be directed to the area desired and assist in maintaining room-pressure differentials.

7.45 The relative locations of supply and extract terminals and their design air-volume rates will determine the basic air-flow between adjacent spaces. Transfer grilles and pressure stabilisers will permit and control the flow of air between spaces ensuring a flow from the clean to less-clean areas of the suite. Failure to provide such devices will lead to uncontrolled airflows when personnel move between rooms and doors being held partially open by air pressure.

Temperature and humidity control

7.46 Supply flow rates to achieve the required room conditions, are calculated conventionally, taking account of all heat and moisture gains and losses, and of maximum permissible temperature differences between the room and supply air. In most applications the room being considered will be within the heated building envelope.

7.47 Temperature differences of up to 10K for winter heating and 7K for summer cooling must not be exceeded.

7.48 It is acceptable for the humidity to swing uncontrolled between 35% and 60% saturation.

Removal and dilution of waste anaesthetic gases

7.49 Anaesthetic gases are subject to occupational exposure limits. The air-movement scheme should ensure that staff are in a clean air-flow path. (See Paragraph 7.21).

7.50 Air extracted from operating suites should not be re-circulated, as it may contain malodorous contaminants. However an energy recovery system should be fitted in the extract in order to reduce the plant energy consumption. (See Paragraphs 4.142 - 4.147).

Fire aspects

7.51 When considering the overall air-flow movement, careful thought needs to be given to the operation of the ventilation system, to limit smoke spread in the event of a fire. However, this is a highly staffed department with a low fire risk/load status and these factors need to be recognised when developing the fire strategy. It is considered satisfactory to treat the complete operating department as a single fire compartment providing there are at least two exits from it. Over-compartmentalisation can lead to difficulties in establishing clean air-flow paths and room-air dilution rates. This will lead to an increased risk of healthcare-associated infections. Staff areas within the department should be treated as a sub-compartment. (See Paragraph 6.18).

Door protection

7.52 Air should flow from the cleaner to the less clean areas as shown in Table A2. The factors that affect the likelihood of a reverse airflow through doorways are discussed in Paragraphs 7.24 - 7.26.

7.53 It is not possible to design an air-movement scheme, within the restraints of the amount of air available that will protect the operating room when two doors are simultaneously opened. The design process that has been used considers that each door is opened in turn and ensures that the direction and rate of air-flow through any open doorway is sufficient to prevent any serious back-flow of air to a cleaner area.

7.54 Provided that the air-change rates in Table A1 are met, dilution will be sufficient to ensure that the occasional small back-flows created (when two doors are opened simultaneously; or when there is a high temperature difference across an open door) will have little effect on the overall air cleanliness of the affected room.

7.55 The following general points should be taken into consideration during the design of operating suites:

- Number of exits – the fewer the number of rooms (and therefore doorways) leading from the operating room the better, as traffic is reduced and less complicated air-movement control schemes are required.
- Scrub and hand-wash facilities – these may be a part of the operating room, often in a bay. The bay would count as part of the operating room volume

and should have a low-level active or passive extract to remove the moisture-laden air. Should a separate room be required for the scrub area, a door between the scrub-up room and the operating room is an inconvenience to scrubbed staff, and could be replaced by an opening. This opening should be larger than a normal single doorway, but the scrub would not, in these circumstances, be considered part of the operating room volume.

- If an alcohol scrub regime is employed, individual theatre scrubs may not be required and would be replaced by a common departmental pre-/post-operation scrub position in the corridor. This would require local extract to prevent a build-up of moisture.
- Preparation 'Sterile Pack Store' (SPS) – if it is intended to 'lay-up' instruments in the operating room, the preparation room is then used simply as a sterile pack store. The nominal room pressure can therefore be the same as that of the operating room and the airflow between the two rooms in either direction. Air supplied to the preparation room may be directed into the operating room either through a door mounted transfer grille or if no door is fitted, through the opening. Alternatively, stock ready-use sterile items can be located in a bay within the theatre. In this case, a portion of the total theatre supply air should be provided in the bay to ensure it is actively ventilated.
- Preparation room 'lay-up' – when the preparation room is used as an instrument 'lay-up' room, it should be regarded as being of greater cleanliness than the operating room, and the design should minimise the transfer of air from the operating room to the preparation room. Air supplied to the room may be directed to the operating room through a pressure stabiliser taking care not to compromise the airflow pattern in the operating room. The air may also be directed into a corridor;
- Service corridor – if materials to be disposed of are placed in impervious material for transportation, it is not necessary to have a separate corridor for this purpose. However, a service corridor has many operational advantages it terms of the flow of materials through the theatre suite. It also permits routine service and maintenance access without compromising the use of adjacent theatre suites.

Standard air-movement control schemes

7.56 In the previous versions of this guidance standard air movement control schemes were given that provided a range of design solutions to typical operating suite layouts. These were satisfactory design solutions for 'standard' sized rooms within the suite but were never intended to be universal for any sized room or suite. Guidance on operating suites contained in HBN 26 (2004) has increased the recommended size of operating room from approximately 35m^2 to 55m^2. Associated room sizes and air change rates have also increased. This means that the original standard solutions are no longer appropriate for new-build installations.

7.57 Because of the resulting increase in the volume of air supplied to the theatre, provision needs to be made either to actively remove it or allow it to escape

passively through pressure stabilisers. The increase in room size has also made the number and position of air-supply terminals critical to the effective ventilation of the room.

7.58 Four new standard solutions have been developed to reflect the current guidance on theatre suite layout and room sizes given in HBN 26 (2004) as well as the general increase in air-change rates.

7.59 The most commonly used original standard solutions have been revised and updated. They have been retained in this guidance, as they will remain applicable to older theatre suites that are being refurbished to their original performance standards. They will also be applicable in existing departments where space constrains do not permit the upgrading of suites to the latest standard of performance or where a pre-built "shell" is being fitted out.

7.60 It is important to recognise that in any situation where a "non-standard" room size or theatre suite layout is being considered, the designer must return to first principles when developing a solution. Examples of non-standard configurations would be:

- cardiac theatres that typically have an operating room half as big again as normal, a perfusion laboratory and no anaesthetic room;
- operating departments served by a central instrument lay-up preparation area rather than individual prep rooms;
- balanced-flow theatres for infectious cases.

Appendix 4 contains a methodology for assisting the designer to arrive at a suitable solution.

7.61 The new and revised standard design solutions are as follows:

No 1 – Typical Conventional theatre – room sizes as HBN 26;

No 2 – Typical UCV theatre – room sizes as HBN 26;

No 3 – HBN 26 illustrated Conventional theatre;

No 4 – HBN 26 illustrated theatre with UCV terminal fitted;

No 5 – Pre-2006 Conventional theatre, single corridor (former SHTM 2025; 1b);

No 6 – Pre-2006 UCV theatre, single corridor (former SHTM 2025; 1a);

No 7 – Pre-2006 Conventional theatre, two corridor (former SHTM 2025; 5b);

No 8 – Pre-2006 UCV theatre, two corridor (former SHTM 2025; 5a).

7.62 Details of these standard solutions are given in Appendix 3. They contain diagrams that show the relationship of rooms and the various doors and transfer devices between them, **but should not be regarded as architectural layouts.**

The schemes have been developed using the calculation procedure described in Appendix 4. Important features of the solutions are:

- Zone trimmer heaters – a trimmer heater battery is advocated when calculations indicate that the temperature differential between rooms may be greater than 2K. Generally this will only be the case in the preparation room when designated as a lay-up.
- The preparation room (sterile pack store)/operating room interface – these rooms are deemed to be of equal cleanliness, and thus a transfer grille is required between these rooms or the door can be replaced with an opening wider than a standard door.
- Preparation (lay-up)/disposal room interface – pressure relief dampers are recommended here to provide an air path when doors are closed, while preventing back-flow when a door is opened elsewhere.
- Operating room/anaesthetic room interface – pressure stabilisers, or in some cases, carefully sized transfer grilles are recommended here, and between the anaesthetic room and corridor, and between the operating room and corridor.
- Operating room/scrub room interface – an opening is provided between these rooms. The flow of air through the opening provides protection, and gives bacterial dilution within the scrub room; the air is then exhausted to the corridor via a pressure stabiliser.

7.63 No mechanical supply or extract ventilation is provided in the scrub room, and thus when a door is opened elsewhere in the suite, the stabiliser will close, allowing the air to be re-directed to help protect the doorway. If the scrub is a bay within the theatre then a suitably positioned pressure stabiliser and / or active extract should be provided to ensure air movement and prevent a local build-up of moisture.

7.64 Any other scheme may be used and the standard solutions applied, if the following conditions are met:

- room relationships in air network terms are as shown in the plans;
- door-gap measurements approximate to those given in Scottish Health Technical Memorandum 58: ‘Internal doorsets’, (but see also Table A3 and Note 3);
- casual heat gains are accounted for;
- a trimmer battery is installed in the air supply system to the preparation room;
- leakage through the structure is kept to a minimum.

Note 3: It should be noted that many doors are now fitted with cold smoke seals as standard. These will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design door leakage is factored into the sizing of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air gap whistles and doors being held partially open by air pressure.

7.65 It is recommended that every effort should be made to adopt one of the schemes described above.

Air terminals and air distribution within rooms

7.66 The selection and sighting of air diffusers will be critical in establishing an efficient pattern of mixing. To this end the diffusers selected must be fit for purpose. Ceiling mounted circular 'air master' style, square 'four-way blow' or similar diffuser designs that provide a downward displacement, turbulent airflow are the preferred option. (See Paragraph 5.68).

7.67 Plenum-type 'laminar'-flow-style diffusers with a footprint that encompasses the operating site are acceptable but may be prone to buoyancy effects as a result of temperature difference. Manufacturers' type-test data should be consulted to ensure that the terminal will achieve the required performance envelope. Note that these are not true laminar-flow systems in the strict sense of the word but produce a downward-displacement parallel-flow style of air distribution.

7.68 The diffuser equipment chosen should not cause 'dumping' and it should provide a velocity 1 metre above floor level at the operating position of between 0.2 m/s and 0.3 m/s.

7.69 In the operating room, the supply air terminals must be at high level, and should all be adjustable for rate of flow as well as being easily cleaned and silent in operation.

7.70 In order to ensure that all parts of the operating room are actively ventilated, there should be an air-out path on each face or in each corner of the theatre. This may be provided by a pressure stabiliser, transfer grille, active or passive extract terminal. A minimum of three, but preferably four, air-out paths - approximately equally spaced - should be provided.

Automatic control

7.71 The automatic control of ventilation in operating suites needs to be simple and robust. Over-reliance on complex room pressure and flow relationships linked to automatic fan speed control is unnecessary and in the long term have been shown to be unreliable. Complex software algorithms that can only be accessed and interpreted by off-site specialists should not be used. Whichever control strategy is chosen it is important that on-site staff have the facility to override the control system and keep the ventilation operating at least until the surgical procedure is complete. (See also Paragraph 6.11)

7.72 Theatre air-conditioning control sensors should be actively ventilated. They would typically be located in a sampling extract duct mounted in the surgeon's

panel, positioned at normal working height (1.8m above finished floor level) and be accessible for cleaning and the removal of fluff and lint.

7.73 Wall-mounted passive-temperature and humidity sensors are not recommended.

7.74 Controls should be provided to enable operating department ventilation plants to be closed down when the operating suites are unoccupied. (See also Paragraphs 6.24 - 6.26)

7.75 When in the 'off' mode, the control system should ensure that the ventilation plant is automatically reinstated if the space temperature falls below 15°C.

7.76 The theatre control panel should include plant status indication; clearly-readable temperature and humidity indicating gauges; and means of adjusting the set point for temperature. Theatre ventilation plant status indication should be located at the staff control base.

7.77 Where it is considered necessary to fit a humidifier, it should be selected to humidify to 40% saturation at 20°C during the design winter outside conditions. The cooling coil should be able to remove sufficient moisture so that 60% saturation at 20°C is not exceeded during the design summer outside conditions.

7.78 Each operating suite should be served by an independent supply and extract plant.

Ventilation of operating department ancillary areas

General

7.79 There are advantages in providing mechanical ventilation to all areas of the department. Maintaining operating suite airflow patterns is simpler and grilles and diffusers can be sited to eliminate condensation on windows. Where radiators or embedded wall or ceiling panels are installed they should be confined to the corridors and staff-only areas of the department.

Ventilation requirements

7.80 Table A2 gives guidance on the operating department areas in descending order of cleanliness, and this should be considered in the overall design of the department ventilation systems. The specified flow rates of air through doors given in Table A4 for the operating suite are not necessary for other areas of the department. However, the air-flow directions must be maintained from the clean to the less clean areas.

7.81 All windows in the department should be double-glazed and hermetically-sealed in order to ensure that the desired airflow pattern is maintained under all external environmental conditions and to avoid infestation. Trickle vents if fitted will need to be sealed.

Systems design

7.82 The design of the ventilation system for the ancillary rooms depends on the overall configuration of the department. The plant for the ancillary rooms may need to be interlocked to the theatre suite plants so that reverse air-flow patterns do not occur.

7.83 Extract grilles should be sited and balanced to promote air movement along the clean and access corridors towards the reception/transfer areas. This should not affect the air distribution in the operating suite(s).

Reception

7.84 The aim in these areas is to provide comfortable conditions having regard to the movement control requirements of the department as a whole. The number of air changes will depend on the particular design.

Sterile pack bulk store

7.85 The store needs to be maintained at a positive pressure in order to preserve the cleanliness of the outside of the packs; 6 air changes are recommended.

Recovery

7.86 The air-change rate in the recovery room will be rather higher than that needed merely to provide clean, comfortable conditions, as it is necessary to control the level of anaesthetic gas pollution; 15 air changes are recommended, with a balanced air flow.

7.87 The supply air terminals should be ceiling mounted above the foot-end of the recovery bed positions. Extract should be at low (bed height or below) level behind the bed head positions or in the corners. This will establish a clean airflow path so that staff do not inhale anaesthetic gases exhaled by recovering patients.

7.0 (b) Ultra-clean ventilation systems

General requirements

7.88 The design philosophy of a conventionally ventilated operating suite is based on the need to dilute contaminants and control both the condition and movement of air in an operating suite. Ultra-clean ventilation (UCV) is a means of significantly increasing the dilution effect by providing a large volume of clean filtered air to the zone in which an operation is performed and sterile items are exposed. Air is discharged above the operating zone and while not truly laminar, its downward displacement purges the clean zone of contaminants and particles generated by the activities within it. The airflow in and around the clean zone also serves to prevent particles originating outside the zone from entering it. The resulting reduction in contaminants has been shown to reduce significantly post-operative sepsis following certain orthopaedic procedures.

7.89 The number of bacteria that are present in the air at the wound site and exposed surgical items is dependent on the operating team, their procedural discipline, choice of clothing and the type of UCV system. Ultra-Clean air is defined as that containing not more than 10 CFU/m^3.

7.90 UCV systems are very successful in reducing contaminants at the wound site so it is often considered that there is no need for complex air movement control schemes in the rest of the suite. However, when designing the ventilation scheme, it should be noted that the users may switch the UCV terminal to "set-back" when non-orthopaedic surgery is taking place. This is because the high airflow rates can cause increased moisture evaporation of exposed tissue that may be detrimental to the surgical outcome. In recognition of this, the ventilation scheme should be capable of providing operating conditions to at least a "conventional" theatre standard throughout the suite with the UCV in set-back mode. It should also be remembered that suitable levels of ventilation will always be required in the peripheral rooms.

7.91 UCV systems can be designed and built from first principles or a range of bespoke modular units of varying shapes and sizes are available with each manufacturer having a slightly different approach to UCV design. Some systems are fitted with partial or full walls to delineate the clean zone and direct a laminar or exponential downflow of air within it. Other designs utilise slotted linear supply terminals to produce an air curtain around the clean zone together with laminar-flow diffusers to provide a downward-displacement supply within it. **Notwithstanding any variation in the design philosophy, all UCV systems will be required to achieve completely the performance standard set out in the "Validation" section of this document**. (Section 8)

7.92 As with conventional theatres, each UCV operating suite should have its own dedicated air handling unit (AHU) to the standard set out in Section 4 of this document. To ensure operational flexibility and permit routine maintenance, air handling units should not be shared between suites.

7.93 In retrofit installations, site conditions may preclude individual AHUs for each suite. In these circumstances an AHU may be shared between not more than two operating suites providing each suite has its own control of temperature. An accessible airflow measurement test point should be provided in the supply branch duct to each theatre so that the primary air volume to each UCV canopy can be determined. In addition the branch supply and extract should be capable of being physically isolated and the main air-flow rate reduced so that either suite can be taken out of use without detriment to operating conditions in the other.

7.94 An inherent feature of a UCV system is its large airflow so it is essential to re-circulate the air supplied to the operating theatre and/or to recover its energy in order to optimise operating costs.

7.95 The primary fresh-air volume supplied to a UCV suite will be the same as in a conventional suite and it should be dispersed to the rooms in the suite in the same manner. This is an important aspect of the design and requests by UCV suppliers for increased primary air-supply volumes should be resisted.

7.96 Laying-up in the clean zone is preferable for infection control reasons. Where a Sterile Pack Store (SPS) Preparation room is provided a transfer grille will be required in the preparation room / theatre door.

7.97 If the Preparation room is intended to be used for laying-up instruments, a pressure stabiliser will be required between the prep room and theatre. It should be fitted with a stand-off baffle to prevent air transfer interfering with the ultra-clean airflow distribution.

7.98 Separate scrub-up or disposal facilities are not necessary for air cleanliness although operational policy may prefer such a provision. A separate anaesthetic room should, however, be provided.

7.99 There is no aerobiological reason why two or more UCV systems should not be installed in a common area as long as adequate spacing is provided. These are known as “barn theatres” and require special design considerations and operational discipline. The relative positions of the UCV units, temperature control range and location of doors and openings to other areas will all significantly affect the airflow at the operating positions.

Types of UCV system

Remote plant systems

7.100 In a remote plant system, all the air-conditioning equipment is located outside of the operating room, except for the unidirectional air-flow terminal, terminal filter, air diffuser and the return-air grilles (see Figure 6).

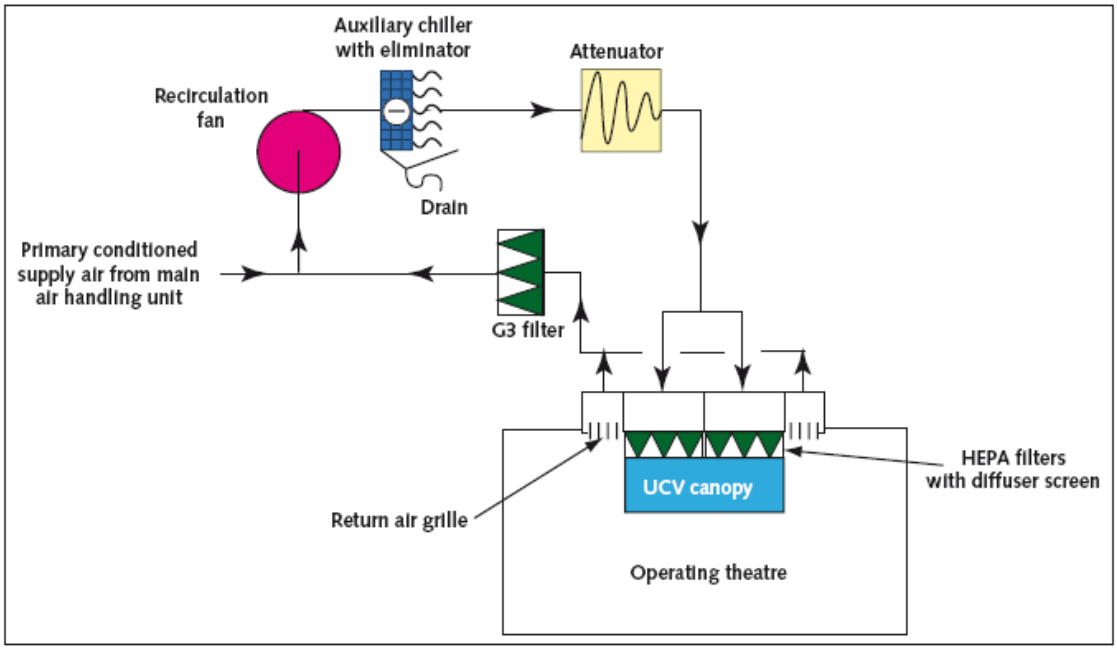


Figure 6: UCV theatre with remote air recirculation

7.101 This arrangement is the preferred option for new installations as it has the following advantages:

- the recirculation fans are out of the theatre thus reducing noise. Multiple recirculation fans can be replaced by a single fan unit with its drive out of the air stream;
- casual heat gains from recirculation fan(s), canopy lights, equipment and people within the theatre can be removed by a chiller battery in the return air stream. This will prevent heat build-up in the theatre;
- the return-air filters can be changed without needing access to the theatre making routine maintenance more feasible;
- the opportunity exists to locate the HEPA filter in the primary supply duct rather than the theatre terminal. This will reduce the number of filters required and allow them to be changed without entering the theatre.

Modular systems

7.102 Modular systems are frequently used in retrofit applications. Vertical or horizontal units are available.

7.103 Vertical-flow modular units comprise a ceiling-mounted air-terminal module containing return-air filters, return-air fans, final filter and air diffuser. Primary air is supplied by a remote air-conditioning unit at the volume and to the standard required for a conventional operating suite. (see Figure 7)

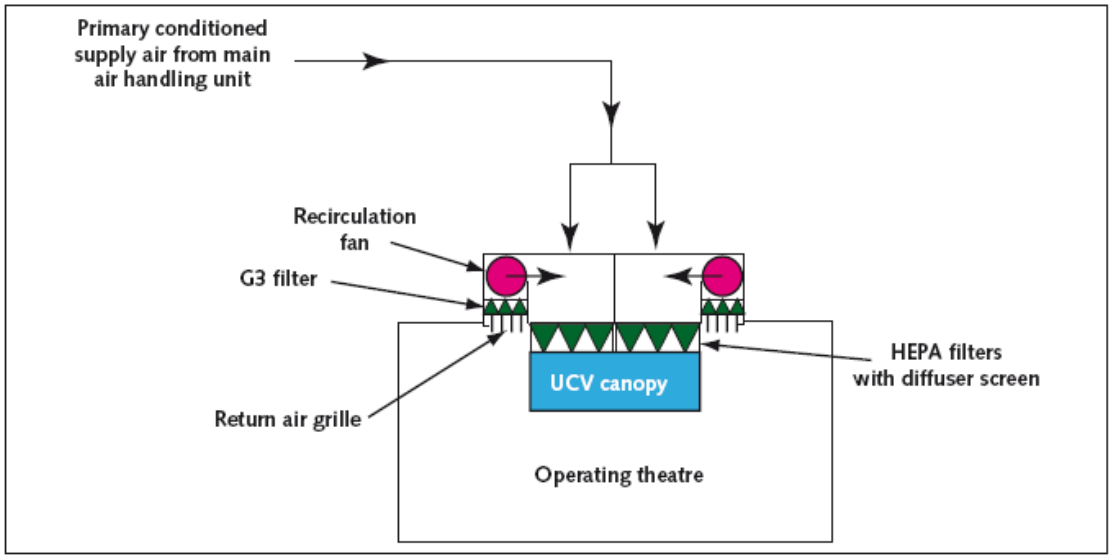


Figure 7: UCV theatre with modular system

7.104 Horizontal or cross-flow modular units comprise a wall-mounted air-terminal module standing vertically to produce a horizontal flow of air and containing final filter/diffuser, return-air filters and fans. The module may incorporate a cooling unit or be supplied with 'fresh air' from a separate primary cooling system.

Vertical flow UCV systems

7.105 Vertical-flow systems have a superior performance and are more effective at reducing infection risks. Air-curtain or partial-wall systems are acceptable, but are known to be more susceptible to problems arising from performance

deterioration, poor operating-team discipline and high occupancy rates than is the case with full-wall systems. A full-wall is considered to be any wall terminating not more than one metre above the finished floor level.

7.106 Because of the large volume of air being moved in a relatively small space, the siting of the return-air grilles can cause short-circuiting of the air discharged through the UCV terminal. If the return-air grilles are positioned at high level, partial walls should be provided to control short-circuiting. The partial-walls shall be not less than 1m from the operating room walls and terminate at least 2m above floor level. The clearance should be increased proportionally for larger terminals (that is, 1.15m for 3.2m x 3.2m units and 1.25m for 3.5m x 3.5m units). In all cases, the sidewalls should terminate at 2m above floor level.

7.107 Siting the return-air grilles around the periphery of the theatre at low level will eliminate short-circuiting, remove the need for partial walls and give an improved airflow path. In any event there should be an air-out path on each face or in each corner of the theatre. These may be provided by combination of pressure stabilisers and passive or active low level extract grilles. Failure to provide air-out paths on all faces of the theatre may result in the surplus air causing entrainment into the clean zone.

7.108 Vertical systems should have a clean zone large enough to encompass the operating site and all of the instrument trays likely to be needed for the surgical procedures to be undertaken. Ophthalmic and minor hand surgery would typically require a 1·4m circular or rectangular terminal. For major orthopaedic procedures a minimum size of 2·8m x 2·8m will be required. This is the area projected on the floor under the supply air terminal within the partial walls, full walls or air curtain. Any air outside this zone cannot be guaranteed to be ultra-clean although given the dilution factor the level of microbiological contamination will be much lower than the general level in a conventional operating room. The use of lines or a coloured area on the floor delineating the extent of the clean zone will assist staff and is therefore essential.

7.109 When upgrading an existing conventional theatre to an ultra-clean standard the only solution may be the installation of a modular system. In these units, the heat gains from the return-air fans and terminal lights may warrant the inclusion of supplementary cooling within the module although modern luminaries contribute substantially less unwanted heat. However issues of cooling coil drainage, condensate removal and maintenance access within the space constraints of the module may make this option impracticable. The additional cooling load should then be catered for by conditioning the primary air to compensate.

7.110 If an existing AHU is to be retained, it may require modification to ensure that it achieves the minimum standards set out in Section 4 of this document. The fan may need re-rating to accommodate the change in system resistance. The cooling coil may also need to be upgraded to cater for the increased load resulting from the return air fans and terminal lights. Failure to make adequate provision for this may make the theatre unusable during prolonged warm spells.

7.111 A factor affecting the air-flow pattern is the supply or room air temperature difference. When the supply-air temperature is significantly above room temperature, buoyancy effects will reduce the volume of air reaching the operating zone. If it is anticipated at design stage that this will be a regular occurrence, then a system incorporating full-walls should be used. Demountable extensions that convert a partial-wall to a full-wall unit are available.

7.112 Convection up-currents from the surgical team and operating lamp tend to counter the movement of clean air towards the operating site, hence the air velocity reaching the operating level is critical. The minimum velocity given below has been selected to take account of these factors and is greater than the theoretical minimum value.

7.113 For all vertical UCV systems the design discharge velocities will be as follows:

Air velocity 2 metres above floor level:

- partial-wall system = 0.38 m/s average;
- full-wall system = 0.30 m/s average.

Air velocity 1 metre above floor level:

- all systems = 0·2 m/s minimum within the operating zone.

The validation Paragraphs 8.75 – 8.86, gives details of the method of measurement.

7.114 Variable-speed recirculation fans with differential pressure control may be the most suitable solution for maintaining consistent performance and energy saving.

Horizontal UCV systems

7.115 Horizontal UCV air-flow systems have been shown to be less effective than vertical systems and are not the preferred solution. There may be occasions, however, where architectural, engineering, economic or workload considerations prevent the installation of a vertical-flow system and only a horizontal-flow system can be installed.

7.116 Horizontal- or cross-flow modular units comprise a wall-mounted air terminal standing vertically to produce a horizontal flow of air across the operating field. The terminal module contains the final filters, air diffuser, return-air grilles, filters and fans. The module may incorporate a full air-conditioning unit or be supplied with 'fresh-air' from a separate primary air-conditioning system. In the latter case the return-air fan power may warrant the inclusion of a supplementary cooling coil within the module.

7.117 The system should have sidewall panels at least 2·4m apart. The panels may fold to facilitate cleaning of the theatre. The minimum height of the terminal should be 2·1m and a deflector at the top of the filter/diffuser will be acceptable

as an alternative to a full roof. These dimensions reflect currently available equipment and may impose operational constraints in addition to a lower level of performance common to these systems.

7.118 In the horizontal flow systems, personnel working between the filter and surgical wound will disperse bacteria that are more likely to contaminate exposed surgical instruments and enter the wound. This may be minimised by the use of improved clothing and operating procedure to reduce dispersion of bacteria. The use of lines on the floor delineating the extent of the clean zone and hatching or colour coding the 'no-entry' zone between the air diffuser and patient will serve to prompt staff and are therefore essential.

7.119 The air discharge velocity as measured 1m from the diffuser face should have a mean value of 0·4 m/s. The validation Section 8 gives details of the method of measurement.

Filters

7.120 The main plant primary and secondary filters should be to the standards and in the location set out in Section 4.

7.121 Terminal filters should be provided within the airflow terminal or in the air supply to it. High efficiency particulate air (HEPA) filters grade H10 as specified in BS EN 1822 will be required as a minimum. There is no aerobiological benefit in fitting filters of a higher grade than this, although for practical reasons most UCV manufacturer recommend the fitting of H12-grade filters.

7.122 In some modular UCV units, the terminal filter is used as a pressure equaliser to balance airflow and filters of a higher grade with a greater pressure drop may be recommended by their manufacturer. The increased resistance may affect the velocity of air reaching the operating level and there will be penalties in terms of installed fan power and higher noise levels.

7.123 The final filters should be installed in a leak-proof housing in a manner that allows the terminal unit, filters and their seals to be validated. A challenge test will be carried out during commissioning to prove the effectiveness of the complete installation.

7.124 Where UCV units are constructed in sections, a means of measuring the pressure drop across the terminal filters in each section should be provided. The pressure test-points should be located outside of the partial wall, capped to prevent air leakage and accessible within the theatre without the need to open the unit inspection panels. Alternatively direct-reading pressure gauges should be fitted.

7.125 The UCV system will require a return-air filter to capture the relatively coarse particles that would otherwise significantly reduce the life of the final filter. This should be at least a G3 grade to BS EN 779. In remote recirculation systems there may be advantages in fitting a higher grade return air filter, as it will reduce the load on the terminal HEPA filters and extend their life.

Noise level

7.126 If sound-attenuating material is used to line any portion of the inside of the UCV unit it should be non-particle-shedding and fire-resistant. (Further guidance can be found in SHTM Firecode suite of documents).

7.127 The maximum noise level in an operating room fitted with a UCV terminal of any type shall not exceed 50 NR. The validation section gives details of the method of measurement.

Lighting and operating lights

7.128 CIBSE lighting guide LG2 and BS EN 12464-1 give detailed information of lighting requirements. Operating luminaires should comply with the photometric requirements detailed in relevant sections of BS EN 60601.

7.129 The position of the UCV light fittings and style of partial walls, where fitted, should neither adversely disturb the airflow nor result in significant spatial variations in illuminance levels.

7.130 In vertical units, specialised task lighting should be provided by toroidal, cruciform or small multiple dome-shaped luminaires as they have good aerodynamic properties. The ideal luminaire will have a minimal effect on the airflow regardless of where it is positioned. Large-diameter saucer-shaped luminaires should not be used in vertical-flow systems as they will occlude the airflow in the critical central zone. It is important to consider the suitability of existing luminaires when retrofitting UCV systems.

7.131 In vertical UCV installations a minimum of 2·75m from floor to underside of the diffuser is required to allow for supporting mechanisms and lamp articulation. When upgrading existing systems this dimension may not be achievable. However, when parked, the lowest point of the central light stem, luminaire and articulation arms should never be less than 2m above floor level.

7.132 The traditional means of light support is a central column that passes through the UCV terminal and is rigidly fixed to the building structure. The position of the support therefore prevents air being supplied at the centre of the terminal. Separate supports displaced from the centre of the clean zone would lead to improved airflow. This approach was advocated in the 1994 version of HTM 2025 but at the time of writing no UK manufacturer has chosen to adopt this solution.

7.133 In horizontal units the size or shape of the specialised task luminaire has little effect on the air-flow pattern.

Controls and instrumentation

7.134 The functions of the supply AHU and extract ventilation should be continuously monitored by a BEMS control unit. The controls and instrumentation for the main plant are set out in Section 6.

7.135 UCV systems will additionally require:

- a set-back facility that can reduce the air supplied through the UCV terminal to a volume that equates to not less than 25 air changes per hour of the operating room gross volume whilst still leaving the supply AHU operating at full speed;
- a facility to turn the entire system, supply AHU and UCV terminal, off. (an emergency stop is not required);
- a read-out sufficiently large to be clearly visible from the operating table that shows the temperature of the air being supplied by the UCV terminal;
- a read-out sufficiently large to be clearly visible from the operating table that shows the relative humidity of the air being supplied by the UCV terminal;
- a red indicator light that will illuminate when either the supply AHU or the UCV terminal fails, either or both are switched off or are at set-back;
- an amber indicator light that will illuminate when the UCV terminal is at set-back and the supply AHU is running;
- a green indicator light that will illuminate when both the supply AHU and UCV terminal are operating at full speed;
- a blue indicator light that will illuminate when the UCV terminal air flow, as detected by a differential pressure sensor, falls below 80% of the design flow rate.

AHU	UVC terminal	Indicator light	Comment
Off or Fault	Off or Fault	Red	Ventilation not operating at a suitable level to commence surgical procedures
Off or Fault	On (set-back)		
Off or Fault	On (full speed)		
On (set-back)	Off or Fault		
On (full speed)	Off or Fault		
On (set-back)	On (set-back)		
On (full speed)	On (set-back)	Amber	Ventilation provided to at least conventional theatre standard
On (full speed)	On (full speed)	Green	Full UCV standard conditions
-	-	Blue	HEPA-filter resistance causing low air flow

Table 7: Indicator light logic table

7.136 The switching devices and indicators should be incorporated in the surgeon's panel and their functions clearly labelled. In retrofit installations an auxiliary panel for the UCV may be the most practical option. If fitted it should be mounted adjacent to the surgeon's panel and their control functions interlocked as necessary.

7.137 When a system is designed to have partial walls with full-wall extensions, a volume control facility may be incorporated to allow the system to be run with reduced velocity when the demountable full-walls are in place. It would be the responsibility of the user to ensure correct operation of the system. To assist the user an explanatory notice should be included on the theatre control panel.

7.138 A direct-reading gauge should be fitted in the theatre to show a representative pressure drop across the final filters. If the UCV control box is located out of the theatre and has a means of manually adjusting the return air-fan speed then it should also be fitted with a direct-reading differential pressure gauge. The means of adjusting the return-air fan speed should be lockable to prevent casual adjustment. The direct-reading gauges should be fitted with a means of indicating the correct operating pressure range.

7.139 The UCV-unit manufacturer's control box should be located in an accessible position preferably in the operating department adjacent to the operating theatre that it serves. A service corridor, if provided, is an ideal location. The control box should be clearly labelled with the identity of the operating theatre that it serves.

7.0 (c) Extract systems

7.140 Extracts may be provided for a variety of reasons including:

- simple odour control (for example in a WC or mortuary);
- to receive and remove moisture-laden air (for example, in a kitchen);
- as part of a combined supply/extract balanced system (for example, in an operating suite);
- to capture a hazardous substance at source (for example a safety cabinet).

7.141 Devices that use an inflow of air to control exposure of staff to hazardous substances are classified as Local Exhaust Ventilation (LEV) systems under the COSHH Regulations.

7.142 An LEV system may comprise a self-contained unit incorporating its own carbon filter such as a simple bench-top fume cupboard. Alternatively it may be a complete "ventilation system" comprising a make-up air supply, multiple-exhaust-protected work stations, branch and central extract ductwork, duplex extract fans and a high-level discharge terminal. It may also incorporate a special filtration system appropriate to the hazardous substance being controlled. Such systems could be required for workshops containing woodworking machinery or large centralised pathology laboratories housing multiple safety cabinets, dissection benches, fume cupboards and specimen stores.

7.143 It is important to recognise at the design stage whether an extract is being provided for comfort or as an LEV system. Typical systems in healthcare include:

- microbiological safety cabinets and Category 3 containment rooms;
- fume cupboards;
- welding-fume extracts;
- woodworking machinery duct collectors;
- battery-charging bay extracts;

- powered plaster and bone saws;
- pharmaceutical preparation cabinets and tablet machines;
- dissection benches, cut-up tables and some specimen stores;
- medium- and high-risk infectious disease isolation facilities;
- decontamination facilities;
- dental furnaces, grinders and polishers.

7.144 General design information and guidance for LEV systems is produced by the Health and Safety Executive (HSE) as HS(G)37. Information on the design and installation of microbiological safety cabinets is given in BS5726 and that for fume cupboards is given in BS EN 14175. Their recommendations should be closely followed.

7.145 LEV systems are statutory items that will be subject to an independent inspection every 14 months.

Hood extract systems

Special requirements

7.146 Extract canopies will be required over steam-and-heat-emitting appliances, for example sterilisers, catering and washing equipment; and for the extraction of toxic fumes over benches used for mixing, sifting and blending procedures.

7.147 Perimeter-drain gulleys and corrosion-proof grease eliminators should be provided on kitchen hoods.

Typical arrangements

7.148 The air-flow rate must be sufficient to ensure an adequate capture velocity in the vicinity of the process; typical values are as follows:

- evaporation of steam and like vapours 0.25 m/s to 0.5 m/s;
- chemical and solvent releases 1.0 m/s;
- vapour of gases 5 m/s to 6 m/s;
- light dusts 7 m/s to 10.0 m/s.

Excessive velocities will be wasteful of power and generate noise.

7.149 The lowest edge of the canopy should be 2m above finished floor level, with a minimum of 300mm overhang beyond the edge of the equipment on all sides.

7.150 A compact arrangement of equipment (but with access for maintenance) will minimise the canopy area, and hence reduce the air volume necessary to achieve the optimum capture velocity.

7.151 Hoods required for the control of heat gain and vapours may be connected to the general extract system when it is convenient to do so, but where non-corrosive ductwork materials are necessary, a separate discharge is preferred.

7.152 Lighting and internal divider plates are often required to be built into the perimeter of large canopies. However, built-in shelving systems are not recommended, as they interfere with the air-flow, and constitute a maintenance problem.

Control of hood extracts

7.153 Provided that it does not interfere with the operation of the department when not in use, the ventilation system for the hood extract and any associated supply can be shut down. To this end, local control should be provided.

Bench extract systems

Special requirements

7.154 Bench extract ventilation is required in departments such as pathology and mortuary, where activities involve the release of malodorous or toxic fumes that should not be inhaled. Where hazardous substances are being controlled, the system should be designated an LEV.

Typical arrangements

7.155 Each ventilated position will usually be accommodated in a continuous run of benching, which should not be more than 650mm from front to rear and which should be provided with a continuous upstand at the rear. Each position should have a 1200mm x 150mm linear extract grille mounted on a purpose-designed plenum box (incorporating guide vanes as necessary), with its face flush with the upstand. The bottom of the grille should be as close as practicable to the level of the working surface (usually 75mm above, to allow for cleaning). The minimum velocity across any part of the grille should be 1 m/s. The grille should be readily demountable to allow for cleaning.

Control of bench extract systems

7.156 Provided that it does not interfere with the operation of the department when not in use, the ventilation system for the bench extract and any associated make-up supply can be shut down. However, a run-on timer with a minimum setting of 30 minutes must be provided. To this end, local or automatic-use control should be provided.

7.157 Processes that produce hazardous vapours, fumes, dusts or noxious vapours should be enclosed or semi-enclosed in a suitable cabinet or exhaust protected workstation.

Safety cabinet and fume-cupboard extract systems

7.158 Safety cabinets and fume cupboards are devices that use an inflow of air to control exposure of staff to hazardous substances. The units, their exhaust

systems, filters, fans and discharge terminals are all classified as Local Exhaust Ventilation (LEV) systems under the COSHH Regulations. The make-up air system to a room that contains an LEV system should also be considered as an essential part of the system and be included in the LEV classification. Information on the design and installation of microbiological safety cabinets is given in BS5726 and that for fume cupboards is given in BS EN 14175. Their recommendations should be closely followed.

7.159 The Advisory Committee on Dangerous Pathogens (ACDP) publishes 'The Management, Design and Operation of Microbiological Containment Laboratories' covering the general environment in which they are used and operational considerations.

Special requirements

7.160 The supply-air system should not distort the unidirectional and stable air pattern required for fume cupboards and microbiological safety cabinets. In general, supply-air ceiling diffusers should not discharge directly towards fume cupboards or safety cabinets, unless the terminal velocity is such that the air-flow pattern of the cabinet is unaffected. The design should ensure that high air-change rates, and/or the opening and closing of doors do not have any adverse effect on the performance of safety cabinets or fume cupboards. A damped door-closure mechanism may help.

7.161 In order to safeguard the user, all safety cabinets and fume cupboards must be fitted with a clear indication that they are operating correctly. Direct-reading gauges or falling-ball indicators are preferred (in addition to electronic pressure indicators). The system should be set to alarm audibly if the face velocity falls below the minimum safe operating level.

Arrangements for safety cabinet installations

7.162 The manufacture and installation of microbiological safety cabinets must be in accordance with the relevant national standards and guidance issued by the Advisory Committee on Dangerous Pathogens (ACDP).

7.163 A Class 1 microbiological safety cabinet must be specified for routine work involving Group 3 pathogens. It should be housed in a Category 3 containment room. Specific design information on containment rooms is issued by ACDP in conjunction with the Health and Safety Commission.

7.164 Siting and installation of microbiological safety cabinets are of particular importance because:

- the protection afforded to the operator by the cabinet depends on a specific and stable unidirectional air flow through the open front;
- the protection to the environment by the cabinet depends on the high efficiency particulate air (HEPA) filters. The exhaust air should never be considered as totally free from microbiological hazard.

7.165 Microbiological safety cabinet is HEPA filtered prior to being discharged to outside. The extract ductwork should as far as practicable be kept under negative pressure while inside the building.

7.166 Current standards permit the installation of microbiological safety cabinets with integral fans, provided that the extract ductwork can be kept short (that is, less than 2m); such an installation however, is likely to be noisy and is not recommended for use in new buildings.

7.167 The discharge from the cabinet should be fitted with a back-draft damper. In multiple installations where several cabinets discharge into a common extract and discharge duct, it must be possible to isolate each cabinet from the system when not in use.

7.168 Roof-level discharge, wherever practicable, is preferred since it removes much of the uncertainty over air re-entering the building through ventilation inlets and/or windows. In such an installation, the extract fan should be situated separately from the cabinet and close to the discharge outlet, to maintain the duct within the building under negative pressure. The discharge point on a flat roof should be through a 3m high terminal. This is required to safeguard staff who may need to access the roof periodically for maintenance. This requirement will also be applicable to fume-cupboard discharges.

7.169 Where this is impracticable, discharge into the room via a double HEPA filter has been accepted. The preferred method, however, is to discharge 3m above the roofline in line with the similar standard for fume cupboard designs.

Arrangements for fume cupboard installations

7.170 The manufacture and installation of fume cupboards must be in accordance with the relevant national standards and associated guidance.

7.171 The primary factors that contribute to the effective performance of fume cupboards include:

- an adequate volume of supply air;
- an effective exhaust system to promote the safe dispersal of waste products to atmosphere.

7.172 The air velocities through sash openings must be sufficient to prevent hazardous materials from entering the laboratory while avoiding excess flow rates that interfere with the investigation process. Average face velocities should be between 0.5 and 1.0 m/s, with a minimum at any point within 20% of the average, the upper end of the range being applicable to the containment of materials of high toxicity. The design velocity must be maintained irrespective of whether the sash opening is varied, or whether doors or windows are open or closed. Variable Air Volume (VAV) cupboards are available which offer a reduction in energy use.

7.173 The possibility of a fire or explosion that may not be contained by a fume cupboard must always be considered. A fume cupboard should not, therefore,

be sited in a position where exit to an escape route will necessitate passing directly in front of it.

7.174 Fume-cupboard fans should be installed as near as possible to the termination of the duct, thus maintaining the maximum amount of ductwork at negative pressure.

7.175 Where there are adjacent buildings with opening windows, or where downdraughts occur, it may be necessary to increase the height of discharge ducts in order to achieve adequate dispersal. In complex locations, airflow modelling or wind tunnel tests may be required to determine the optimum height of the stack (see also Paragraph 7.167).

7.176 Fume-cupboards for certain processes must have separate extract systems. However, where appropriate, individual fume-cupboard exhaust systems may discharge via non-returning dampers into a single collection duct rather than having a large number of separate stacks. The collection duct should have a large cross-sectional area to minimise its effect on the individual exhaust systems; be open to atmosphere upstream of the first connection; and be designed to discharge a total air volume at least equal to the combined individual extract systems.

7.177 Individual fume-cupboard extract systems, discharging either directly to atmosphere or into a collection duct, do not require duplex fans. However, a collection duct designed to provide dispersal of effluent from a number of individual extracts, should have duplex fans with automatic changeover.

7.178 Some fumes are particularly corrosive, so the choice of material for the ductwork, and type of extract fan fitted should reflect the nature of the fume being conveyed.

Control of extract systems

7.179 It is desirable to provide local control of safety cabinets in order to maximise the life of the HEPA filter, and to permit the sealing of the cabinet and room for fumigation if spillage occurs.

7.180 To cope with the risk of an accident or spillage outside safety cabinets, a ‘panic button’ should be provided to switch off the supply to that area; and discharge all extracted air to atmosphere.

7.181 In pathology departments, it will be necessary to have one or more microbiological safety cabinets and one or more fume cupboards available for use at all times, including weekends, therefore, local overriding controls for all these items and any associated ventilation plant will be necessary.

7.0(d) Plantroom ventilation

General requirements

7.182 Plant rooms are required to be ventilated in order to maintain acceptable temperatures for satisfactory operation of the plant and controls, and for

maintenance activities. In the case of plant rooms housing combustion equipment, a secondary function of the ventilation is to provide make-up air for the combustion process.

7.183 The air required for these purposes should be introduced into the space through inlets positioned to minimise the discomfort to occupants; they should be unlikely to be blocked, closed deliberately (except in the case of fire shutters if required), or rendered inoperative by prevailing winds.

7.184 Plantroom ventilation air should not be used for any other purposes, such as make-up air for extract; and where the plantroom contains combustion equipment, the appliance pressure must not fall below the outside air pressure.

7.185 Specialised healthcare air handling equipment must not be located in a fire compartment that houses combustion equipment.

7.186 Statutory regulations for plantroom ventilation are contained in the Scottish Building Regulations, and further guidance is given in CIBSE Guides A & B.

Assessment of ventilation levels

7.187 Ventilation requirements must take into account all heat sources within a plantroom, and where there are large glazing areas, solar gains. The ventilation rate should limit the maximum temperature within the plantroom to 32°C.

7.188 As the level of equipment operating during mid-season and summer is often lower than the winter condition, and the cooling effect of the outside air is reduced, it is necessary to calculate the minimum volume for each season of operation, and the inlet and outlet grilles or fan sizes should be chosen to cater for the largest seasonal air volume.

7.189 Replacement air should not be drawn through pipe trenches or fuel service ducts. Where metal ducts penetrate walls and floors, effective sealing should be provided to confine the ventilation to the boiler room and to meet fire protection requirements. Penetration of fire barrier walls by ventilation ducts should be avoided if possible.

7.190 Fire dampers in plant room ventilation ducts should be electrically interlocked with the boiler plant.

7.191 Care must be taken to prevent any noise generated in the boiler room emerging from natural or mechanical ventilation openings to the detriment of the surrounding environment. Particular care is necessary with mechanical flue draughts and fan-diluted flue systems.

7.192 Information on required air volumes in contained in the CIBSE Guide A & B.

7.193 Where combustion plant is installed, the high-level (outlet) openings should be sized to cater for the total ventilating air quantity; and the low-level (supply) openings sized to cater for the total combined ventilating and combustion air quantity.

Choice of ventilation system

7.194 Ventilation air may be introduced and exhausted by either natural or mechanical means or a combination of both. However, natural systems are preferred where possible.

7.195 Generally, small installations at or above ground level should have their combustion and ventilation air provided by natural means, employing both high- and low-level openings.

7.196 Basement, internal and large installations at or above ground level will usually require a combination of natural and mechanical ventilation. If the airflow rate is difficult, both supply and extract may require mechanical means.

7.197 Whether natural or mechanical, the system should be designed to avoid both horizontal and vertical temperature gradients. Both inlet and outlet openings should be placed on opposite or adjacent sites of the building to reduce the effect of wind forces.

7.198 Where mechanical air supply is employed, electrical interlocks with the boiler plant should be provided to prevent damage in the event of failure of the supply fan(s) once the air volume is established.

7.199 The necessary free opening areas for a naturally ventilated plantroom may be calculated using either the method in A4 of the CIBSE Guide A or the table in section B13 of CIBSE Guide B.

7.200 A combined natural and mechanical ventilation system should allow for natural extract at high level, to take advantage of convective forces in the room, with mechanical supply at low level. The high level natural ventilators should be sized to cope with the total quantity of ventilation air, as above.

7.201 To prevent leakage of flue gases and to ensure that the flue draught is not impeded at any time, the air pressure in the boiler room must not exceed the prevailing outside pressure. Therefore, the fan duty should exceed the calculated total combined combustion and ventilation air quantity by at least 25%. Fan-powered inlets should be arranged to flow outside air into the space at a point where cross-ventilation will ensure pick-up of heat without causing discomfort to occupiers.

7.202 Where it is impractical to provide sufficient natural ventilation to remove the heat emitted by the plant, both mechanical supply and extract will be required.

7.203 The high-level extract should be sized to cater for the total ventilating air quantity and the low-level supply should exceed the total combined combustion and ventilating air quantity by at least 25%, as above.

7.0(e) Ventilation of hydrotherapy suites

General requirements

7.204 In a hydrotherapy suite heat recovery should be via heat pump.

7.205 The quantity of supply air should be calculated as 25 litres/sec/m^2 wetted surface, with the wetted surface taken as 110% of the pool water surface area.

7.206 A re-circulation plant is recommended, with a minimum of 20% fresh air.

7.207 As far as practicable, re-circulated pool air should be provided to the ancillary changing and recover accommodation, with the only extract from the toilets, laundry/utility room and pool hall.

7.208 Supply air to the pool hall should be introduced at high level and directed towards the perimeter to mitigate condensation, with extract air taken from directly over the pool. Dampers should not be located over the pool water.

Control of hydrotherapy pool installations

7.209 The supply and extract fans should be interlocked so that the supply fan does not operate until flow is established within the extract system.

7.210 Time-clock control should be provided, with a local override switch to extend the normal operating period as required.

7.211 Night setback temperature (in the range of 21°C -25°C) and high humidity control (in the range of 60-75% sat) should be provided to override the time clock in order to prevent condensation. The exact set points should be ascertained post-installation.

7.212 A remote indication panel should be provided in the pool hall, giving a visual display of the pool water and pool air temperature.

8. Validation of specialised ventilation systems

Definitions

Commissioning - Commissioning is the process of advancing a system from physical completion to an operating condition. It will normally be carried out by specialist commissioning contractors working in conjunction with equipment suppliers. Commissioning will normally be the responsibility of the main or mechanical services contractor.

Validation - A process of proving that the system is fit for purpose and achieves the operating performance originally specified. It will normally be a condition of contract that "*The system will be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.*"

Note: Commissioning is often sub divided into sections e.g. air handling unit, automatic controls, airside balance, building fabric and fittings. Each section may be commissioned by its specialist installer and they are often accepted in isolation. Validation differs from commissioning in that its purpose is to look at the complete installation from air intake to extract discharge and assess its fitness for purpose as a whole. This involves examining the fabric of the building being served by the system and inspecting the ventilation equipment fitted as well as measuring the actual ventilation performance.

It is unlikely that 'in house' staff will possess the knowledge or equipment necessary to validate critical ventilation systems such as those serving operating suites, pharmacy clean rooms and local exhaust ventilation systems. Validation of these systems should therefore be carried out by a suitably qualified independent Authorised Person appointed by the NHS Board.

It is anticipated that training in the validation of specialised healthcare ventilation systems for independent Authorised Persons will become available during the life of this SHTM.

Commissioning general

8.1 Commissioning is an essential process for ventilation systems. It is therefore important that adequate provision for the process be made at the design stage of the project. Procedures for commissioning air-handling systems are given in CIBSE Commissioning Codes and BSRIA Application Guide Set COMPAK 1.

8.2 The duct-sizing procedure should take into account the requirements of system balancing, and the position and number of regulating dampers included in the design should be sufficient for this purpose.

Location of dampers and test holes

8.3 Balancing/commissioning dampers will be required in each branch of the distribution ductwork.

8.4 Test holes for the measurement of air-flow will be required at carefully selected points in main and all branch ducts. The number and spacing of holes are given in the BSRIA Application Guide Set COMPAK 1. Their positions must be identified at the design stage.

8.5 The test positions need to be accessible for commissioning to take place. They may also be required for subsequent annual verification of the system performance, so they should not be covered by permanent lagging.

8.6 The measurement point should be in a straight length of duct as far away as possible from any upstream bends, dampers or other elements that could cause disturbance to the airflow. The actual location should be:

- at least 1.5 duct diameters upstream of sources of turbulence such as dampers and bends;
- if this is not possible, 10 diameters downstream of dampers, bends or tees, and 5 diameters downstream of eccentric reducers;
- where there is enough space round the duct to insert the pitot tube and take readings;
- where the duct has a constant cross-sectional area.

8.7 Test holes for measuring total airflow from a fan should be located either 4 diameters upstream or 10 diameters downstream of the fan. Provision should also be made for measuring the speed of rotation.

Information to be provided

8.8 It is essential that the designer should pass on his intentions fully to the commissioning engineer by indicating which parts of the system are high, medium and low pressure, and by providing:

- relevant parts of the specification;
- schematic drawings indicating performance data as indicated in Table 8;
- equipment schedules;
- controller and regulator schedule;
- fan performance curves;
- wiring diagrams for electrical equipment, including interlock details.

Items in system	Information to be provided
Fans	Fan total pressure Volume flow rate at high and low speed Maximum motor current
Plant items	Type and identification numbers from equipment schedules Fluid and air volume flow rates Fluid and air side pressure losses Dry bulb temperatures Wet bulb temperatures Humidity
Dampers, including motorised and fire dampers	Identification numbers from equipment schedules Location Identification number Volume flow rate
Main and branch ducts	Dimensions Volume flow rates and velocities Identification numbers from equipment schedules
Terminal	Location Identification number Grille or diffuser factor Volume flow rate and neck velocity Operating static pressure
Test holes and access panels	Location Identification number
Controllers	Set points

Table 8: Information to be provided on schematic drawings

Notes: For Table 8

1. Fan total pressure is the difference between the total pressure (static pressure + velocity pressure) at the fan outlet and the total pressure at the fan inlet.

2. Where volume flow rates are variable, maximum and minimum values should be provided.

Commissioning personnel

8.9 As one individual is unlikely to possess all of the required commissioning skills, a commissioning team is therefore usually needed. The objective of commissioning is to ensure that the necessary performance and safety requirements are met.

8.10 During the commissioning process a great deal of information will be generated which will form an invaluable future source of reference about the plant. It is essential to ensure that it is collected together in the form of a commissioning manual and handed over to the client on completion of the contract together with the 'as fitted' drawings. This information should be both in hard copy and electronic format.

8.11 In order to be successful the commissioning process must start before achieving practical completion as many parts of the system will become progressively less accessible. The correct installation of those parts will need to be witnessed and leak-rate tests carried out as construction proceeds. Failure to establish responsibility for commissioning early enough will delay the completion of the project or lead to unsatisfactory plant performance.

Commissioning brief

8.12 The commissioning team will require a detailed brief from the system designer. This should include:

- a 'user' brief comprising a description of the installation and its intended mode of operation;
- the precise design requirements with regard to the scheme of air movement, room static pressures, supply and extract air-flow rates and acceptable tolerances;
- full details of the design conditions both inside and out, for winter and summer together with the control strategy;
- equipment manufacturer's type test data, commissioning, operation and maintenance recommendations;
- drawings showing the layout of the system, positions of air-flow measurement test points, dampers, regulating devices and filters within the duct runs, together with sizes of ducts and terminal fittings. It will save time if these drawings are annotated with the design volumes and static pressures required at each branch and outlet point;
- wiring diagrams for all electrical equipment associated with the air handling systems including motor control circuit details and any interlocking and safety devices such as emergency-stop buttons adjacent to the item of plant.

8.13 The CIBSE Commissioning Code, Series 'A' – "Air Distribution", provides full guidance on the information that will be required by the commissioning team.

8.14 The designer should include in the contract document instructions on verifying the accuracy of test instruments that should be supported by reference to relevant calibration certificates.

8.15 The system, on completion, should be operated by the contractor as a whole and subject to performance tests in accordance with the contract requirements. For critical systems, these may include independent validation of the system performance on behalf of the client.

8.16 Prior to dynamic commissioning, it is essential that builders' work in the area served by the system is complete, all rubbish and dust is removed, concealed plumbing (IPS-type) panels are in position and ceiling tiles are in place and clipped. Floors should be mopped and visible dust removed from all other surfaces.

8.17 Once the system is shown to meet the design intent the handover documentation should be completed. In the event of performance not being acceptable, the matter should be dealt with in accordance with the contract arrangements.

Pre-commissioning checks

8.18 The pre-commissioning checks consist of visual inspection, manual operation of equipment, static measurements and functional tests of individual components. They should be carried out prior to setting the system to work and undertaking the dynamic commissioning process set out in Paragraph 8.29 onwards of this guidance.

Standard of installation

8.19 During the installation of the system the following must be witnessed:

- that the plant and installations have been provided and installed in accordance with the design specification and drawings;
- that only approved sealants have been used in the installation;
- that all components function correctly;
- that the satisfactory sealing of access doors and viewing ports have been carried out;
- that air pressure tests and air-leakage tests on ventilation ducting have been carried out in accordance with the methods set out in the HVCA's DW/143: Ductwork Leakage Testing. It is usual to carry out these tests, a section at a time, as the ductwork is installed and before its insulation is applied. The results must be recorded in the commissioning manual;
- that gaps around doors and hatches are as specified in the design;
- that the correct operation of pressure stabilisers, control dampers, isolating and non-return dampers have been checked and installed in the correct orientation for air-flow;
- that test holes have been provided in their specified locations and are sealed with suitable grommets;
- that control dampers are secured and their quadrants fitted correctly;
- that any interlocks are operative and in accordance with specification;
- that the electric circuits are completed, tested and energised;
- that electric motors have been checked for correct direction of rotation both at full speed and set-back;
- that cooling and heating media are available at correct temperatures and pressures and in specified quantities;
- that the air-conditioning plant components and controls function correctly;
- that the air-conditioning plant interlocks and safety controls function correctly;

- that the plant is physically complete, insulation is applied and all ducts and pipework are identified as specified;
- that the building housing the ventilation plant is generally in a fit condition for commissioning and performance tests to commence, that is, windows, doors, partitions etc are completed, surfaces sealed and their final finish applied;
- that the areas containing the ventilation plant and those being served by it are clean;
- that access to all parts of the system is safe and satisfactory.

Cleanliness of installation

8.20 During installation it must be established that ductwork is being installed to the 'advanced level' as defined in the HVCA (2005) 'TR/19 – Guide to good practice: internal cleanliness of ventilation systems'. This specifically includes ensuring that ductwork sections arrive on site and are stored with their open ends sealed and that open ends remain sealed during installation to prevent the ingress of builders' dust.

8.21 Should any doubt exist whether the guidance has been observed, the ducts must be cleaned internally to restore them to this standard before being taken into use.

8.22 "Builders work" ducts of brick or concrete must be surface sealed to prevent the release of dust before being taken into use.

8.23 The area around the supply air intake must be free of vegetation, waste, rubbish, builders' debris or any other possible source of contamination.

Certification of equipment

8.24 The following test certificates should be assembled by the commissioning team and be available for inspection at any time during the contract period. They will form part of the handover information and should be placed in the commissioning manual:

- type-test performance certificates for fans;
- pressure-test certificates for:
  - heater-batteries;
  - cooling coils;
  - humidifiers (if appropriate);
- type-test certificates for attenuators;
- type-test certificates for primary and secondary filters;
- individual test certificates for high efficiency particulate air (HEPA) filters.

Equipment tests

8.25 Prior to setting the system to work, the checks in Paragraphs 8.26 - 8.28 should be witnessed, and proving tests should be carried out as detailed.

Filters

8.26 The quality of filter housing and in particular, the seals is a critical factor in maintaining the efficacy of the filtration system by ensuring that air does not bypass the filter panels. Therefore, the following checks should be made:

- filter seals should be fitted and in good condition;
- filters should be installed correctly with respect to air flow;
- bag filters should be installed so that the bags are vertical and their pockets free;
- HEPA filters should be installed in a sealed housing and their seals tested to DIN 1946 if specified;
- all filters should be checked to ensure they are free of visible damage;
- the differential pressure indicators should be checked for accuracy and that they are marked with the initial and final filter resistance.

Drainage arrangements

8.27 The drain should conform in all respects to the “Design considerations” of this SHTM. In addition the following must be proved:

- that the drain tray is easily removable;
- that a clear trap is fitted and is easily removable;
- that the drain has a clear air gap of at least 15mm;
- that the pipework is supported so that the air break cannot be reduced;
- that the drain system from each drain tray is independent up to the air break;
- that the operation of the drainage system is proved by introducing water into the duct at the drain tray and observing that it completely drains out. This check is to be repeated both at normal speed and set back once the fans have been commissioned. At this time the clear trap can be marked to indicate the normal water level with the fan running.

Fire dampers

8.28 The following must be witnessed and proving tests should be carried out as detailed:

- the operation of all fire dampers;
- the access provided to enable the dampers’ to be visually inspected and / or re-set should be sufficient for the purpose;

- indication should be provided of the dampers' position (open/tripped);
- indication of the fire dampers' location should be provided both on the ductwork and at a visible point on the building fabric if the ductwork is concealed.

Dynamic commissioning

Air-handling and distribution system

8.29 The fan drive, direction of rotation, speed and current drawn should be set in accordance with their manufacturer's instructions.

8.30 After the installation has been checked to ensure that it is in a satisfactory and safe condition for start-up, it should be set to work and regulated to enable the plant to meet its design specification. The proportional balancing method described in the CIBSE Commissioning Code "A" must be followed. The air-flow rates must be set within the tolerances laid down in the design brief. This will normally be the design airflow rate +10% -0%.

8.31 When combined supply and extract systems are to be balanced and the area that they serve is to be at or above atmospheric pressure then the supply should be balanced first with the extract fan switched off, and then the extract balanced with the supply fan(s) on.

8.32 For combined systems where the area that they serve is to be below atmospheric pressure then the extract should be balanced first with the supply fan switched off and then the supply balanced with the extract fan on.

8.33 On completion of the balance all volume air-flows in supply and extract ducts and from grilles and diffusers must be measured and recorded. The true air change rate can them be calculated from the data obtained.

8.34 The main supply and extract duct volume control dampers must be locked and their position marked.

8.35 All grille and diffuser volume control registers must be locked to prevent alteration and their final position marked.

Room air distribution

8.36 The pressure-relief dampers and pressure stabilisers must be set to achieve the specified room static pressures and locked. The grille direction control vanes and diffuser cones must be set to give the specified air-movement pattern. Visualisation techniques may need to be employed in order to prove that the required air-flow pattern is being achieved. This may be a potential requirement when commissioning LEV systems or rooms that contain them.

Air-conditioning plant

8.37 The specified flow rate and/or pressure drops must be set for all heater batteries, cooling coils and humidifiers. The methods described in the CIBSE

Commissioning Codes “W” and “R” should be followed. On completion their regulating devices must be locked to prevent alteration.

Control system

8.38 The control system should not be commissioned until both the air distribution system and air-conditioning equipment have been commissioned.

8.39 Because of the specialised nature of control systems and the fact that each manufacturer’s system will contain its own specialist components and settings, the commissioning should be completed by the supplier and witnessed by a representative of the user.

8.40 The location of all control and monitoring sensors should be checked and their accuracy proved.

8.41 The control system’s ability to carry out its specified functions must be proved.

8.42 If the plant is provided with a “user’s” control panel in addition to the one located in the plantroom then the operation of both must be proved. This will typically apply to operating departments and laboratory systems.

Specific performance standards

Air movement

8.43 The performance of the system should be measured and compared with information provided by the designer.

Plant capacity and control

8.44 When setting to work and proving the design, both the manufacturer of the air-handling plant and the control specialist should attend site together and jointly commission the system.

8.45 If any doubt exists as to the capacity of the installed system, then its ability to achieve the specified inside design conditions with the plant operating at winter and summer outside design conditions must be proved. Artificial loads will be required in order to simulate the internal gains/losses and the outside design conditions.

8.46 On completion of the plant performance test, recording thermo-hygrographs should be placed in each room/area served by the plant and also the supply air duct upstream of the frost battery. The plant should be run for 24 hours with all doors closed. During this period the inside conditions must stay within the tolerances specified. The BEMS should be used to obtain the information required wherever possible. Periodic tests will be required during the defects liability period.

Noise levels - general

8.47 The commissioning noise level is the level measured with a sound-level meter in the unoccupied room and taking account of the external noise together with the noise generated by the ventilation system. When occupied and in use this commissioning level will constitute a continuous background noise that will allow the overall noise level to be achieved. The ventilation plant design noise level is that generated by the plant alone with no other noise source being considered. The levels suggested make recognised allowance for the ingress of environmental noise.

8.48 The noise levels apply at the maximum velocity for which the system is designed to operate. Acoustic commissioning tests should be carried out with all plant and machinery running normally and achieving the design conditions of airflow, temperature and humidity.

8.49 An industrial-grade sound-level meter to BS3489 or IEC 651 Type 2 will normally be sufficient to check the noise level.

8.50 The noise level readings are to be taken at typical normal listening position 1.5m above floor level and at least 1m from any surface and not on any line of symmetry. In critical rooms the noise should be measured at the centre of the room and at the centre of each quarter. The mean of the 5 readings should then be calculated.

8.51 In the event of a contractual deficiency, a Type 1 precision-grade sound-level meter should be used and the noise level determined by the procedure given in Scottish Health Technical Memorandum 08-01 (2011).

Filter challenge

General ventilation filters

8.52 In-situ performance tests will not normally be required for primary and secondary filters and their housings. However the filters should be visually inspected for grade, tears, orientation and fit within their housing. Filters should be clean and a replacement set available. Bag filters should be installed so that their bags are vertical and spaced so that air can move through them freely. Any filter found to be wet should be replaced and the cause investigated.

HEPA filters (for exhaust protective enclosures and laboratories)

8.53 Pathogenic material may be discharged through damaged or badly installed HEPA terminal filters. The complete installation must be tested using the method set out in BS EN: 14644 ‘Method of Testing for the Determination of Filter Installation Leaks’.

8.54 The challenge tests may be carried out using either of the following techniques:

- use Dispersed Oil Generator (DOP) to provide the challenge and a photometer to detect leaks;

- use a Discrete Particle Counter (DPC) to detect leaks. (In order to obtain a sufficient challenge it may be necessary to remove temporarily the supply AHU secondary filters).

8.55 In both cases the upstream challenge should be measured. A measurement of particle penetration through a representative section of the HEPA filter media is then taken and used as the reference background level. These two readings enable the range of the detecting instrument to be set.

8.56 A challenge aerosol of inert particles of the type produced by a DOP generator should be introduced into the air, upstream of the HEPA filter. The downstream face of the filter, its mounting seal and housing would then be scanned for leakage using a photometer. A leak should be deemed to have occurred if a steady and repeatable reading on the photometer at any point exceeds 0.01% of the upstream reading.

8.57 Alternatively a Discrete Particle Counter (DPC) may be used. For the Discrete Particle Counter method the filter face is sampled at several points to establish the smallest non-penetrating particle size. If particles at or above this size are detected when subsequent scans of the filter face, its seal and housing are made, then there is deemed to be a significant leak at, or near, the test position.

8.58 Should the HEPA filter fail this test it must be replaced. Should the filter mounting seal or housing fail this test it may be repaired and the test repeated.

Bacteriological sampling

General ventilation systems

8.59 Bacteriological sampling will not normally be required for either general or local exhaust ventilation (LEV) systems unless otherwise specified.

Conventional operating rooms

8.60 The level of airborne bacteria introduced by the supply air can be checked by closing all doors and leaving the operating room empty with the ventilation system running for 15 minutes. An active air sampler set to 1 cubic metre and mounted on the operating table should then be activated remotely. Aerobic cultures on non-selective media should not exceed 10 bacterial and/or fungal colony forming units per cubic metre (CFU/m^3).

8.61 The results should be examined to establish the broad category of organisms present. A high preponderance of fungal organisms may be an indication of inadequate filtration for the particular installation. Precise guidance is inappropriate and will depend on local circumstances.

8.62 It may be appropriate to carry out a check of airborne bacteria during a surgical operation. If required this should be carried out as soon as possible after handover. Unless there are unusually high numbers of personnel or extensive activity in the room, the number of airborne bacterial and/or fungal CFU

averaged over any five-minute period, would be unlikely to exceed 180 per cubic metre.

8.63 Information on the additional validation testing of UCV Operating suites is given in Section 8.0(a).

Ventilation system commissioning/validation report

8.64 Following commissioning and/or validation a full report detailing the findings should be produced. The system will only be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.

8.65 The report shall conclude with a clear statement as to whether the ventilation system achieved or did not achieve the required standard. A copy of the report should be lodged with the following groups:

- the user department;
- infection control (where required);
- estates and facilities.

8.0(a) Validation of UCV operating suites

General

8.66 Commissioning of a UCV terminal will normally be carried out by its supplier. Commissioning of the air-handling unit, fire dampers, distribution ductwork and control systems may be undertaken by different teams. It is therefore important to recognise that the UCV terminal is only one element of the specialised ventilation system serving the operating suite and it cannot be accepted in isolation.

8.67 In order to ensure that the complete system operates correctly it will be necessary to validate the system as a whole from the air intake through to the extract discharge. It is unlikely that “in house” staff will possess the knowledge or equipment necessary to undertake this process. Validation of Ultra-Clean operating theatre ventilation systems should therefore be carried out by a suitably qualified independent Authorised Person appointed by the client.

8.68 It is anticipated that training in the validation of specialised healthcare ventilation systems for independent Authorised Persons will become available during the life of this SHTM.

8.69 The following regime of inspection and testing should be applied to the validation of new installations designed to provide Ultra-Clean conditions in an Operating suite. The test regime has been devised to ensure that the system as installed fully achieves the design requirement for these systems as set out in Section 7.0(b) of this document.

Basic requirement

8.70 The operating suite to be validated should be physically complete with final finishes applied. All ventilation systems serving it should be operating correctly and delivering the design air-flow rates.

8.71 In order to avoid pre-loading the UCV terminal's recirculation ducts and HEPA filters, the Operating suite should be free of any obvious dust and at least "builders clean" before the recirculation fans are set to work.

8.72 The validation procedure for a conventional theatre suite should have been satisfactorily completed to the standard set out in Section 8 prior to attempting to validate the UCV unit. In particular:

- the supply AHU will have achieved the minimum standard;
- the operation of all fire dampers will have been proved;
- the supply and extract air-flow rates as measured in ducts and at room terminals will achieve their design values +10%; -0%;
- room differential pressures will be correct.

Evidence of the satisfactory achievement of the foregoing standard should be available for inspection and independently measured as necessary *prior to validating the UCV unit.*

UCV unit validation procedure

8.73 Tests to validate the suitability and performance of an ultra-clean operating suite should be undertaken in the order that they appear below. Should an item fail to meet the required standard it should be rectified and successfully retested before passing on to the next test.

Summary of test regime

- Challenge tests to ensure that:
  - the UCV terminal unit is correctly assembled and sealed so that no air will bypass the filters;
  - the terminal filters are correctly sealed in their housings;
  - the terminal filters are of the same grade, of uniform quality and undamaged.
- Air velocity measurements to ensure that
  - a sufficient quantity of air is being delivered by the terminal;
  - the terminal quadrants are in balance;
  - the air flow has sufficient velocity to reach the working plane.
- An entrainment test to ensure that contaminants arising outside of the UCV terminal footprint are not drawn into it.

- Visualisation techniques to gain an understanding of the overall system performance.
- Noise measurement to ensure that working conditions are satisfactory.
- Control system checks to ensure that the system operates as specified.
- Biological monitoring to determine how effective the system is in use.

Test and measuring conditions

8.74 While validating the UCV terminal, the conditions in the Operating room shall be stable and within the given ranges.

temperature: – 19°C - 23°C dry bulb.

humidity: – 30 – 65% relative humidity.

Test and measuring equipment

8.75 Any test or measuring equipment used should have a certificate to prove that it has been validated within the previous 12 months at a calibration facility using traceable national standards.

8.76 In the case of a noise meter, its “matched sound source” should have a certificate to prove that it has been validated within the previous 12 months at a calibration facility using traceable national standards. The noise meter should be calibrated to the sound source on each occasion that it is used.

Test grid – vertical units

8.77 A test grid should be constructed on the floor within the ultra-clean terminal footprint as projected by the inside dimensions of the sidewalls or boundary air curtain. A suitably marked test sheet will provide a consistent standard of test grid.

8.78 The test grid should comprise test squares of 280mm each side.

8.79 The test grid should be aligned along the centre lines of the terminal footprint with its centre under the centre point of the terminal.

8.80 Any test square with 80% of its area within the UCV footprint should be used as a test position.

8.81 An inner zone should be designated that is not less than 36% of the total footprint. It should be made up of a number of test squares distributed symmetrically about the terminal footprint centre line. Regardless of the shape of the terminal footprint, the inner zone should comprise a minimum grid of 6 x 6 test squares.

8.82 Unless specified otherwise, a test position should be in the geometric centre of a test square.

8.83 Test position 1 should be the leftmost test square in the row nearest to the operating room wall that houses the surgeon's panel.

(For an example of a grid for a 2.8 x 2.8 metre terminal see Figure 8)

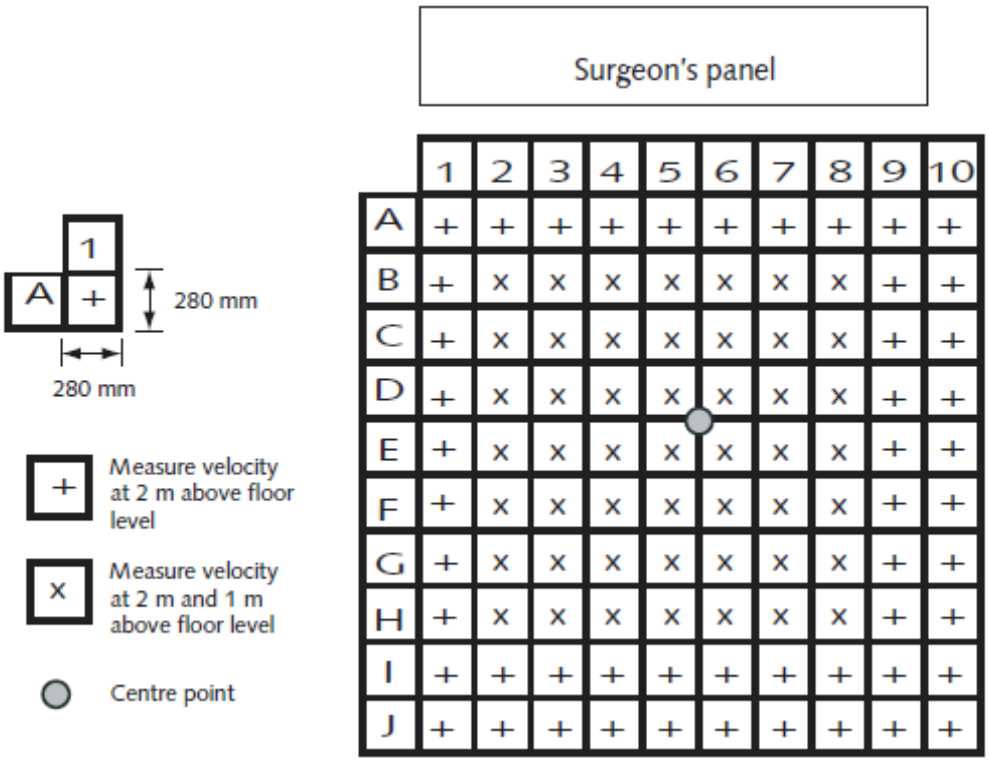


Figure 8: Example of a Test Grid for a 2.8m x 2.8m UCV Terminal

Test grid – horizontal units

8.84 A line of test positions should be marked on the floor 1m in front of the face of the UCV terminal.

8.85 A test position should be marked in the centre of the line. Additional test positions should be marked at 280mm spacing along the line either side of the centre position, up to the full-face width of the unit.

UCV terminal challenge tests (Vertical and horizontal systems)

8.86 The diffuser screen fitted below the face of the terminal HEPA filters should be lowered or removed while the challenge tests are being carried out.

8.87 The installed HEPA filters should be checked to ensure that their grade accords with the design specification and that their performance has been certified by the manufacturer.

8.88 The challenge tests may be carried out using either of the following techniques:

- use DOP to provide the challenge and a photometer to detect leaks;
- use a DPC to detect leaks. In order to obtain a sufficient challenge it may be necessary to remove temporarily the supply AHU secondary filters.

8.89 In both cases the upstream challenge should be measured. A measurement of particle penetration through a representative section of the HEPA filter media is then taken and used as the reference background level. These two readings enable the range of the detecting instrument to be set.

8.90 For the DOP test this should be set as the reference level and a leak will be declared significant if penetration greater than 0.01% of the range is detected. (See Paragraph 8.56 for details).

8.91 For the DPC method the filter face is scanned to establish the smallest non-penetrating particle size. If significant particles at or above this size are detected when subsequent scans are made then there is deemed to be a significant leak at, or near, the test position. (See Paragraph 8.57 for details)

UCV terminal unit clean zone leak test

8.92 This test will confirm that there is no unfiltered air bypassing the HEPA filter.

8.93 The joints and service penetration points under the UCV terminal within its side walls or boundary air curtain should be scanned to prove that there are no leaks.

8.94 A leak is defined as a significant rise above the background level.

Terminal HEPA filter seal leak test

8.95 The test will confirm that there is no unfiltered air bypassing the HEPA filter's seal.

8.96 Each HEPA filter's seal should be scanned to prove that there are no leaks.

8.97 A leak is defined as a significant rise above the background level.

Terminal HEPA filter media leak test

8.98 The test will confirm that the HEPA filters have not sustained damage while being installed.

8.99 The face of each HEPA filter should be scanned to prove that there are no leaks.

8.100 A leak is defined as a significant rise above the background level.

Vertical UCV terminal air velocity tests

Test set up

8.101 The terminal face diffuser screen should be in place for these tests.

8.102 Take spot readings to establish that the room is within the specified temperature and humidity test conditions.

8.103 Set out the test grid as described previously.

8.104 Swing the operating lamp arms and any other stem arms so that they align to present the least resistance to air flow, are perpendicular to the front edge of the test sheet and face the back edge. Any lamp and equipment heads should as far as practicable be outside of the UCV terminal footprint.

Test instrument

8.105 The measuring instrument should be a hot-wire anemometer with a digital read-out. The instrument resolution should be at least 0·01m/s, have a tolerance of ±0·015 m/s or 3% of that reading and be calibrated down to 0·15 m/s or lower. An alternative instrument may be used providing it is of no lesser specification.

Test method

8.106 The instrument should be mounted on a test stand and set to take a mean reading over a ten-second sample interval.

8.107 It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. Alternatively they could be downloaded to a computer or data logger at the end of the test.

8.108 The test stand to be positioned on each test point in turn and the reading taken when the instrument has stabilised.

8.109 When taking a reading the test person should not stand within the same quadrant as the test instrument.

8.110 Readings are to be taken at the test positions with the instrument probe facing the wall housing the surgeon's panel, commencing at the first test position. Readings are taken working along the row from left to right and back, or for all text positions in one quadrant at a time.

8.111 When all test positions under one half of the terminal have been covered, readings of temperature and humidity are then taken at the specified height in the centre of the terminal. The read-outs on the surgeon's panel should be recorded at the same time.

8.112 Having completed one half of the test grid, the operating lamp arms and any other stem arms should be swung round through 180º and the test stand reversed so that the wall housing the surgeon's panel is behind the test person. Readings are recommenced starting at the right of the test row and working from right to left a quadrant at a time, as above.

UCV high-level discharge velocity test

8.113 Measurements of air velocity are to be taken at every test position 2m above floor level and the results averaged.

8.114 The average of the total readings taken is to be not less than:

0.38 m/s for a partial-wall system;

0.30 m/s for a full-wall system.

The average air velocity for each quadrant should not exceed ±6% of the measured average velocity for the terminal

UCV low-level air velocity test

8.115 Measurements of air velocity are to be taken at each of the inner zone test position 1m above floor level.

8.116 The measured velocity at every test position in the inner (operating) zone shall be not less than 0·2 m/s.

Horizontal UCV terminal air velocity test

Test set up

8.117 Set out the line of test positions as described previously.

8.118 Swing the operating lamp arms and any other stem arms so that they align to present the least resistance to air flow and are perpendicular to the line of test positions.

Test instrument

8.119 See that specified for vertical systems (Paragraph 8.105 refers).

Test method

8.120 The instrument should be mounted on a test stand and set to take a mean reading over a ten-second sample interval.

8.121 It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. Alternatively, they could be downloaded to a computer or data-logger at the end of the test.

8.122 The test stand should be positioned on each test point in turn and the reading taken when the instrument has stabilised.

8.123 When taking readings the test person should stand well downstream of the instrument.

8.124 Readings are to be taken at the test positions with the instrument probe facing the UCV terminal, commencing at the first test position on the left and working along the row from left to right at the specified height.

8.125 The instrument should be reset to the next specified height and the test repeated and so on.

8.126 Readings of temperature and humidity should be taken at the specified height in the centre of the terminal. The read-outs on the surgeon's panel should be recorded at the same time.

UCV discharge velocity test

8.127 Measurements of air velocity are to be taken at all test positions at 1m, 1·5m and 2m above floor level.

8.128 The average of the total readings taken should be no less than 0·4 m/s.

UCV entrainment test (Vertical systems only)

Rationale for the entrainment test

8.129 The performance of UCV systems may be compromised by room air being drawn into the ultra-clean airflow, a phenomenon known as “entrainment.” Significant levels of entrainment could lead to microbial contamination of items left exposed on instrument trolleys laid out beneath the canopy.

8.130 UCV systems having permanently fitted full sidewalls do not need to be tested, as the sidewalls physically prevent entrainment.

Principle of the test

8.131 A source of particles is produced outside of the UCV terminal and is used to challenge the system. A detector is placed within the ultra-clean airflow and used to determine the percentage penetration of the test particles at predefined locations under the UCV terminal footprint. The source and detector are moved in tandem around the UCV canopy and pairs of readings taken, from which the percentage penetration at specified locations is calculated. The degree of penetration should be below specified maximum limits if entrainment is to be declared not significant.

8.132 The entrainment test may be carried out using either of the following techniques:

- use DOPs to provide the challenge source at the specified release position and a photometer to measure the entrainment; or
- duct non-HEPA-filtered air to the specified release position and use a DPC to measure the entrainment.

Test set-up

8.133 The terminal face diffuser screen should be in place for these tests.

8.134 The test should be performed without any equipment in place beneath or closely adjacent to the UCV terminal.

8.135 The theatre lights should be moved to a central position beneath the terminal and raised to 2m above floor level, so as not to interfere with the peripheral airflows.

8.136 Take spot readings at the centre of the canopy, one metre from floor level, to establish that the room is within the specified temperature and humidity test conditions.

8.137 Set out the test grid as described previously.

8.138 For either of the following entrainment tests, a measurement of particle penetration through a representative section of the HEPA filter media is to be taken and used as the reference background level.

Test equipment, challenge source, measuring instrument and detector head

8.139 The challenge and detector equipment should be chosen so that:

- the tracer particles are mainly within the size range 0.3 to 5 microns and thus capable of remaining airborne for a substantial time;
- the particles used should not be able to penetrate the terminal filters in sufficient numbers to cause a background count that is more than 0.1% of the challenge count;
- the choice of particle and detector will enable a minimum of a three-logarithm (1,000-fold) range of counts to be recorded between the highest (that is, source) and lowest (that is, background) readings expected. (A concentration of approximately 10^5 particles per cubic metre of source air has been shown to be adequate.)

Source – Dispersed Oil Particles (D.O.P.)

8.140 The DOP generator should be able to produce a cloud of test particles in the form of a visible smoke. The test smoke should be delivered via an aperture so that it flows vertically downward from the lowermost edge of the partial wall, on the outside of the UCV canopy.

8.141 The test smoke is to be delivered via an aperture.

Note 4: To prevent undue contamination of the theatre and filters with deposits of oil, DOP should only be released for the minimum amount of time necessary to complete the test.

Challenge source – natural particles

8.142 The source unit should be a fan/blower or other method that takes non-HEPA-filtered air and expels it via a delivery head at the specified release position to provide the particle challenge. The challenge air should be delivered vertically downwards from the lowermost edge of the partial wall, on the outside of the UCV canopy, parallel to the airflow coming from the diffusers. The challenge air velocity should be the same as the measured average velocity at 2m from the terminal under test.

Note 5: The use of DOP for testing is gradually being phased out and replaced by a natural challenge measured with a DPC. At the time of writing research is under way to define more precisely a challenge source unit for natural particles. It is anticipated that such a unit, together with a matching test methodology, will become available during the life of this Scottish Health Technical Memorandum.

The detector (defined in terms of range and resolution)

8.143 This may be a photometer or a DPC. It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. The instrument should be capable of sampling a minimum a 28.3 litres of air per minute and in the case of the DPC, provide readings for particle size ranges from 0.3 microns to 5.0 microns and greater. The instrument should be compliant with the requirements of BS EN ISO 14644-1. An alternative instrument may be used providing it is of no lesser specification.

Test positions and orientation of source and detector

8.144 The test positions should be at the centre of each test square, as defined for the velocity test.

8.145 For rectangular UCV terminals, measurements of penetration are to be taken at the four corner test squares of the test grid and at intermediate positions along the line of test squares between the corners. The number of intermediate test positions will be as equally spaced as possible around the periphery with no fewer than 3 and no more than 5 complete test squares between test positions.

8.146 A further series of measurements are to be obtained around the periphery of the inner zone. Measurements of penetration are to be taken at the four corner test squares of the inner zone of the test grid and if necessary at intermediate positions along the line of test squares between the corners as equally spaced as possible, with no fewer than 3 and no more than 5 complete test squares between test positions.

8.147 A single measurement should be taken at the geometrical centre of the UCV terminal footprint. The centre measurement will be taken with the detector head mounted vertically upwards 1 metre above floor level.

8.148 The centre of the challenge particle source should be aligned with the centre of the designated test square, with its longer edge against the outer edge of the partial wall and delivering the challenge from the lower edge of the partial wall. The air containing challenge particles is directed vertically downwards from the lower edge of the partial wall, in a plane parallel to the adjacent partial wall. Where there is physical interference due to obstructions such as gas pendants, the source will be moved to the next available non-obstructed test-square location nearest to the stipulated sampling position. The detector should then also be moved to remain opposite the source.

8.149 In the case of non-rectangular terminals, an interpretation of the above strategy should be adopted that will yield a no less searching examination of the unit's ability to control entrainment.

Test method

8.150 The sampling head of the detector instrument is mounted on a test stand with its sampling orifice facing outwards horizontally from the centre of the UCV canopy, 1m above floor level. The sampling head should be orientated at right angles to the partial wall when sampling along the sides of the test grid but will be set to bisect the angle when measuring at the corner test positions (Figure 88 illustrates the challenge and detector orientations when evaluating a 2.8m x 2.8m UCV terminal).

8.151 The test will commence at the first test position, this being designated the leftmost corner of the test grid when facing the wall housing the surgeon's panel. The penetration will also be measured at the corresponding test point on the inner zone commencing at the corner nearest to the first test position. When these tests have been completed, the source and detector equipment should be moved to the next test positions, working around the test grid in a clockwise direction.

8.152 The test stand should be positioned on each test point in turn and a pair of readings (challenge, then penetration) taken when the instrument has stabilised. The detector should be set to take a reading over a 15 second sample interval.

8.153 When taking a reading the test person should stand within the UCV terminal footprint but not in the same quadrant as the detector head.

Analysis and interpretation

8.154 The following standard is to be achieved:

- penetration to be not greater than 10% of the challenge at each test position in the outer zone;
- penetration to be no greater than 1% of the challenge at each test position in the inner zone;
- penetration to be no greater than 0·1% of the challenge at the centre of the test grid.

If a result is close to, or above the given limits, then a further reading must be obtained using a longer time base (1 minute) and the penetration must not exceed the given limit.

Basis of the test

8.155 Whyte W, Shaw BH, Freeman MAR. An evaluation of a partial-walled laminar-flow operating room. *J Hyg Camb* 1974; 73: 61 – 75.

Whyte W, Lidwell OM, Lowbury EJL, Blowers R. Suggested bacteriological standards for air in ultraclean operating rooms. *J Hosp Infect* 1983; 4: 133 – 139.

UCV visualisation

8.156 The use of smoke to gain an understanding of the overall performance of the system may prove useful at this stage in the validation process but cannot be relied on to produce a contractually definitive measure of performance.

UCV noise level

8.157 An industrial-grade sound-level meter to BS EN 61672 Type 2 fitted with a muff should be used to check the noise level. The instrument should be calibrated using a matched sound source prior to each set of readings.

Vertical systems

8.158 The noise level readings should be taken at typical normal listening positions 1·5m above floor level and at least 1m from any surface and not on any line of symmetry. Measurements should be taken under the centre of each quadrant of the UCV terminal and the four readings averaged.

Horizontal systems

8.159 The noise level readings are to be taken at typical normal listening positions 1·5m above floor level on the test line. The width of the unit should be divided in two and a measurement taken in the centre of each half but avoiding any line of symmetry. The two readings should be averaged.

8.160 Measurements should also be taken in each room of the suite.

8.161 In the event of a contractual deficiency a Type 1 precision-grade sound-level meter complying with BS EN 61672 should be used. Readings should be taken at the positions specified above and in each case the logarithmic mean of the results should be calculated in order to determine the noise level. Further information can be found in SHTM 08-01 (2011).

8.162 For vertical or horizontal systems, the noise level shall not exceed:

- 50NR [55dB(A)] – for UCV operating rooms and spaces without doors that open directly on to it (for example the scrub);
- 40NR [45dB(A)] – for all other peripheral rooms of the suite.

UCV control system checks

Temperature

8.163 The readings of temperature taken under or in front of the UCV unit should be within ±1 K of each other and the read-out on the surgeon's panel.

Humidity

8.164 The readings of humidity taken under or in front of the UCV unit should be within ±5% of each other and the read-out on the surgeon's panel.

Direct-reading differential pressure gauges

8.165 The differential pressure across the terminal filter(s) should be measured to confirm the accuracy of the indicated reading of any gauge.

Control functions

8.166 The operation of all control functions provided on the surgeon's panel should be proved for conformity with the design specification.

8.167 If an auxiliary panel has been fitted then its interlocking with the main surgeon's panel control functions must be proved to conform to the design specification.

Panel indicator lights

8.168 The panel indicator lights should illuminate as appropriate when the control functions are selected or warning levels are reached

BEMS interface

8.169 The operation, monitoring and alarm functions must be proved to conform to those set out in the design specification.

UCV theatre microbiological tests

8.170 There is little value in performing microbiological sampling in a new theatre supplied with ultra-clean ventilation. The foregoing filter challenge tests, air velocity measurements and entrainment test should have proved that the system operates satisfactorily and achieves the contracted level of performance. The HEPA filters will remove bacteria-sized particles from the air supplied through the UCV terminal. Therefore there will be an insignificant number of bacterial and/or fungal CFUs present until the Theatre is actually used.

8.171 Once the theatre has been taken into use, microbial sampling during a surgical procedure should help to confirm the satisfactory performance of the system and discipline of the users. Before commencing bacteriological testing, the room and its ventilation system should have achieved a steady state condition: (see also Paragraph 8.74)

8.172 The installation should be tested during surgical procedure at intervals between the time of the first incision and final closure of the wound. On average, the air sampled within 300mm of the wound should not contain more than 10 CFU/m^3.

UCV validation report

8.173 Following validation a full report detailing the findings should be produced. The report shall conclude with a clear statement as to whether the UCV theatre suite achieved or did not achieve the standard set out above.

8.174 A copy of the report should be lodged with the following groups:

- operating department;
- infection control;
- estates and facilities.

Appendix 1: Recommended air-change rates

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
General ward	S / N	6	-	G4	30	18-28	
Communal ward toilet	E	10	-ve	-	40	-	
Single room	S / E / N	6	0 or –ve	G4	30	18-28	
Single room WC	E	3	-ve	-	40	-	
Clean utility	S	6	+ve	G4	40	18-28	
Dirty utility	E	6	-ve	-	40	-	
Ward Isolation room	-	-	-	-	-	-	See SHPN 4; Supplement 1
Infectious disease Iso room	E	10	-5	G4	30	18-28	Extract filtration may be required
Neutropenic patient ward	S	10	+10	H12	30	18-28	
Critical Care Areas	S	10	+10	F7	30	*18-25*	Isolation room may be –ve press
Birthing Room	S & E	15	-ve	G4	40	*18-25*	Provide clean air-flow path
SCBU	S	6	+ve	F7	30	*18-25*	Isolation room may be –ve press
Preparation room (Lay-up)	S	>25	35	F7*	40	*18-25*	*H12 if a lay-up for a UCV Theatre
Preparation room / bay sterile pack store	S	10	25	F7	40	*18-25*	*50NR if a bay in a UCV Theatre
Operating theatre	S	25	25	F7	40	*18-25*	
UCV Operating theatre	S	25*	25	H12	40	*18-25*	Fresh air rate; excludes re-circulation
Anaesthetic room	S & E	15	>10	F7	40	*18-25*	Provide clean air-flow path
Theatre Sluice/dirty utility	E	>20	-5	-	40	-	
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path

Table A1

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path
Cardiac catheterisation lab	S	15	+ve	F7	40	*18-22*	
Endoscopy room	S	15	+ve	F7	40	*18-25*	
Endoscopy cleaning	E	>10	-ve	-	40	-	
Day case theatre	S	15	+ve	F7	40	*18-25*	
Treatment room	S	10	+ve	F7	35	*18-25*	
Pharmacy aseptic suite	S	20	#	H14	-	*18-22*	# See EGGMP (Orange guide) a
Cat 3 or 4 containment room	#	>20	#	H14*	-	*18-22*	# See ACDP guide; *Filter in extract
Post mortem room	S & E	S = 10 E = 12	-ve	G4	35	*18–22*	Provide clean air-flow path
Specimen store	E	-	-ve	-	-	-	Fan accessible from outside of store

Table A1 continued

Notes: 18°C-22°C indicates the range over which the temperature may float

18°C-22°C indicates the range over which the temperature should be capable of being controlled

S = supply N = natural ventilation

E = extract [a] – European guidelines on good manufacturing practice published by the Medicines and Healthcare products Regulatory Authority (MHRA)

Appendix 2: Hierarchy of cleanliness

			Air-flow rate for bacterial contaminant dilution	
Class	**Room**	**Nominal pressure (Pa) a**	**Flow in or supply m^3/s**	**Flow out or extract m^3/s**
Sterile	Preparation room (a) lay-up (b) sterile pack store Operating room Scrub bay b	 35 25 25 25	See standard schemes in Appendix 3 for recommended design values	
Clean	Sterile pack bulk store Anaesthetic room c Scrub room	 +ve 14 c 14	6 ac/h The greater of 15 ac/hr or 0.15 -	- The greater of 15 ac/hr or 0.15 0.10
Transitional	Recovery room Clean corridor General access corridor Changing rooms Plaster room	3 0 0 3 3	15 ac/hr d e e 7 ac/hr 7 ac/hr	15 ac/hr d 7 ac/hr 7 ac/hr 7 ac/hr 7 ac/hr
Dirty	Service corridor Disposal room	0 -5 or 0	- -	f 0.41 or 0.10

Table A2

Notes (applicable to Table A2):

a. Nominal room pressures are given to facilitate setting up of pressure relief dampers, the calculation process, and the sizing of transfer devices. In practice, the resultant pressures are not critical, provided the desired airflow rates and movement are achieved.

b. An open or semi-open bay is considered to be part of the operating room; provided air movement is satisfactory, no specific extract is required. However if the layout means that air movement is poor, a local extract may be required to control local condensation on the building surfaces, which can result in mould growth.

c. For design purposes, anaesthetic should be assumed to be at 14Pa. When commissioning 10Pa is considered suitable.

d. 15 ac/hr are considered necessary for the control of anaesthetic gas pollution.

e. Supply airflow rate necessary to make up 7 ac/hr after taking into account secondary air from cleaner areas.

f. No dilution requirement. Temperature control requirements only.

Type	Pressure difference - Pa						
	5	10	15	20	25	30	40
Single door (CDB Size 2.4.3.2.6.)	.03	.05	.06	.06	.07	.07	.08
Double door (CDB)	.04	.08	.10	.11	.12	.13	.14
High permanent length of 3mm gap	.004	.008	.010	.011	.012	.012	.013

Table A3: Leakage flows in m^3/s through closed door gaps

Note: CDB = Component Data Base

It should be noted that many doors are now fitted with cold smoke seals as standard. These will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design leakage is factored into the sizing of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air gap whistles and doors being held partially open by air pressure.

Factory-assembled door-sets with a steel frame and pre-hung leaves have become common. There is effectively no leakage across these doors when closed. Therefore, when this type of door assembly is fitted, the door leakage can be ignored and the design airflow into the room reduced accordingly. The design airflow would then become that required either (i) for open door protection, or (ii) to achieve the specified air-change rate - whichever is the greater.

Room class		Dirty	Transitional	Clean	Sterile
Sterile	Hatch Single door Double door	0.3 0.47 0.95	0.24 0.39 0.75	0.18 0.28 0.57	 0 or 0.28 a 0 or 0.57 a
Clean	Single door Double door	0.39 0.75	0.28 0.57	0 or 0.28 a 0 or 0.57 a	
Transitional	Single door Double door	0.28 0.57	0 or 0.28 a 0 or 0.57 a		
Dirty	Single door Double door	0 0	Open single door = 0.80m x 2.01m high Open double door = 1.80m x 2.01m high		

Table A4: Recommended air flow rates in m^3/s through a doorway between rooms of different cleanliness to control cross-contamination

Designer's Notes:

a. The degree of protection required at an open doorway between rooms is dependent upon the degree of difference in cleanliness between them.

b. Flow rate required between rooms within the same class tends to zero as class reduces.

c. If two rooms are of equal cleanliness, no flow is required (in practice there will be an interchange in either direction) and the design of the air movement will assume zero air-flow. In certain cases, however, interchange is not permitted and protection airflow of 0.28 is assumed in the design, for example, in the case of a preparation room used as a "lay up".

		Effect on other rooms	
Door open between	Resultant pressure in these rooms (Pa)	Room	Pressure (Pa)
Operating room and corridor or Scrub bay and corridor	0	Anaesthetic Preparation – lay up Disposal Preparation – sterile pack store	0 12 -6 5
Operating room and anaesthetic room (or other series room with double doors)	17	Preparation – lay up Disposal Preparation – sterile pack store	26 -9 22
Operating room and disposal room or Operating room and preparation room	25	No change	
Anaesthetic room and corridor (or other series room with double doors)	0	Preparation – lay-up Disposal Operating room Preparation – sterile pack store	30 -6 20 25
Preparation room – corridor Disposal room & corridor	0	No change	
Disposal room & outer corridor	0	No change	

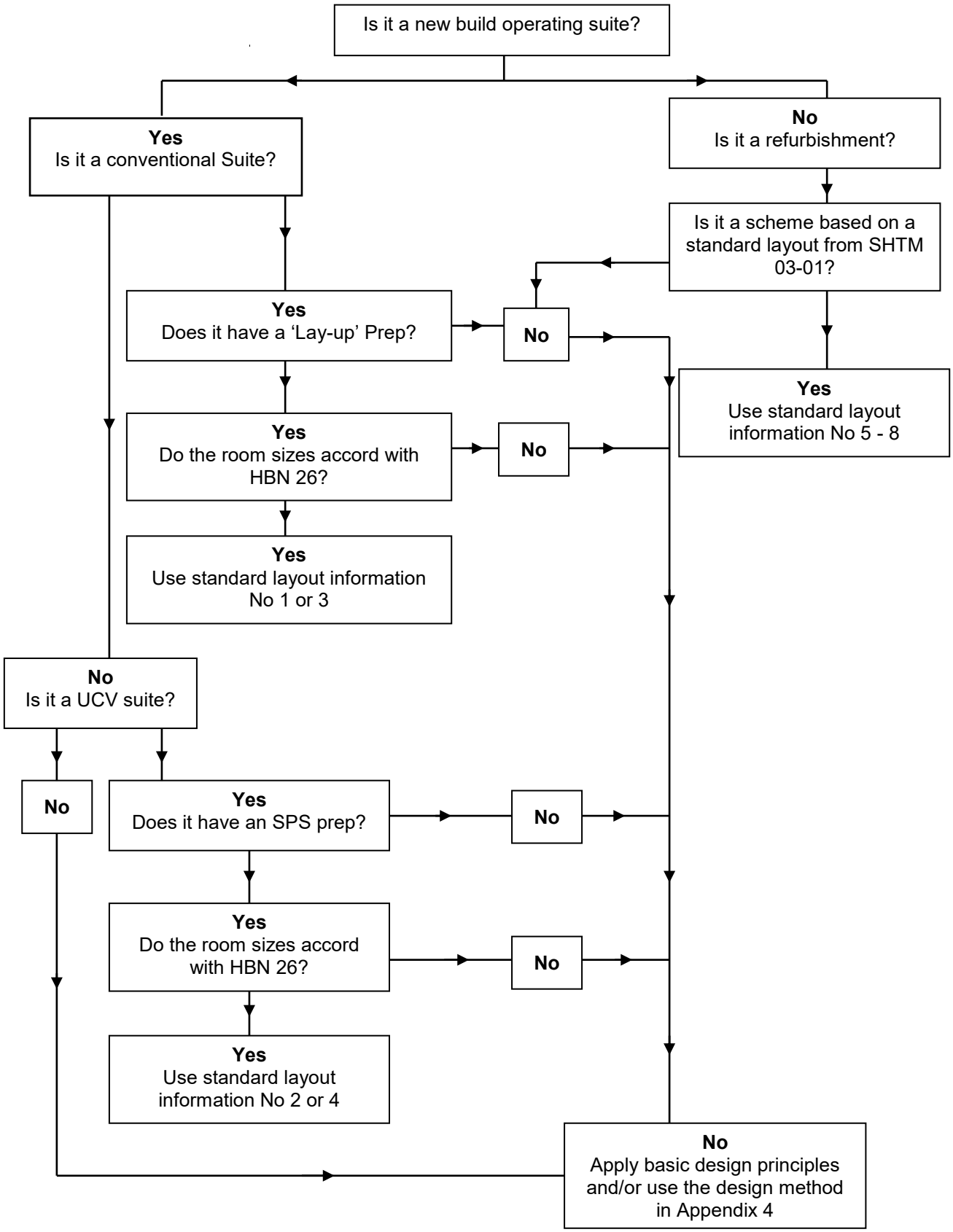
Table A5: Typical pressures in an operating suite when a given door is open

Notes: 1. The room differential pressure protects against reverse flows when the door is closed.

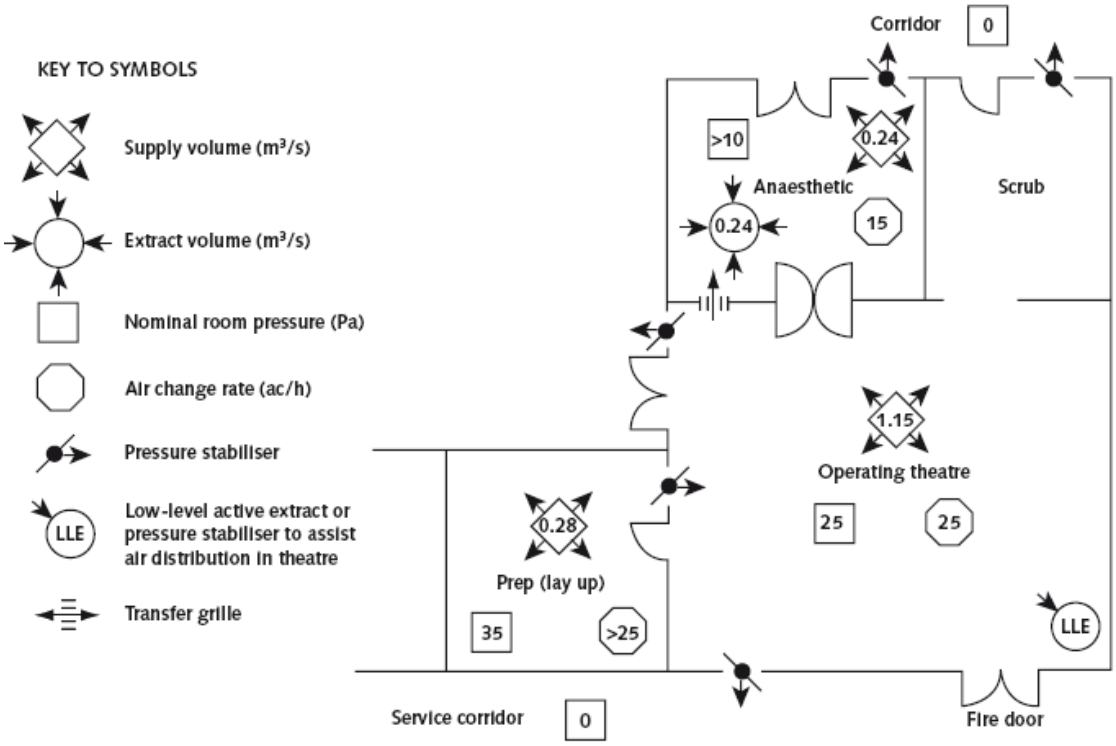
2. The flow of air through a doorway protects against reverse airflow when the door is open.

3. Pressure stabilisers control flow and ensure a known air-flow path between rooms when doors are closed and reduce back-flow between rooms when doors to other rooms are open.

Appendix 3: Operating suite design logic



New Standard Layout N° 1 - Suitable for a typical conventional theatre suite (Room sizes as specified in HBN 26)



Room	Size m³ Derived from HBN26	Air-Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15
Anaesthetic	57	15	>10	0.24
Lay-Up-Prep	36	>25	35	0.28**
Scrub	*	-	25	-

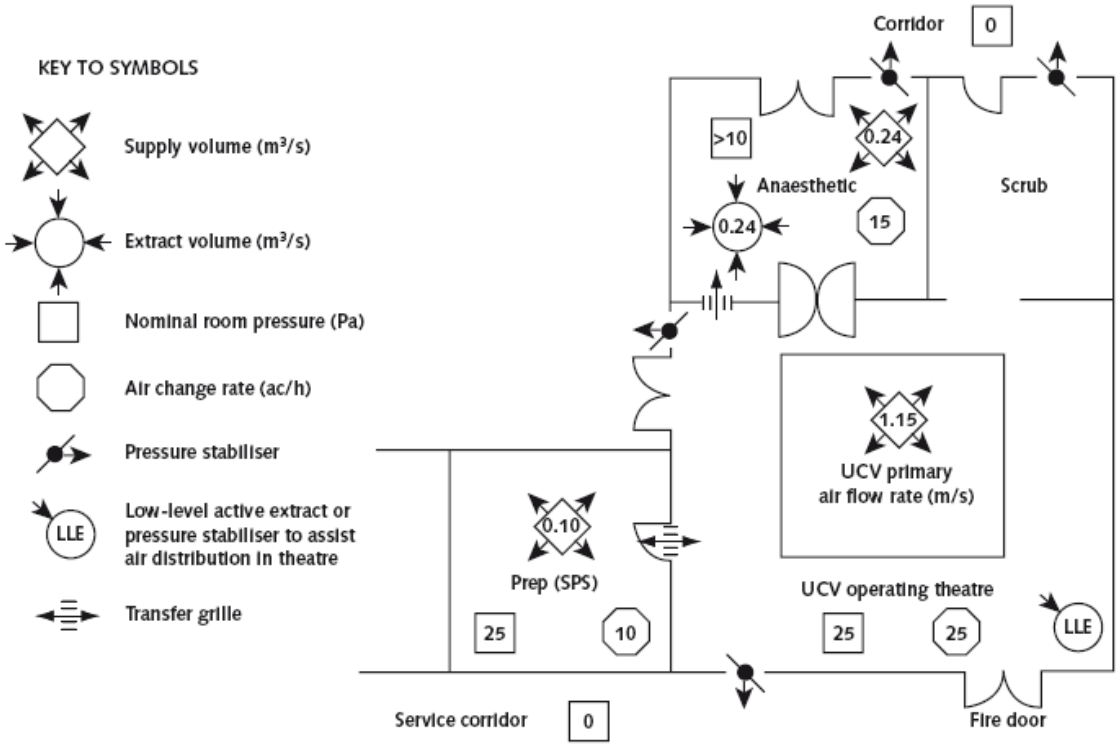
*This is a separate scrub and is not considered as being part of the theatre volume.

**Interchange is not permitted between the theatre and lay-up prep; therefore an airflow protection of 0.28 + 0.06 closed-door airflow is required as a minimum.

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilisers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 2 - Suitable for a typical UCV theatre suite (Room sizes as specified in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15**
Anaesthetic	57	15	>10	0.24
Sterile Prep	36	25	25	0.10
Scrub	*	-	25	-

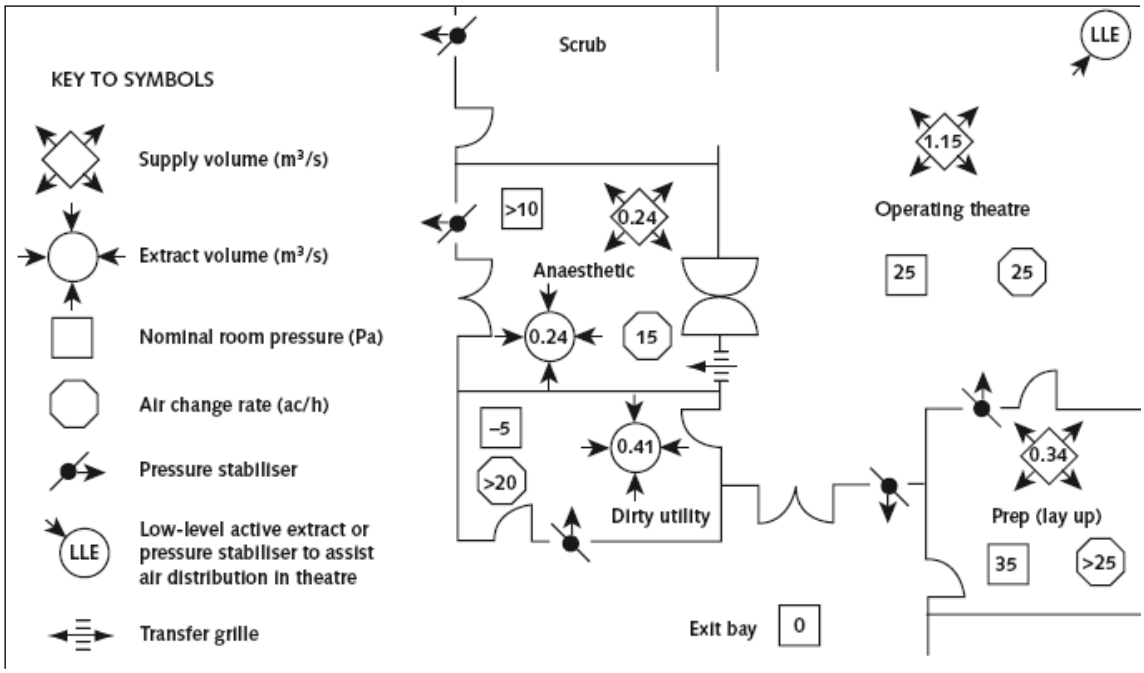
*Separate scrub and not considered as part of theatre volume

**Primary Fresh air Volume Only

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 3 - Suitable for a typical Conventional theatre suite (Layout and room sizes are as illustrated in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15
Anaesthetic	57	15	14	0.24
Lay-Up Prep	36	>25	35	0.34**
Scrub	*	-	25	-
Dirty Utility	36	-	-5	0.41

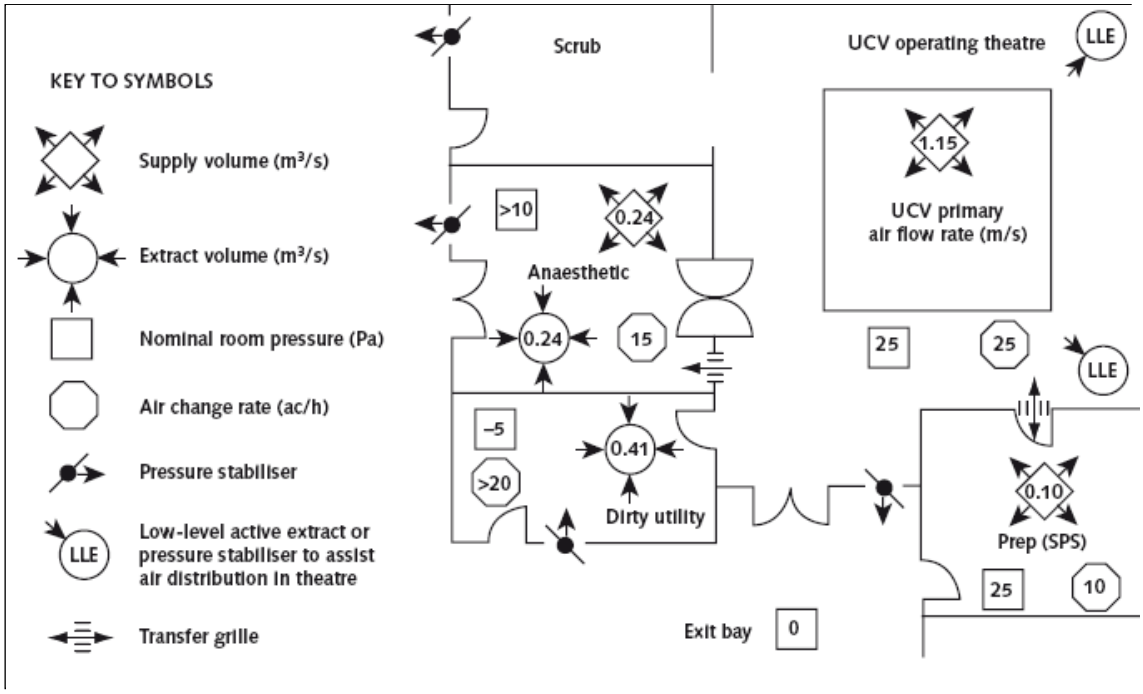
*Separate scrub not considered part of theatre volume.

**Interchange is not permitted between the theatre and lay up prep therefore as Table 4 an airflow protection of 0.28 + 0.06 closed door air flow is required as a minimum.

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 4 - Suitable for a typical UCV theatre suite (Layout and room sizes are as illustrated in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15**
Anaesthetic	57	15	>10	0.24
Sterile Pack Prep	36	10	25	0.10
Scrub	*	-	25	-
Dirty Utility	36	-	-5	0.41

* Separate scrub not considered part of theatre volume

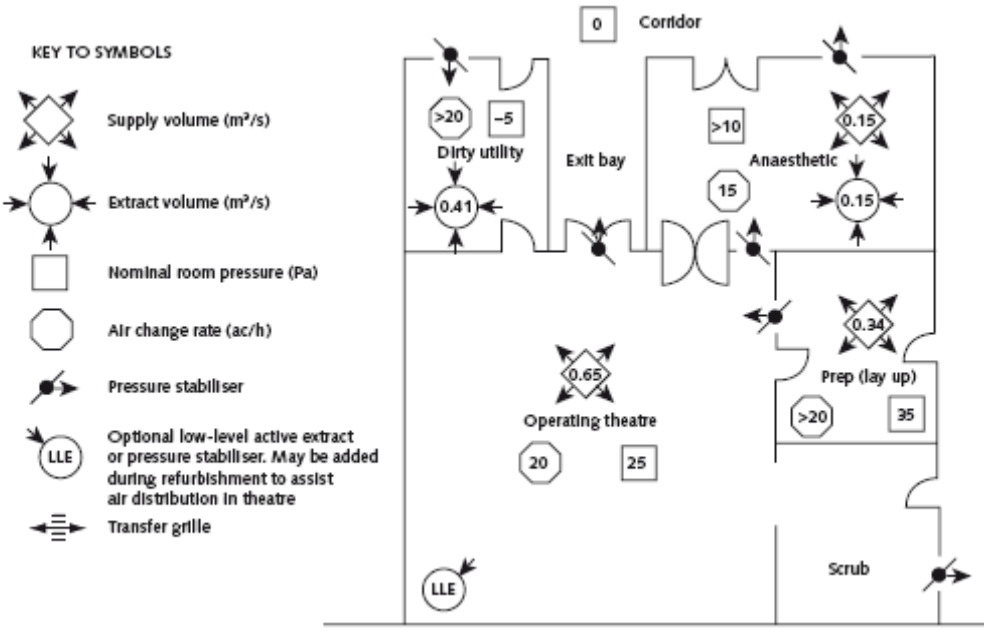
**Primary Fresh air Volume Only

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 5 - SHTM 2025 Existing standard plan '1b' typical layout for a conventional theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.

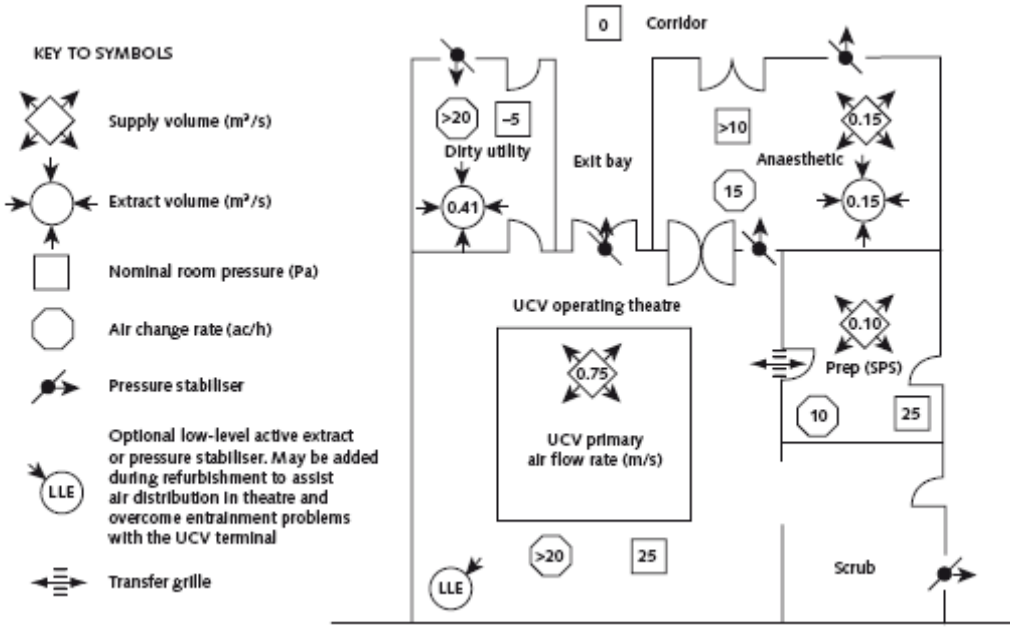


Room	Size m^3	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m^3/s
Theatre	Existing Theatre Suite to Be measured on site	20	25	0.65
Anaesthetic		15	14	0.15
Lay-Up Prep		-	35	0.34
Scrub		-	25	Included within theatre
Disposal		-	-5	0.41

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor.

Standard layout No 6 - SHTM 2025 Existing standard Plan '1a' Typical layout for a UCV theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.



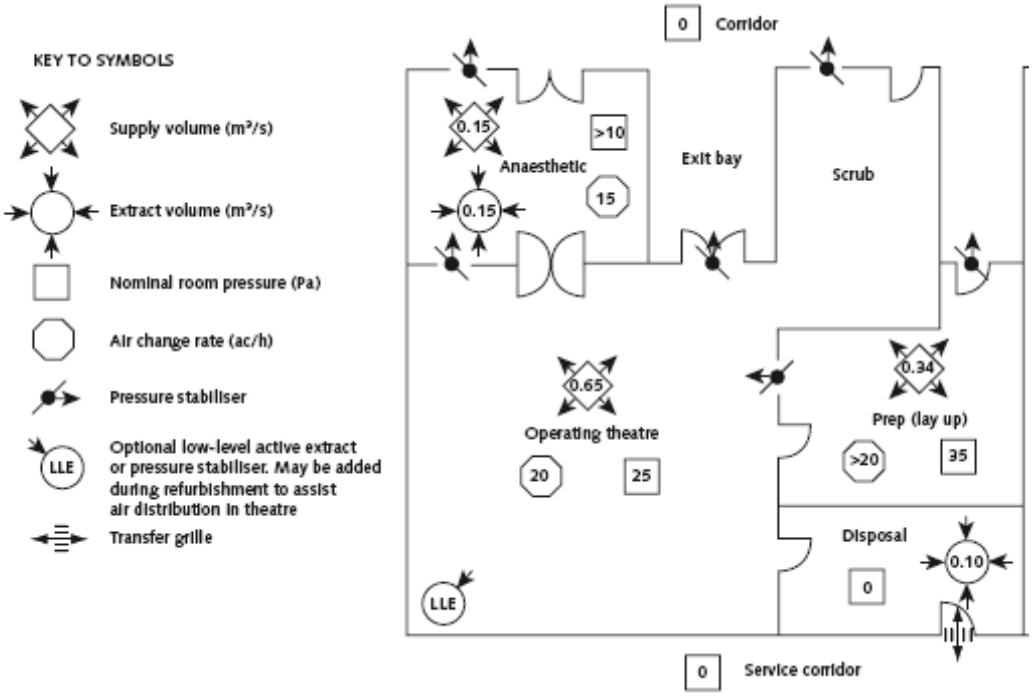
Room	Size m^3	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m^3/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.75*
Anaesthetic		15	>10	0.15
Sterile Pack Prep		10	25	0.1
Scrub		-	25	Included within theatre
Disposal		-	-5	0.41

*Primary fresh airflow volume

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor.

Standard layout N° 7 - SHTM 2025 Existing standard Plan '5b' Typical layout for a conventional theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.

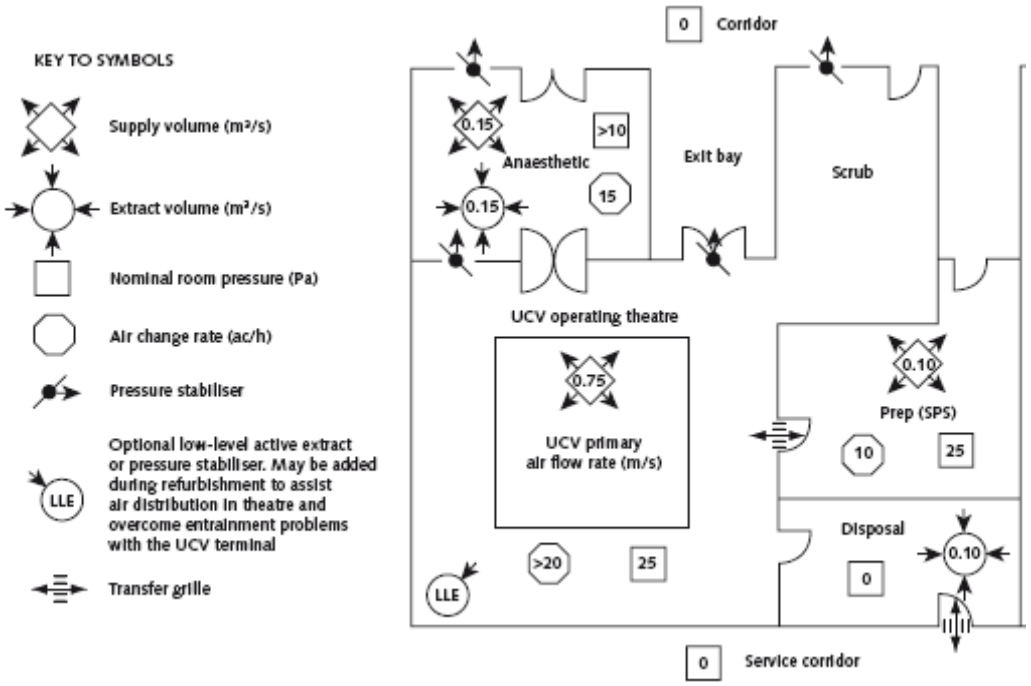


Room	Size m³	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.65
Anaesthetic		15	>10	0.15
Lay-Up Prep		>20	35	0.34
Scrub		-	25	Included within theatre
Disposal		-	0	0.1

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor. Alternatively the disposal room could be omitted and replaced with a disposal hatch between the theatre and corridor.

Standard layout N° 8 - SHTM 2025 Existing standard Plan '5a' Typical layout for a UCV theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.



Room	Size m³	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.75*
Anaesthetic		15	>10	0.15
Sterile Prep		10	25	0.1
Scrub		-	25	Included within theatre
Disposal		-	0	0.1

*Primary fresh air-flow volume only

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor. Alternatively the disposal room could be omitted and replaced with a disposal hatch between the theatre and corridor.

Appendix 4: Design of air-movement control schemes for operating theatres.

General

A4.1 Standard operating suite design solutions are given in Appendix 3. If these standard solutions cannot be used, the following procedure should be adopted, which will result in an acceptable design. Note that the method employed can equally be used to provide a design solution to a ventilated suite of rooms for any application.

A4.2 The method is concerned with the calculation of airflow rates to ensure that correct air movement occurs between rooms when any one door is open. Under most circumstances, the air quantities required for air-movement control will approximate to those for either temperature control or bacterial contaminant dilution. This flow rate is sufficient to control the effects of any slight reverse flows occurring when a door is opened.

A4.3 The progression through the design procedure is shown in the airflow design procedure chart (Figure A4/3) and is supported by worksheets WS1 to WS7 described in Paragraph A4.4. It is recommended that a plan of the suite and an airflow network be made (Figure A4/2) to collate all information. Flow rates, air-transfer devices etc should be entered as required. The remainder of this Appendix may be treated as reference data to assist in the various steps. The following symbols are used:

S_S – supply airflow rate for summer temperature control;

S_W – supply airflow rate for winter temperature control;

S_D – supply airflow rate for dilution of bacterial contaminants;

S_L – supply airflow rate for heat loss;

S_G – supply airflow rate for heat gain;

E_D – extract airflow rate for dilution of bacterial contaminants;

S_F – final supply airflow rates;

E_F – final extract flow rates;

S_{AMC} – air-supply flow rate for air-movement control;

E_{AMC} – air-extract flow for air-movement control;

L_{OUT} – leakage airflow rate outward;

L_{IN} – leakage airflow rate inward;

$\sum_{OUT}$ – total airflow rate outward;

$\sum_{IN}$ – total airflow rate inward.

A4.4 To simplify the procedure, standard worksheets (WS1 to WS7) have been devised. For each operating suite, a set is required comprising one each of WS1, WS3, WS5, WS6a, WS6b and WS7, one WS4 for each corridor and one WS2 to cover each peripheral room. WS2 has five versions:

- WS2a single flow;
- WS2b parallel/series multi-flow;
- WS2c parallel multi-flow or series multi-flow (unbalanced);
- WS2d series multi-flow (balanced); and
- WS2e bay (semi-open).

Peripheral room type

A4.5 The rooms in the operating suite other than the operating room and corridor are referred to as peripheral rooms. Peripheral rooms have been classified according to the flows in and out. These room classifications are defined below in Paragraphs A4.6 – A4.11.

Single flow

A4.6 This is a room with only one door and a net surplus of supply or extract air.

Parallel multi-flow

A4.7 This is a room with two or more doors through each of which the air-flows either outwards (high-pressure) or inwards (low-pressure) (for example the Prep (lay-up) in standard layout 5).

Parallel/series multi-flow

A4.8 This is a room having a net surplus of supply or extract and with two or more doors. One or more doors will be to an area of equal cleanliness and need not be protected; hence, the flow may vary between inwards and outwards, the remaining door being to an area of greater or lesser cleanliness (for example the Prep (SPS) in standard layout 6).

Series multi-flow (unbalanced)

A4.9 This is a room having a net surplus of supply or extract and with two or more doors. Air flows inwards through one or more doors and outwards through one or more doors.

Series multi-flow (balanced)

A4.10 This is a room as in Paragraph A4.9 above, but having either no mechanical ventilation or no net surplus of supply or extract. (for example an anaesthetic room).

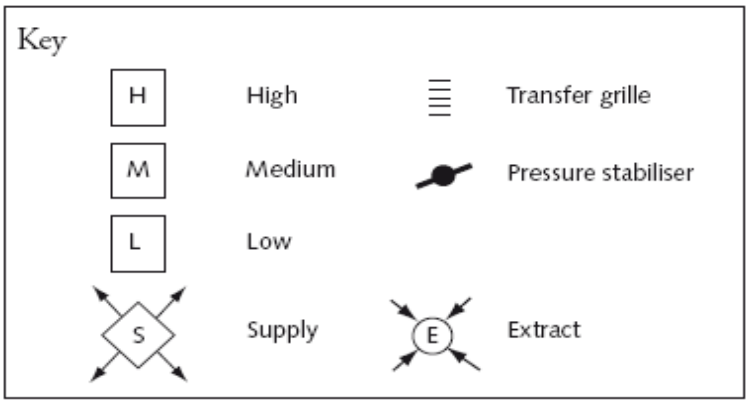
Bay

A4.11 A room that has a permanent opening to the operating room may be considered as a bay off the latter (for example a scrub). Two categories exist:

- open bay – the opening is larger than a normal single door opening. The bay may be considered as part of the main room;
- semi-open bay – the opening is no larger than a normal single door opening. In this case it is possible to protect the bay from the main room by provision of air supply or extract in the bay, or by passing air to or from another area.

Air-movement control in peripheral rooms

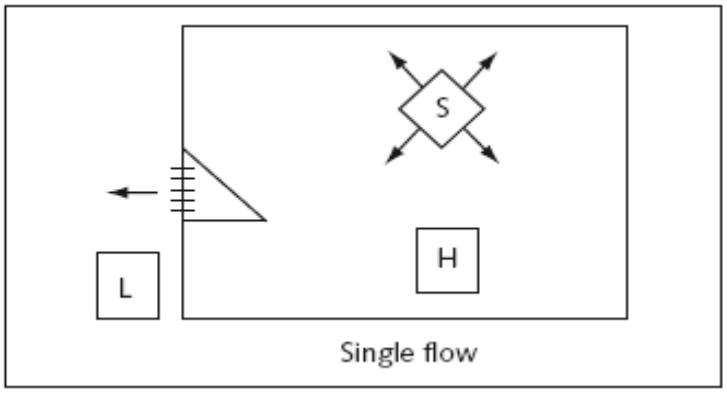
A4.12 For the design of air-movement control, two types of air-transfer device are considered. These are transfer grilles and pressure stabilisers. Each has a particular field of application within the design, as described in Paragraphs A4.34 – A4.43. Air movement is controlled in each of the different room types described in Paragraphs A4.13 – A4.31.



Note: This key applies to each diagram in A4.13 - A4.27.

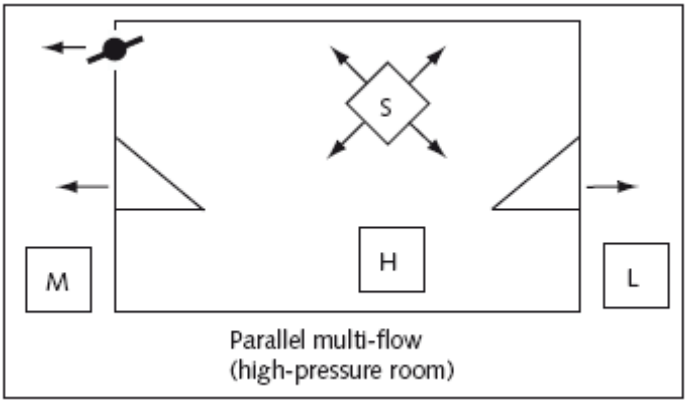
Single flow rooms

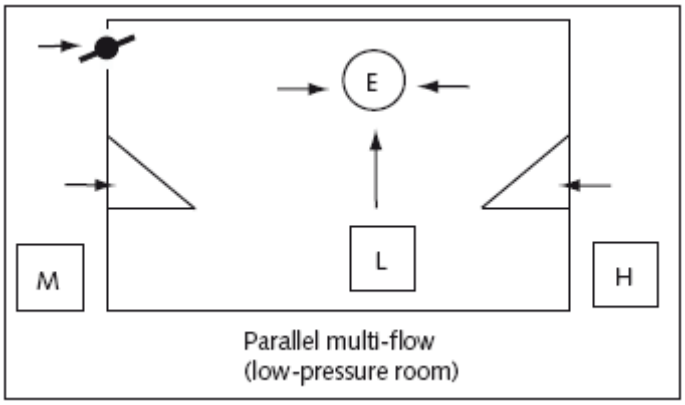
A4.13 An appropriately sized transfer grille should be located in or adjacent to the door of each single flow room to relieve the pressure differences across the door when closed.



Parallel multi-flow rooms

A4.14 The pressure difference across the closed doors must be relieved, but transfer grilles are not appropriate where two doors lead to areas of different pressures, because reverse flow could occur when the other door is open. For this reason, pressure stabilisers are used.



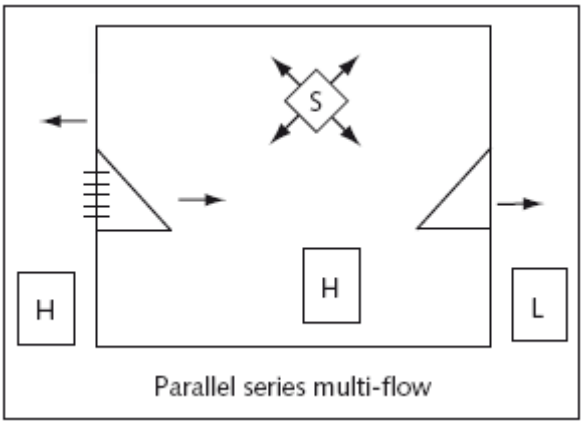


A4.15 These rooms will be either high-pressure or low-pressure with respect to the adjacent areas (see preparation lay-up room and disposal room, respectively, in standard layout 5). The pressure-relief damper is always situated between the room and area, which results in the smaller differential pressure to ensure best use of air.

A4.16 Just as reverse flow can occur if transfer grilles are used, it can similarly occur via door gaps when the other door is opened. It is not possible to avoid this, except by using air locks, but due to the low flow rates and short durations involved, this is not considered to be of importance.

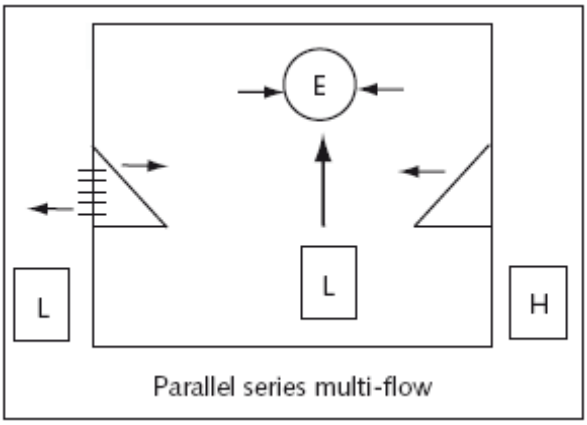
Parallel-series multi-flow rooms

A4.17 These rooms are similar to those in Paragraph A4.14 above, but because the room is of equal cleanliness to one of the adjacent rooms the nominal pressures will be equal and air may flow through the adjoining doorway in either direction. (for example the Prep (SPS) in standard layout 6).



Parallel series multi-flow

A4.18 Where the nominal room pressure equals that of the higher-pressure adjacent room, the best use of air is by supplying air required for bacterial dilution only and allowing this to exhaust via a transfer grille to the area of equal cleanliness. The doorway to the lower pressure area is protected by the combination of the supply air and the air that will flow inwards through the transfer grille from the area of equal cleanliness.

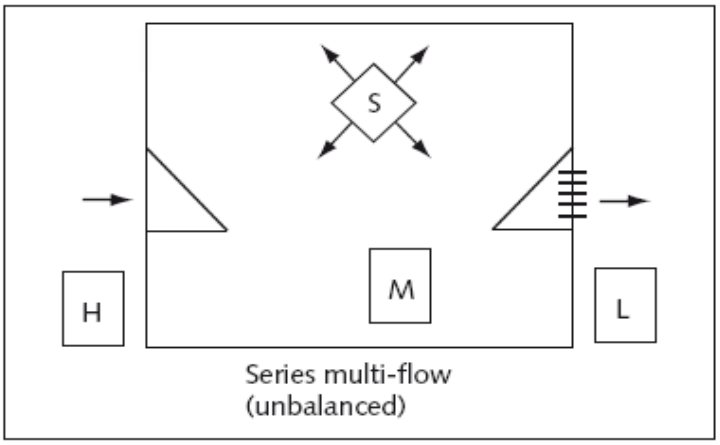


Parallel series multi-flow

A4.19 Conversely, where the nominal pressure equals that of the lower-pressure adjacent room, extract ventilation and a transfer grille to the lower pressure adjacent room should be provided. (for example, the disposal room in standard layout 8).

Series multi-flow (unbalanced)

A4.20 These rooms are somewhat similar to those in Paragraph A4.15 above, but because the pressure lies between that of the rooms on either side, the back-flow problem does not exist.



Series multi-flow (unbalanced)

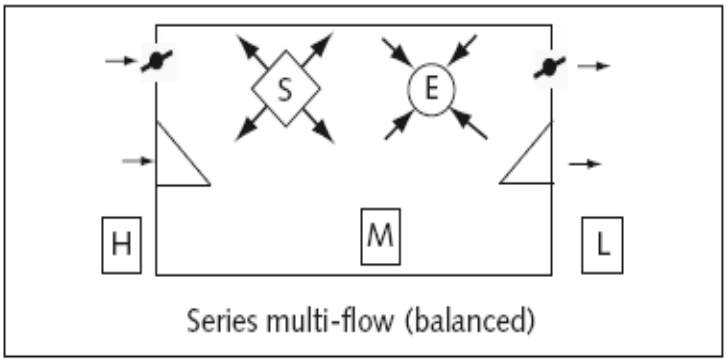
A4.21 Where the room has a net surplus of mechanical supply air, a transfer grille should be located in or adjacent to the door through which air flows outwards, and the mechanical supply flow rate to the room should be chosen to give protection when this door is open.

A4.22 Where the room has a net surplus of mechanical extract air, a transfer grille should be located adjacent to the door through which the air flows inwards, and the mechanical extract flow rate to the room should be chosen to give protection when this door is open.

A4.23 The grille must be sized for the protection requirement of the opposing door when open. When the room on the high-pressure side depressurises, there is a possibility of back-flow through gaps around the door, but this problem may be ignored.

Series multi-flow (balanced)

A4.24 In these rooms, a transfer device adjacent to each doorway is required in order to provide a flow path for the air required to protect the opposing door when opened.



Series multi-flow (balanced)

A47168969

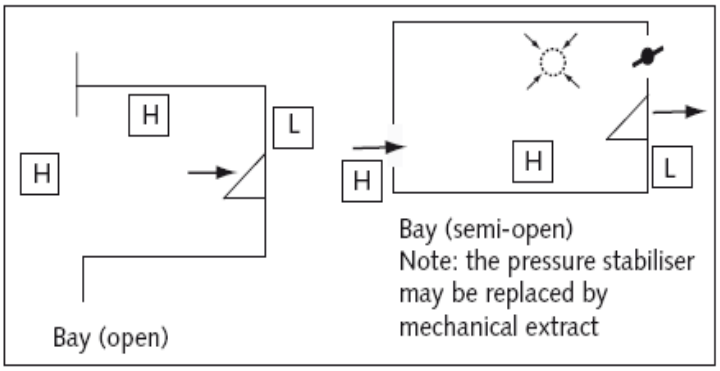
A4.25 These transfer devices will normally be pressure stabilisers, although transfer grilles may be used where a large amount of excess air is to be exhausted from the operating room when all doors are closed. (for example, anaesthetic rooms).

A4.26 The calculation procedure is to assume that pressure stabilisers are being used; then (if there is sufficient excess air) change to transfer grilles as described in Paragraph A4.50.

Bay

Open bay

A4.27 A bay of the open type (for example scrub-up) is considered to be part of the operating room. Provided air movement is satisfactory, no specific extract is required.



Semi-open bay

A4.28 In a bay of the semi-open type, protection of one area from the other is possible. (For example scrub-up).

A4.29 As stated previously, the need for protection between operating room and scrub-room is not very great. Better use of air can therefore be achieved in this case by installing a pressure stabiliser between the scrub-room and clean corridor. This will allow a flow of air through the scrub-room at all times, except when a door is opened elsewhere in the suite. The pressure stabiliser will then close and the air will be diverted to the other door. When it is considered necessary to protect the scrub-room at all times, either a transfer grille to the corridor or mechanical extract in the scrub-room should be provided.

Operating room

A4.30 Once the peripheral rooms have been considered, the operating room requirements may then be decided and the supply flow rate required for air-movement control calculated. This flow rate should be such that, with any one door open, the correct air movement directions are maintained. There will be one door in the suite that will require the largest supply flow rate to the operating room for protection when open. This is called the “key door” and is discussed separately in Paragraph A4.33. Use of this concept avoids repetitive

calculations for each door in turn. Having established the required supply flow rate, a relief route must be provided to the clean corridor for any excess air when the doors are closed. This would be via transfer grilles or pressure stabilisers through a series-flow room or via pressure stabilisers to the clean corridor directly.

Corridors

A4.31 All surplus air from the suite, except that lost through structure leakage and any passing to the outer corridor, will arrive in the patient/staff corridor. Should this air be insufficient to achieve the required air-change rate (see Appendices 1 and 2), some additional air supply should be provided. (The air balance should take account of structural leakage.)

Door opening

A4.32 Whereas the resulting pressures are dependent on ductwork layout, room relationships and characteristics of the fan, the generalisations shown in Appendix 2 can be used to estimate the change in room pressure when a door is opened.

A4.33 The “key door” will be the open double door which leaves the operating room at the highest pressure, and/or requires the largest air flow. This should be determined using the procedure in worksheet WS3.

Transfer grilles

A4.34 These may be used to limit the pressure differences across the closed door of a single-flow room or, in some instances, for protection of a series-flow or parallel-series-flow room. They allow airflow in both directions and may not be suitable for all applications.

A4.35 The free area of a grille is calculated from the following equation:

$$A = \frac{Q}{0.84\sqrt{\Delta P}}$$

where:

A is free area (m^2)

Q is flow rate (m^3/s)

P is pressure difference (Pa).

A4.36 The flow through a grille at a different pressure may be found from the following equation:

$$Q_2 = Q_1\sqrt{\frac{\Delta P_1}{\Delta P_2}}$$

where:

Q_1 and P_1 are original flow and differential pressure

Q_2 and P_2 are new flow and differential pressure.

A4.37 The transfer grille may be replaced by carefully proportioned door undercuts of the equivalent free area.

A4.38 The function of the transfer grille is to provide a means of airflow control by which the volume and pressure loss can be established. If a grille is used, it should have an easily removable core to facilitate cleaning.

Pressure-relief dampers

A4.39 The functions of a pressure-relief damper are now carried out by pressure stabilisers. Accordingly, all further mention of them has been removed from this document.

Pressure stabilisers

A4.40 Pressure stabilisers can be adjusted to hold the pressure constant over a wide range of flow rates. They are used where requirements exist for accurate room-pressure control or rapid shut-off on pressure fall.

A4.41 The installation of a grille or baffle in association with a stabiliser will alter the operating characteristics. It is recommended that a location be chosen to avoid the need for visual screening, for example, at high level. The location should be chosen to minimise the likelihood of damage.

A4.42 The stabilisers used should be virtually silent in operation, adjustable on site, maintenance-free and of a type that cannot be wrongly inserted. They should not be used in external walls or where the pressure difference is less than 5 Pa. The required size of a pressure stabiliser is dependent on the design pressure difference across it and flow rate through it. The manufacturer should provide data relating pressure difference to mean velocity (or flow rate per unit area). From this, the required area can be calculated and then rounded-up to the nearest size manufactured or nearest combination of smaller sizes.

A4.43 It is sometimes possible to arrange for a pressure stabiliser to perform two tasks. In an anaesthetic room, for example, the two pressure stabilisers may be made to pass the open door protection air, and also control the operating and anaesthetic room pressures with the door closed. To achieve this, the stabilisers are sized for the flow rate required with one of the doors open, but

the pressure setting is adjusted to be the value required with the doors closed. This is shown in Figure A4/1.

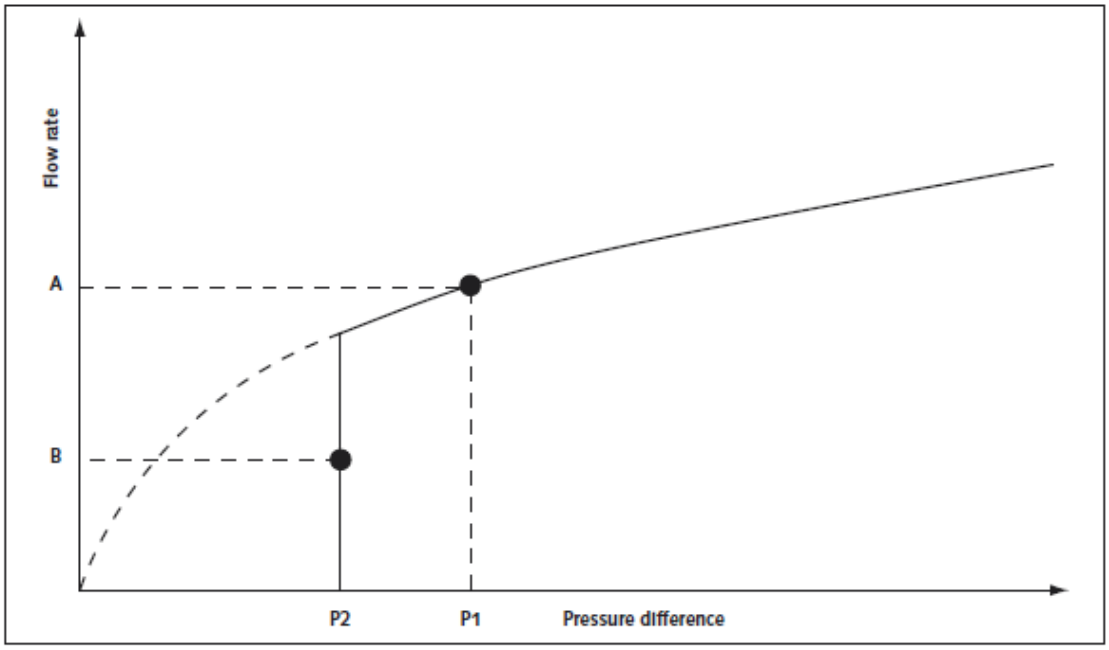


Figure A4/1

Door leakage flows

A4.44 For an air-movement control scheme to work satisfactorily, it is essential that the estimates of door-gap leakage made at the design stage are closely related to those which are achieved in practice. The calculation of gap-flows is complicated by the fact that such flows generally fall into the transition region between laminar and turbulent flow and hence do not follow the normal flow equations. The gaps assumed are 4mm along the bottom, 3mm at the top and sides, and 2mm between double leaves. Doors should not have wider gaps than these. Tighter gaps would result in lower flow-rate requirements and hence lower fan power, but care should be taken to ensure that all doors in the suite have similar gap dimensions. It may be possible to ignore the door leakage and so reduce the airflow requirement (see the notes in Appendix 3).

Room temperature estimation

A4.45 The air-flow rate required to prevent back-flow through an open door is dependent on the temperature difference across the door. The design figures shown in Appendix 3 are based on the temperature differences that will normally occur in practice, assuming heat gains and losses in accordance with Appendix 2.

A4.46 In accordance with the airflow design process, the temperature differences across the doors of all rooms classed as “sterile” is calculated. Worksheet WS6 is recommended for the calculations, using the following criteria:

- assume that the operating room is being controlled at 20°C and calculate the incoming air-supply temperature as shown on worksheet WS6;

- the calculation should be repeated for both summer and winter conditions, with an operation in progress;
- assume all doors are closed;
- use the room supply flow rates from WS1;
- use the inward air flows through air-transfer devices and closed door leakages from WS2a to WS2e;
- the formula used in worksheet WS6 is as follows:

$$T = \frac{(t_1Q_1 + t_2Q_2 + \cdots + t_nQ_n) + 0.828H}{(Q_1 + Q_2 + \cdots Q_n)}$$

where:

Q = flow rate from source (m^3/s)

t = the temperature of source (°C)

H = the room heat gain (kW).

A4.47 If the evaluated temperature differences between rooms do not exceed 2°C, the solution is satisfactory; otherwise proceed as follows:

- check the assumption on which the heat gains are based;
- take steps to reduce the heat gains;
- if the door is to a corridor, the flow through the open door will be larger than the value given in Appendix 2. Calculate on WS3, assuming it is the “key door” with door-flow unknown, and the supply as known;
- if the door leads to a room with mechanical supply, install a trimmer heater in the supply to the room controlled by either a differential thermostat or a thermostat slaved to the operating room thermostat to ensure that T is minimized.
- If the door leads to a room with no mechanical supply, increase the door protection flow as follows:

$$Q_{new} = Q_{old}\left[\frac{\Delta T + 1}{2}\right]$$

A4.48 These options should be considered in the above order, and the first three should be investigated thoroughly before proceeding to the latter two. The mechanical supply may need to be increased in order to achieve the desired air-change rates.

Relief of excess air from operating room when all doors are closed

A4.49 As the mechanical supply to the operating room is sized to provide an appropriate flow outward through any door that is opened, it follows that when all doors are closed, there will be more air supplied to the operating room than

can exit from it via leaks etc. This “excess” air can be relieved by either of the two methods described in Paragraphs A4.50 - 4.54.

By transfer devices via the anaesthetic room

A4.50 For door protection, the transfer devices in the anaesthetic room are typically designed to pass 0.47 m^3/s at a differential pressure of 14 Pa. When the doors are closed, the differential pressure will change to 11 Pa between theatre and anaesthetic room, and 14 Pa between anaesthetic room and corridor; the volume of air passed by the transfer devices will be modified as shown in the following formula:

$$Q = Q_1\left(\frac{\Delta P_1}{\Delta P_2}\right)^{1/2}$$

$$= 0.47\left(\frac{11}{14}\right)^{1/2}$$

$$= 0.42\ m^3/s$$

where:

Q = “excess” air to be vented with doors closed;

Q_1 = air-flow required for door protection through transfer device;

ΔP_1 = nominal differential pressure with door to operating room closed and door to corridor closed;

ΔP_2 = nominal differential pressure between either the anaesthetic room and corridor when the operating room door is open, or the anaesthetic room and operating room when the corridor is open. This differential pressure is used when selecting size of both devices.

A4.51 If the “excess” air is less than 0.42 m^3/s, a pressure stabiliser is required to ensure that the correct protection airflow is available to pass through the door.

A4.52 If the “excess” air is greater than 0.42 m^3/s, a transfer grille is acceptable because at all times the airflow will exceed the flow required for door protection.

By pressure stabilisers to the corridor

A4.53 If it is undesirable to pass operating room air through the anaesthetic room, it may be passed directly to a corridor via a separate pressure stabiliser.

A4.54 If there is sufficient “excess” air, the transfer grille solution at Paragraph A4.52 should be adopted, as it provides the simplest solution and, once set up, will require no further maintenance. With less excess air, it is recommended that the air be passed through the anaesthetic room via the pressure stabilisers as at Paragraph A4.51, thus keeping the number of pressure stabilisers to a minimum. Both these solutions increase the air-change rate in the anaesthetic

room, but care should be taken to avoid passing excessive amounts through that would cause discomfort to the occupants.

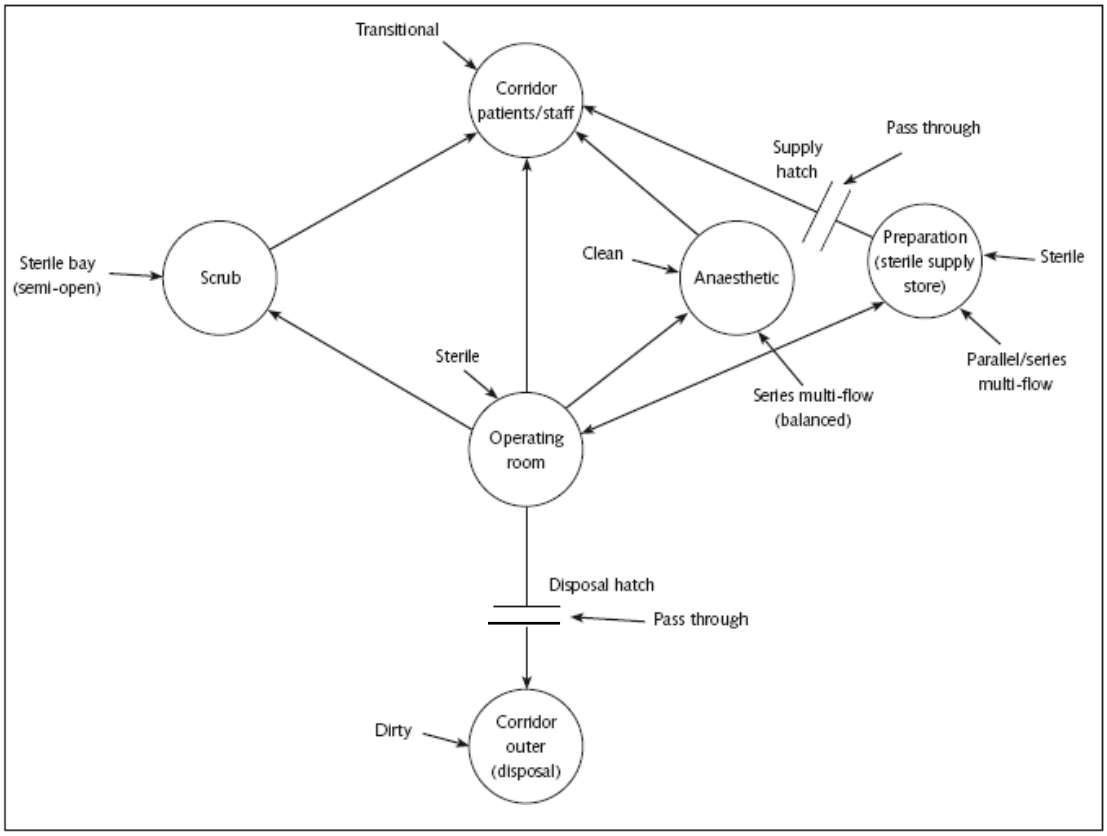
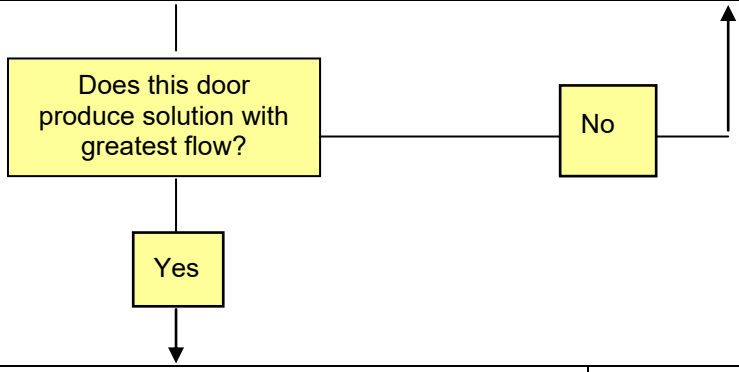
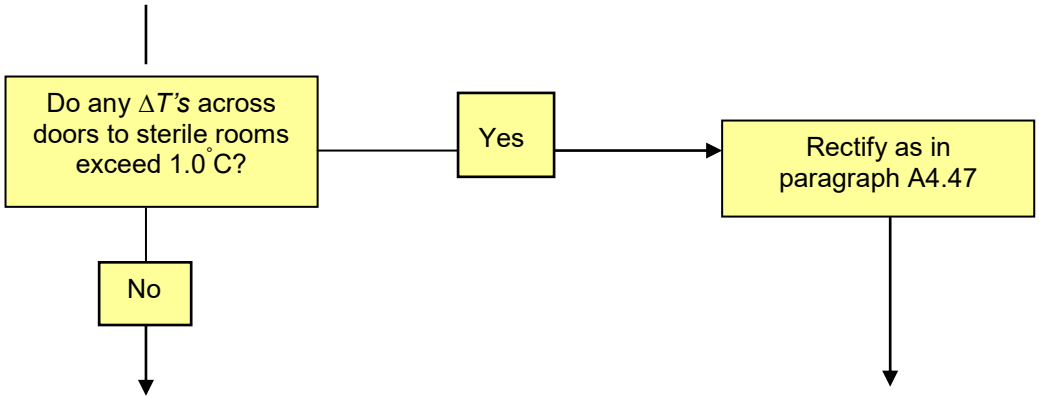


Figure A4/2: An example of an airflow network

Step	Description	Worksheet
1	Show nominal room pressures and air flow directions on the plan of the theatre suite and WS1	WS1
2	Enter heat/loss/gain data and calculate supply airflow rates for temperature control only. Categorise room types e.g. sterile, clean etc.	WS1
3	Enter airflows required for bacterial contamination control or air change rate whichever is the greater, add supply and extract volumes (S_D, E_D) on the plan.	WS1
4	Define peripheral room types, see paragraphs A4.5 - A4.11, and select appropriate worksheets.	Select from WS2a - WS2e
5	Locate air transfer devices, enter details on worksheets and locate on the plan and Figure A4/2	Selected worksheets from WS2a - WS2e
6	For each peripheral room, determine air flows through doors when open and calculate mechanical supply or extract and transfer device flows	As above
7	Select "Key Door" and calculate air supply for operating room	WS3



8	Transfer to WS1 and select final rate S_F and E_F	WS1. WS3
9	Make provision for relief of excess air with doors closed	Selected Worksheets and WS3
10	Calculate supply and extract flow rates for corridor(s)	WS4, WS5
11	Calculate room temperatures (all doors closed) and ΔT's	WS4, WS5



12	Make summary of flows	WS6a and WS6b
13	Size transfer devices, size ductwork, central plant etc	WS7
14	Design ductwork layout, control plant etc	

Figure A4/3: Airflow design procedures

Note: In the following worksheets WS1, WS2a-e, WS3, WS4, WS5, WS6a&b and WS7 it has been necessary to reduce the font size to 8pt instead of the usual 10pt in order to set out the complete tabular information for each within a single page for ease of use.

Calculation sheet for			**Worksheet WS1** **Reference:**			
Room Name:						
1. Summer Temperature Control Heat Gain	kW					
2. Acceptable Δt	°C					
3. Air flow rate (S_G) $= \frac{\text{Gain}}{\Delta t \times 1.2}$	m^3/s					
4. Winter Temperature Control Heat Loss	kW					
5. Acceptable Δt	°C					
6. Air flow rate (S_L) $= \frac{\text{Loss}}{\Delta t \times 1.2}$	m^3/s					
7. Dilution of bacterial contaminations Air flow rate	m^3/s					
S_D or E_D						
8. Desired air change rate	ac/hr					
$\frac{\text{AC/hr x room volume } (m^3)}{3600}$	m^3/s					
9. Maximum of S_G, S_L, S_D or E_D or air change rate from Step 8	m^3/s					
10. Air movement control	S m^3/s					
Air flow for air movement control S_{AMC} or E_{AMC} (from WS2, WS3, or WS4)	E m^3/s					
11. Final Supply Flow Rate (S_F)	m^3/s					
12. Final Extract	m^3/s					
13. Total Supply	m^3/s					
14. Total Extract	m^3/s					

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Air Movement Control **Peripheral Room** ..... **type, single flow**	**Worksheet WS2a** **Reference:** **Nominal Pressure:** ..... **Pa**

Consider door to..... open

	Pa	Δt	Air flow, m^3/s Out	In	Remarks
Flow required through doorway to give protection					
Total					

S_{AMC} $(\sum_{OUT} - \sum_{IN})$ ____ m^3/s

or

E_{AMC} $(\sum_{OUT} - \sum_{IN})$ ____ m^3/s

Transfer S_{AMC} or E_{AMC} to WS1

Consider door to.....closed

	Pa	Δt	Out	In	Remarks
Closed door leakage					
Total					

Return S_F and E_F to WS1 ____ ____

Flow through transfer grille outward ($S_F - E_F - L_{OUT}$ ____

or

Flow through transfer grille inward ($E_F - S_F - L_{IN}$) ____

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Air movement control **Peripheral Room ..... type, parallel/series multi-flow**	**Worksheet WS2b** **References:** **Nominal Pressure: Pa**

Door from this room to ..... (room of equal cleanliness) is not to be protected.
A transfer grille is located in, or adjacent to, this door.

Consider door to..... open

Room pressure now becomes [ ] or [ ] or [ ] Pa (see Appendix 6)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Mechanical supply or extract (S_F/E_F)					
		Total			

X ($\sum$ OUT - $\sum$IN) [ ] Or Y ($\sum$ IN - $\sum$OUT) [ ]

Transfer grille required:

or from high-pressure zone Flow = *X* [ ] at [ ] ΔPa

to low-pressure zone Flow = *Y*

Size of transfer grille (free area) A1 [ ]

Consider doors and hatch closed – room pressure becomes [ ] Pa (nominal)

Closed door leakage from Appendix 4 (assuming no transfer grille)	Pa	ΔP	Out	In	Remarks
Mechanical supply or extract					
		Total			

Air flow required through transfer grille = IN – OUT = Z' [ ]

or OUT – IN = Z'' [ ]

Transfer grille required flow *Z' or Z''* [ ] @ [ ] ΔP

Size of transfer grille (free area) A2 = [ ]

Select larger of A1 or A2 [ ]

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Air movement control **Peripheral Room ..... type, parallel multi-flow high/low or series multi-flow (unbalanced)**	**Worksheet WS2c** **References:** **Nominal Pressure: Pa**

Consider door from this room to ..... open.

Room pressure now becomes [ ] or [ ] or [ ] Pa (see Appendix 6)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Total					

S_1 ($\sum_{OUT} - \sum_{IN}$) [ ] Or E_1 ($\sum_{IN} - \sum_{OUT}$) [ ]

Consider door from this room to ..... open

Room pressure then becomes [ ] or [ ] or [ ] Pa

			Out	In	Remarks
Flow required through open doorway to give protection					
At above pressures leaks through closed doors are:	Pa	ΔP			
Total					

S_2 ($\sum_{OUT} - \sum_{IN}$) [ ] Or E_2 ($\sum_{IN} - \sum_{OUT}$) [ ]

Consider doors closed. Closed doors leakage from Appendix 4

Door to:	Pa	ΔP	Out	In	Remarks
Total					

Return S_F and E_F to WS1 [ ] [ ]

Flow through transfer grille outward ($S_F - L_{OUT}$) [ ] to .....

or

Flow through transfer grille inward ($E_F - L_{IN}$) [ ] from.....

Transfer grille [ ] Pressure relief damper [ ]

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Air movement control **Peripheral Room ..... type, parallel/series multi-flow**	**Worksheet WS2d** **References:** **Nominal Pressure:** **Pa**

Note: In this type of room the supply and extract air flow rates are equal and take no part in the air movement control (AMC)

First, open door to higher pressure area.

Room pressure then becomes [ ] or [ ] or [ ] Pa (see Appendix 2)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Total					

Q_1 ($\sum_{IN}$ - $\sum_{OUT}$) [ ] (+ve inwards)

Next, open door to lower pressure area.

Room pressure then becomes [ ] or [ ] or [ ] Pa

			Out	In	Remarks
Flow required through open doorway to give protection					
At above pressures leaks through closed doors are:	Pa	ΔP			
Total					

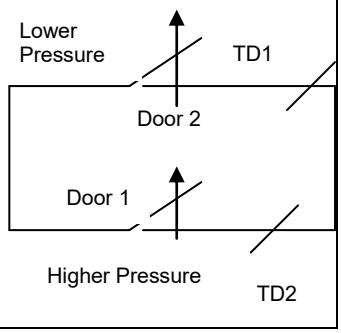
Q_1 ($\sum_{IN}$ - $\sum_{OUT}$) [ ] (+ve inwards)

Flow through transfer device (TD1) to protect Door 1 = Q1 at resultant [ ]

ΔP .....

Flow through transfer device (TD2) to protect Door 2 = Q2 at resultant [ ]

ΔP .....



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Air movement control **Peripheral Room ..... type bay (semi-open)**	**Worksheet WS2e** **References:** **Nominal Pressure:** **Pa**

Note: If the room is of the open bay type (i.e. opening is larger than normal single doorway), then room should be considered part of the main room. No air movement control considerations need then be made, and this sheet can be discarded. Supply and/or extract flow ill be based on air distribution considerations.

Consider permanent opening

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
		Total			

E_{AMC} [ ] or flow outward through transfer ($\sum_{IN} - \sum_{OUT}$) [ ]

Transfer S_{AMC} or E_{AMC} to WS1

Transfer device – transfer grille [ ]

– pressure stabiliser [ ]

Size select transfer device for flow rate [ ] @ ΔP [ ]

Note: A door from the bay is considered with the peripheral room to which it leads or, if it leads to the corridor, it is considered with the main room.

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Air movement control **Operating Room**			**Worksheet WS3** **References:** **Nominal Pressure:** **Pa**		

Note: To avoid considering each door open in turn, the "key door" concept is introduced. This is the door which requires the greatest mechanical flow when open. See paragraph A4.33

Select "key door" (see above).

Consider this door open – room pressure now becomes _____ Pa (See Appendix 2)

See Appendix 3 for room pressures

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
Air flow "out" or "in" via doors, transfer devices etc.	Pa	ΔP			
Mechanical extract					
Total					

S_{AMC} $(\sum_{OUT} - \sum_{IN})$ _____ Transfer S_{AMC} to WS1

Consider all doors closed.

Return S_F and E_F to WS1 _____ Room pressure now _____ Pa (nominal)

Air flow "out" or "in" via door leakage, transfer devices etc	Pa	Δt	Out	In	Remarks
Mechanical extract					
Total					

Flow $(\sum_{IN} - \sum_{OUT})$ through transfer device _____ @ ΔP _____ to……

……

For final selection of transfer device see paragraphs A4.50 – A4.54

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Air movement control **Corridor**			**Worksheet WS4** **References:** **Nominal Pressure:** **Pa**		
Consider all doors closed					
			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
Leaks through closed doors, transfer devices, permanent openings etc.	Pa	ΔP			
Total flow inwards (S_1)					
Add mechanical input (S_2) if necessary to increase S_1 to give 7 AC/hr					
Total Flow Outwards and Inwards					
$S_{AMC} = (\sum_{OUT} - \sum_{IN} + S_2)$		Transfer to WS5			
or $E_{AMC} = (\sum_{IN} - \sum_{OUT} + S_2)$		Transfer to WS5			

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Air movement control **Corridor**	**Worksheet WS5** **References:**

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Air Flow to Corridor	All Doors Closed	Anaesthetic (key door open)
	m^3/s	m^3/s
From Preparation		
From Operating Room		
From Scrub		
From Anaesthetic		
Total (a)		
Air Flow to Corridor from Disposal		
From other source		
Total (b)		
Other Room Supplies.....Total (c)		
Total Air Supply (a) + (b) + (c)		

Consider corridor ventilation (see Appendix 2) and calculate air volume required, based on 7 ac/hr (see Note 1)	
	m^3/s
Additional Air to Ventilate Corridor	
Additional Air to Ventilate Service Corridor (see Note 2)	
Air Extract The size of the extract plant should be of the order of 10% below the supply to assist in maintaining the department under positive pressure relative to the outside departments.	
	m^3/s
Extract Plant = Supply less Leakage	
Less 10% of Supply	
Total Extract (see Note 3)	

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Room Temperature - Summer

Worksheet WS6a

References:

Find summer supply temperature T_{SS} = 20 – 0.828 H/(O/R) _____ = T_{SS} _____ °C

Q(O/R) _____

Note: The temperature of a space may be calculated from

$$T = \frac{t_1 Q_1 + t_2 Q_2 + \ldots\ldots\ldots\ldots + t_n Q_n + (0.828H)}{Q_1 + Q_2 + \ldots Q_n}$$

Where t_1 is temperature of source (1°C)
Q_1 is flow from source 1 when all doors are closed (m^3/s)
H is heat gain in space (kW)

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Room	Heat Gain kWh	Supply		Flows Inwards										Temperature °C T
		Q	T_{SS}	From		From		From		From		From		
				Q	t	Q	t	Q	t	Q	t	Q	t	

Check Doors to Sterile Areas

Door Between	Calculated Room ΔT (°C)	Maximum ΔT *Permitted*	Remarks

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Room Temperature - Winter

Worksheet WS6b

References:

Find winter supply temperature T_{SW} = 20 – 0.828 H/(O/R) _____ = T_{SW} _____ °C

Q(O/R) _____

Note: The temperature of a space may be calculated from

$$T = \frac{t_1 Q_1 + t_2 Q_2 + \ldots\ldots\ldots\ldots + t_n Q_n + (0.828H)}{Q_1 + Q_2 + \ldots Q_n}$$

Where t_1 is temperature of source (1°C)
Q_1 is flow from source 1 when all doors are closed (m^3/s)
H is heat gain in space (kW)

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Room	Heat Gain kWh	Supply		Flows Inwards										Temperature °C T
		Q	T_{SW}	From		From		From		From		From		
				Q	t	Q	t	Q	t	Q	t	Q	t	

Check Doors to Sterile Areas

Door Between	Calculated Room ΔT (°C)	Maximum ΔT *Permitted*	Remarks

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Transfer Grilles, Pressure Relief Dampers and Pressure Stabilisers	**Worksheet WS7** **Reference:**

Transfer Grilles – see paragraphs A4.34 – A4.38

Check Doors to Sterile Areas

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Model	Resultant Δp Pa	Remarks

Pressure Relief Dampers – see paragraph A4.39

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Pressure Setting Pa	Remarks

Pressure Stabilisers –see paragraphs A4.40 – A4.43

Note: where a stabiliser is acting both as series room door protection and operating pressure control, "pressure difference" and "flow rate" are from WS2d; "pressure setting" is from WS3

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Pressure Setting Pa	Remarks

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References

Acts and regulations

NB: Access to information related to the following Acts and Regulations can be gained via **www.legislation.gov.uk.**

Scottish Technical Handbooks Non Domestic. Scottish Building Standards Agency, 2007. http://sbsa.gov.uk

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NHS National Services Scotland

Scottish Health Planning Note 04

In-patient Accommodation: Options for Choice
Supplement 1: Isolation Facilities in Acute Settings

Health Facilities Scotland
Engineering and Environment

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1. Introduction

Context

1.1 Healthcare Associated Infection (HAI) is a burden on the NHS. It affects an estimated one in ten NHS hospital patients each year (DH, 2003) at an annual cost of £1bn (National Audit Office, 2000).

1.2 Many patients with an infection require physical isolation. However, often patients cannot be isolated because of a shortage of single rooms and isolation suites.

1.3 The key to effective isolation on acute wards is the provision of single rooms with en-suite sanitary facilities. Single rooms reduce the risk of cross-infection for non-airborne diseases and help to lower the incidence of HAI. Most patients on acute wards can be isolated in single rooms with en-suite facilities. All single rooms in new-build hospitals should have en-suite facilities so that they can be used to isolate patients for a variety of reasons and not just for infection control purposes.

Purpose of the guidance

1.4 This Supplement to SHPN 04: 'In-patient accommodation: options for choice', provides guidance on the facilities required for isolating patients on acute general wards.

1.5 For infection control purposes, a single room without en-suite is better than no single room at all. However, the guidance in this Supplement is based on best practice, and describes how a single room can be enhanced to provide an effective isolation facility for patients on acute general wards. The Supplement has two aims:

- to set a standard for new-build facilities;
- to provide Health Boards wishing to convert existing accommodation with simple design options that can be implemented relatively quickly and cost-effectively.

1.6 This guidance:

- explains how a single room with en-suite sanitary facilities can be enhanced to provide effective isolation for patients with infections that could be transmitted within healthcare;
- describes how an enhanced single room with en-suite facilities and a ventilated lobby can provide an isolation suite for patients who have airborne infections or who need to be protected from them;

- can be used for both new-build schemes and the upgrading of existing accommodation.

1.7 The guidance also contains examples of room layouts.

1.8 The guidance on isolation suites in this Supplement is based on a validated design model. The aim of this Supplement is to provide practical guidance on how to provide isolation facilities that are simple to use and meet the needs of the majority of patients on acute general wards.

1.9 Information about how good design can prevent cross-infection in healthcare premises generally is provided in SHFN 30 Version 3: 'Infection control in the built environment: design and planning' and Healthcare Associated Infection-System for Controlling Risk in the Built Environment (HAI-SCRIBE). SHPN 04 Supplement 1 should be read in conjunction with SHFN 30 and HAI-SCRIBE.

Exclusions

1.10 This Supplement does not describe the specialist facilities required in infectious disease units or on wards where severely immuno-compromised patients are nursed. Guidance for these facilities will follow in a further Supplement to SHPN 04.

2. Operational policies and planning principles

The need to isolate patients

2.1 Historically, isolation in general wards has been provided in single rooms, sometimes without en-suite facilities. Rooms without en-suite facilities often cannot be used to isolate patients effectively.

2.2 Ventilated isolation suites with en-suite facilities have also been provided. They may have a ventilation system that provides a positive pressure in the room to protect the patient from infection, or a negative pressure to prevent a patient from infecting others, or the ventilation may be switchable from positive to negative. These rooms rely on staff being able to assess the type of ventilation required when a patient arrives on the ward and, for switchable systems, knowing how to select the correct ventilation mode. Patients can be put at risk by user error if the ventilation mode is not set correctly.

2.3 The provision of isolation rooms which are switchable from positive to negative air pressure is no longer recommended because of the risk of cross contamination in the event of the setting being incorrect.

2.4 There are four main reasons for caring for patients in single rooms:

- patient susceptibility to infection from other sources;
- where a patient presents an infection risk to others;
- non-medical, for example patient preference;
- clinical but not infection-related.

In terms of infection control, only patients in the first two categories require isolation. Patients in the latter two categories can be cared for in standard single en-suite rooms.

Isolation facilities

2.5 In order to simplify the use of isolation facilities, this Supplement proposes two room designs for isolating patients in acute general settings:

- enhanced single room with en-suite facilities;
- enhanced single room with en-suite facilities and ventilated bed access lobby (isolation suite).

Enhanced single room with en-suite facilities

2.6 An enhanced single room with en-suite sanitary facilities having extract ventilation is a simple, cost-effective way to provide isolation, and will meet the needs of most patients on general wards.

2.7 The room does not require any specialist knowledge or action by the nursing staff to operate it. When not being used for isolation the room can be used for general nursing.

2.8 See Section 3 for detailed design guidance.

Enhanced single room with en-suite facilities and ventilated lobby (isolation suite)

2.9 An enhanced single room with a positive pressure ventilated bed access lobby and en-suite facilities with extract ventilation provides both source and protective isolation.

2.10 The positive pressure lobby ensures that air from the corridor does not enter the isolation room, and that air from the room does not escape into the corridor. This simple design enables the suite to be used for both source and protective isolation without the need for switchable ventilation or special training for staff. It also provides safe isolation for patients whose exact condition is unknown.

2.11 See Section 3 for detailed design guidance.

Advantages

2.12 Both rooms are suitable for caring for patients not in isolation but who require a single room for other reasons. In addition, both room designs are simple in concept, by default safe in operation, and do not require the nursing staff to have any specialist ventilation knowledge.

Creating pleasant environments

2.13 Some patients with infections need to stay in isolation in hospital for long periods of time. The number of visitors they receive and the length of time they can spend with them may be restricted. This means that patients who are already vulnerable, but not necessarily physically severely incapacitated, will be confined to the room for sometimes several weeks and can experience long periods of boredom.

2.14 Accommodation for these patients should be stimulating and as comfortable as possible. Designers should try to achieve a balance between the need for a clean environment and the comfort of patients. There are a number of publications that describe in detail, evidence that supports the concept that a therapeutic environment has a positive effect on a patient's general feeling of well-being, reduces the length of stay for many patients, reduces depression,

confusion and aggressive episodes and significantly increases a patient's level of satisfaction with the overall quality of their care.

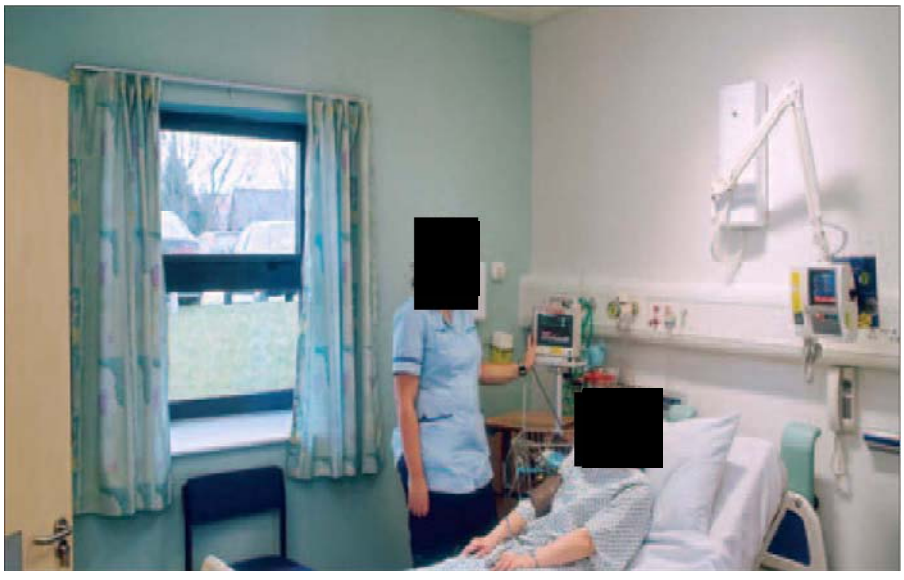
2.15 If patients are to stay in an isolation suite, it is important that they are able to see staff from their beds. Staff should also be able to see the patient in case of emergency. This reduces the psychological problems of isolation. Observation windows should have integral privacy blinds which can be controlled by both staff and patients. The sense of containment can also be reduced by providing outside views using windows with low sills.

Record keeping

2.16 Where staff are required to record lobby air pressures as part of the local COSHH assessment, facilities for completing and storing log books should be provided in the lobby.

Maintenance and cleaning

2.17 Guidance on the maintenance and cleaning of materials and finishes is contained in SHFN 30: Infection Control in the Built Environment: design and planning, planning teams should also refer to the 'Monitoring Framework for NHSScotland National Cleaning Services Specification-Guide for NHS Managers'. All surface finishes must be washable and moisture-resistant. This does not include emulsion paint.



Single Room

En-Suite Bathroom

3. Design guidance

New build isolation facilities

Enhanced single room with en-suite facilities

3.1 The design for a new-build enhanced single room with en-suite facilities is shown in Appendix 1 Sheet No 1: Example room layouts.

3.2 The general specification for single rooms is provided in SHPN 04 (2000). The enhancements and modifications recommended for isolating patients are:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers including alcohol hand rub dispensers, and disposable towel holders;
- a foot operated lidded bin for disposing of paper towels and other non-clinical items;
- suitable extract to the en-suite bathroom;
- transfer grille in en-suite door;
- en-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control (see paragraph 3.20);
- external windows should be openable, but with a fixed maximum opening width for safety. They should also be lockable. Internal windows should be fixed;
- observation window in corridor wall with integral privacy blinds that can be controlled by both patients and staff;
- all windows, including observation windows, should be low enough to provide a view for patients lying in bed.

Enhanced single room with en-suite facilities and ventilated bed-access lobby (isolation suite)

3.3 The design for a new-build enhanced single room with en-suite facilities and ventilated lobby, with bed access through the lobby, is shown in Appendix 1 Sheet No 2 Example Room layouts.

3.4 The ventilated bed access lobby ensures that:

- air entering the bedroom is the clean ventilation supply from the lobby. Air from the corridor is blocked by the ventilation supply in the lobby, that is, the patient in the bedroom is protected from air from the corridor;

- potentially contaminated air from the bedroom is prevented from escaping into the corridor by the ventilated lobby, so the patient will not present a risk of infection to others.

As the lobby simultaneously prevents unfiltered air entering the room and potentially contaminated air escaping from it, the room can be used by both infectious patients and those at risk of infecting others.

3.5 The use of personal protective equipment (PPE) will be determined by local infection control policy. Facilities for putting on and removing PPE, and washing hands, are provided in the lobby. The risk of contaminants being dislodged from used PPE by the ventilation system and blown out into the corridor is considered negligible. However, a hand-wash basin and pedal operated lidded bin are also provided in the bedroom close to the exit door so that PPE can be removed in the bedroom should local policy require.

3.6 The benefits of the isolation suite are that it is simple in concept, requires no specialist knowledge by healthcare staff to operate it, and can also be used for general nursing. In addition, if the ventilation system fails the layout of the suite still ensures a degree of protection.

3.7 The general specification for single rooms is provided in SHPN 4. The enhancements and modifications recommended for isolating patients are:

In the bed access lobby:

- a clinical hand-wash basin with non-touch, fixed temperature mixer tap (see paragraph 3.20);
- wall-mounted soap dispensers, disinfectant hand rub dispensers, and disposable towel holders;
- wall-mounted plastic apron and glove dispensers and storage for other clean PPE items;
- a clinical waste bin for disposal of used PPE;
- a bin for disposing of paper towels and other non-clinical items;
- storage for room cleaning equipment;
- a suitable air supply;
- In the isolation room;
- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers, including alcohol hand rub dispensers, and disposable towel holders;
- a clinical waste bin for disposal of used PPE;
- observation window in corridor wall with integral privacy blinds;
- a pressure stabiliser above bedroom door.

In the en-suite bathroom:

- suitable extract system to the en-suite bathroom;
- transfer grille in the en-suite door;
- en-suite WC to be non-touch flush and wash basin to have single tap with flow and temperature control (see paragraph 3.20).

For the suite as a whole:

- sealed, solid ceiling;
- windows to the exterior and interior to be locked shut and sealed;
- recessed luminaire rated IP44;
- where the configuration of the building permits (e.g. roof space above) consideration should be given to accessing luminaires from above for lamp changing. This will avoid the need for maintenance staff to access isolation facilities to undertake this activity.

3.8 Heating and cooling of the isolation suite will normally be provided via the ventilation system.

3.9 The provision of a two-way intercommunication system between the patient's bedroom and the nurses' base should be provided (see SHTM 2015: 'Bedhead Services').

Converting existing facilities

3.10 The majority of patients requiring isolation can be cared for in enhanced single rooms with en - suite facilities that have an extract system. Only a small number of patients will need an isolation suite.

3.11 Acute general hospitals can create enhanced single en-suite rooms and isolation suites by converting bays and adapting existing single room accommodation. The layout of existing facilities may impose constraints on design, however, and planning teams will sometimes have to resolve the conflict between what is desirable and what is achievable.

3.12 For Health Boards wanting to convert existing accommodation into isolation facilities, the easiest and least expensive option is to adapt existing single rooms with en-suite sanitary facilities. However, where existing single rooms do not have en-suite facilities, Health Boards will need to reconfigure the accommodation (see paragraph 3.16).

Converting a single room with en-suite facilities

3.13 The standard furnishing and fitment requirements for a single room are described in SHPN 04: 'In-patient accommodation: options for choice'.

3.14 The additional requirements for isolation of a single en-suite room are:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers including alcohol hand rub dispensers, and disposable towel holders;
- a foot operated lidded bin for disposing of paper towels and other non-clinical items;
- suitable extract to the en-suite bathroom;
- transfer grille in en-suite door;
- en-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control;
- external windows should be openable, but with a fixed maximum opening width for safety. They should also be lockable;
- observation window in corridor wall with integral privacy blinds that can be controlled by both patients and staff;
- all windows, including observation windows, should be low enough to provide a view for patients lying in bed.

3.15 A typical layout for converting an existing single room with en-suite facilities is shown in Appendix 1 Sheet No 3: Example room layouts.

Converting a single room without en-suite facilities

3.16 In an existing building it may be possible to modify three adjacent single bedrooms into two enhanced single bedrooms each with en-suite facilities - see Appendix 1 Sheet 4: Example room layouts.

3.17 The requirements for disabled access, as set out in sections 4.2 and 4.7 of The Building (Scotland) Regulations, should be met.

Creating an enhanced single room with en-suite facilities and ventilated bed access lobby (isolation suite)

3.18 When converting a single room into an enhanced single room with en-suite and ventilated lobby, any suspended ceiling must be replaced with a sealed solid ceiling. If a single room has a suspended ceiling to permit access to overhead services, a Health Board should install a sealed ceiling with sealable access hatches or move the services.

3.19 The additional requirements for upgrade to an isolation suite are as follows:

In the bed access lobby:

- a clinical hand-wash basin with non-touch, fixed temperature mixer tap (see paragraph 3.20);

- wall-mounted soap dispensers, disinfectant hand rub dispensers, and disposable towel holders;
- wall-mounted plastic apron and glove dispensers and storage for other clean PPE items;
- a clinical waste bin for disposal of used PPE;
- a bin for disposing of paper towels and other non-clinical items;
- storage for room cleaning equipment;
- a suitable air supply.

In the bedroom:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- a clinical waste bin for disposal of used PPE;
- non-opening observation window in corridor wall with integral privacy blinds;
- a pressure stabiliser above the bedroom door into the lobby;
- In the en-suite bathroom;
- suitable extract system to the en-suite bathroom;
- transfer grille in the en-suite door;
- en-suite WC to be non-touch flush and wash basin to have single tap with flow and temperature control (see paragraph 3.20).

For the suite as a whole:

- sealed, solid ceiling;
- windows to the exterior and interior to be locked shut and sealed;
- recessed luminaire rated IP44;
- where the configuration of the building permits (e.g. roof space above) consideration should be given to accessing luminaires from above for lamp changing, This will avoid the need for estates staff to access isolation facilities to undertake this activity.

3.20 Point of use oversink, non-touch, fixed temperature water heaters may be used as an alternative to ‘fixed temperature mixer taps’.

3.21 The provision of a two-way intercommunication system between the patient’s bedroom and the nurses’ base should be provided (see SHTM 2015: ‘Bedhead services’).

3.22 An option for reconfiguring two existing single rooms to provide one enhanced single room with en-suite facilities and ventilated lobby, with bed access through the lobby, is shown in Appendix 1 Sheet 5: Example room layouts. Where space restrictions mean bed access through the lobby is not possible, an

alternative layout gives bed access directly to the bedroom from the corridor shown in Appendix 1 Sheet 6: Example room layouts. In this case the lobby would be sized for personnel access only.

Converting a multi-bed bay

3.23 An existing four-bed bay may be converted to provide two enhanced single rooms with en-suite facilities in Appendix 1 Sheet 7: Example room layouts.

3.24 In this configuration it is not possible to provide a normal observation window. As observation is critical, however, one option would be to provide fully-glazed lobby and bedroom doors, with integral privacy blinds, to enable observation from the corridor and to provide a view out for the patient.

Hand rub dispenser

4. Engineering requirements

Engineering design philosophy

4.1 This Section describes the ventilation system philosophy for an isolation suite with a patient's bedroom, en-suite sanitary facilities and ventilated lobby. A methodology for validation of the performance standard is given in Appendix 2.

4.2 The isolation suite and its ventilation system are based on a validated design. The engineering guidance given in this Section aims to provide a practical, 'fail-safe' design solution for isolating patients on acute general wards.

4.3 The ventilation system is designed on the basis that all its constituent parts, as described in Table 1, work together to form an integrated system. For example, air to the suite is supplied at high level in the lobby, with extract in the en-suite bathroom. This ensures good airflow through the entire isolation suite. Similarly, the volumetric airflow rate in the lobby is determined by the number of air changes required in the patient's bedroom. Modifying or failing to provide one element of the system will jeopardise the performance of the system as a whole.

Basic design parameters

4.4 The patient's bedroom is to have 10 air changes per hour. The entry lobby is to be at +10 Pascals with respect to the corridor. The en-suite room is to have at least 10 air changes per hour and be at a negative pressure with respect to the patient's bedroom. Table 1 gives nominal design values calculated for rooms of the size stated. The air change rates and pressure differentials below should be maintained when filters are dirty. Variable-speed control of fan motors would be an acceptable method of flow control, within the normal operating range of the fan's speed.

Room	Parameter	Nominal Design Values
Lobby	Room volumes Bed access lobby (5m2 x 2·7m) Personnel access lobby (4m2 x 2·7m)	 13·5 m^3 10·8 m^3
	Pressure differential to corridor	Nominally 10 Pascals
	Supply air flow (for a room of this size)	Bed access lobby - 238 l/s Personnel access lobby - 208 l/s
	Air change rate	Bed access lobby – 63 per hour Personnel access lobby – 69 per hour
Isolation Room	Room volume (19m2 x 2.7m)	51.3m^3
	Pressure differential to corridor	Nominally zero
	Room air flow (for a room of this size)	158 l/s
	Air changes rate	10 per hour
En-suite	Room volume (6m2 x 2·7m)	16·2m^3
	Pressure differential to isolation room	Negative
	Extract air flow (for a room of this size)	158 l/s (If extract is fitted in the isolation room this reduces to 45 l/s in the en-suite with 113 l/s extract in the isolation room)
	Air change rate	At least 10 per hour

Table 1: Isolation Suite – Ventilation Parameters

Note: In this example the design parameters are based on SHPN 04: 'In-patient accommodation: options for choice'. The en-suite is sized to comply with BS 8300 accessibility requirements.

The airflow rates quoted do not include any allowance for construction leakage. This has been set at 1 l/s of air per 1m^3 of suite envelope volume (see Appendix 2).

Where immuno-compromised patients are to be accommodated, such as in transplant units or specialist cancer units, there could be a need for positive pressure isolation rooms.

Isolation Suite

Ventilation – general

4.5 Ideally each suite should have its own dedicated supply and extract system. If two or more suites share a ventilation system there will be an inevitable increase in the complexity of the system and a corresponding reduction in reliability and serviceability. Further complications will occur when individual suites have to be isolated for deep cleaning following occupation. Routine maintenance of the ventilation system will result in complete closure of all suites

that it serves. For these reasons it is strongly recommended that each suite should have its own ventilation system. However, refer also to paragraph 4.8.

4.6 The object should be to keep the ventilation systems as simple as possible. Standby fans or motors are not required for either supply or extract. This is because the system as designed is robust enough to withstand fan failure without significantly compromising the level of protection. A flow sensor should be fitted to each system that will alarm on fan failure at a designated nurse station and the estates department.

4.7 Ductwork should be kept as direct and simple as possible. In order to facilitate duct cleaning, volume control devices and other obstructions in the distribution ducts should be avoided. Supply and extract flow rates should, where possible, be set by terminal and duct size design. In the unlikely event that volume control devices are required, iris dampers are the preferred type.

4.8 In a high-rise building a common supply and extract system may be the only feasible solution. In this case, run and standby fans would be required for the extract and a duplicate supply unit may be considered necessary. The supply and extract branches to each isolation suite should be fitted with spring-close gas-tight dampers. This will permit individual suites to be shut down for cleaning and maintenance. The common supply and extract systems will need to be controlled to ensure a constant volume in each isolation suite branch regardless of the number in use. The overall design should ensure that short-circuiting couldn't occur between isolation suites.

Fire strategy

4.9 The isolation suite is intended to be built as a single fire compartment. The positive pressure in the lobby will deter smoke originating in the corridor from entering the room. Smoke from a fire in the room will be contained within the suite and extracted via the en-suite extract. Due to this. the ventilation system serving the isolation facility should be kept running in the event of a fire.

4.10 Fire rated ductwork should be provided such that ducts can be considered an extension of the isolation suite. Fire dampers, where the ducts penetrate walls and floors, will not then be required.

4.11 A motorised smoke/fire damper should be fitted at the discharge of the supply air handling unit (AHU). The damper should close in the event of an AHU or intake fire under the control of a smoke detector mounted in the AHU.

Extract ventilation

4.12 An extract terminal should be fitted at high level in the en-suite room. An additional terminal may be fitted in certain circumstances at low level adjacent to the bedhead in the bedroom. The clinical requirement for this should be verified and such requirements would probably relate to highly infectious patients.

4.13 A transfer grille should be fitted at low level in the door between the bedroom and en-suite room.

4.14 The extract duct should be fitted with a spectacle plate or gas-tight damper so that the system can be sealed to allow the isolation suite to be disinfected. The plate or damper should be fitted at the inlet of the extract fan. This will also permit isolation of the extract fan for service and maintenance.

4.15 The extract fan unit should be located outside the building so that all ductwork within the building is under negative pressure. Access and cleaning hatches should only be fitted where absolutely necessary. If fitted they should be of the sealed type and marked with a bio-hazard symbol. If the fan has to be located inside the building it should be as close as practicable to the outside. The extract fan motor should be mounted out of the air stream and should be capable of being changed without withdrawing the impeller or opening up the ductwork. The extract fan should draw its power from the essential electrical system.

4.16 Extract filters will not be required provided that the fan can discharge in a safe location 3 m above the building height. If extract filters are fitted they should be in a 'safe change housing' outside the building on the suction side of the fan. Extract filters, where fitted, should be of H14 grade. Even if filtered, extract air must not be re-circulated.

4.17 Extract ductwork, the fan and discharge stack must be clearly marked to identify the isolation suite that they serve. Service, maintenance, cleaning and filter change of the system will be subject to a 'Permit to Work'.

Supply ventilation

4.18 The supply AHU should comply in all respects with the minimum standards set out in SHTM 2025:'Ventilation in Healthcare Premises'. (*This SHTM is under review and is listed for replacement by SHTM 03*). Heating and cooling should be provided, but not humidification. The fire/smoke damper fitted in the discharge from the AHU should close on plant shutdown and/or airflow failure, sealing the AHU from the distribution ductwork. This will prevent any reverse airflow and permit routine maintenance or system disinfection. The supply fan should draw its power from the essential electrical system.

4.19 The supply AHU and distribution ductwork must be clearly marked to identify the isolation suite that they serve. Access and cleaning hatches should only be fitted where absolutely necessary. They should be of the sealed type and marked with a bio-hazard symbol. Service, maintenance, cleaning and filter change of the system will be subject to a permit to work.

4.20 A G3 pre-filter and final filter should be fitted in the AHU. The lobby air supply terminal should be of a type into which a HEPA filter can be fitted. While it is not envisaged that a HEPA filter will be routinely required, this arrangement will allow for subsequent fitting when appropriate with the least disturbance. A

sealable upstream DOP injection test point will be required in the supply duct so that, if a HEPA filter is fitted, it can be challenge tested on installation.

4.21 A pressure stabiliser of the balanced blade type, set to operate at 10 Pascals, should be fitted above the door between the lobby and the bedroom. The stabiliser should be visible so that its correct operation can be seen. It should be of a style that will operate silently, and be correctly sized and positioned so that it does not cause a draught that would be uncomfortable for patients.

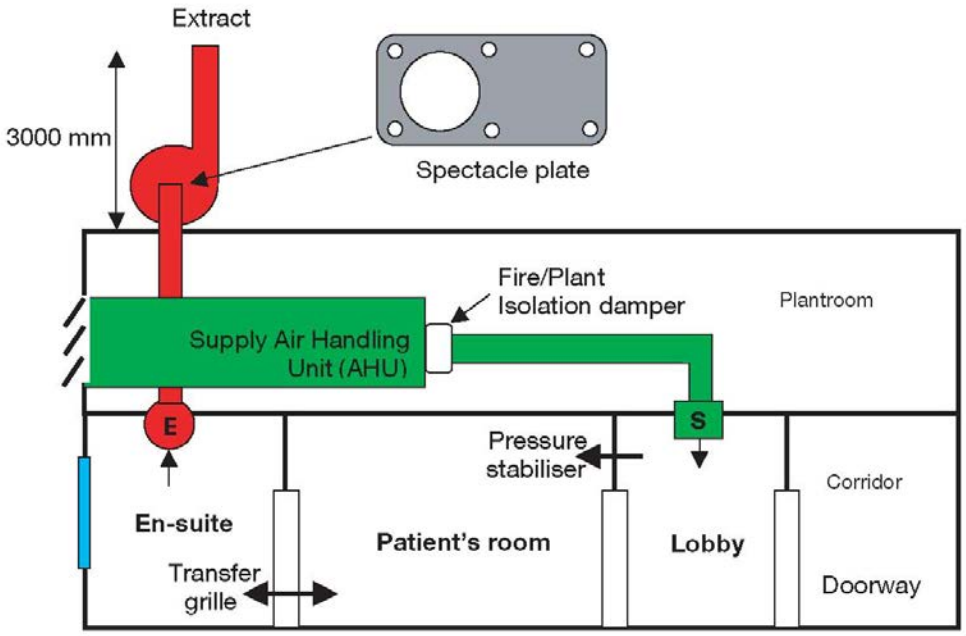
4.22 A direct reading gauge showing the pressure in the lobby with respect to the corridor should be mounted at eye level on the corridor wall adjacent to the lobby entry door. The gauge and lobby entry door must be clearly marked to identify the isolation suite to which they refer. In common systems serving more than one isolation room, automatic closing backdraught dampers will be required. Where HEPA filters are installed, these should be located so that staff can access them without recourse to entering isolation suites. Audio and visual alarms must be located at the entrance to the lobby and bedroom to warn nursing and maintenance staff of potential unsafe conditions. Continuous monitoring should be provided with remote indication at nurses stations, interlinked to the Building Management System with time delay (adjustable by Estates personnel) to take account of running-up of standby motors or damper operations or other plant items that may take time to open or close. Alarms based on sensing airflow failure should be provided rather than electrical failures. Alarm sound levels should be sufficient to attract attention without distress or annoyance and, if muted, should re-activate at 5-10 minute intervals.

Record keeping

4.23 A logbook will be required for each isolation suite. It should contain the following information:

- a schematic layout of the isolation suite and ventilation system serving it;
- information on the ventilation design parameters;
- a record of the actual ventilation performance at initial validation. (All of the tests set out in Appendix 2 ‘Acceptance testing of isolation suite’ should be carried out);
- records of the annual validations. (The parameters set out in Appendix 2 should be measured);
- records of the lobby pressure, taken by ward staff from gauges and monitoring devices provided;
- records of any routine service and maintenance activities;
- records of any repairs or modifications;
- a method statement for disinfecting the system.

Estates management should ensure that nursing staff are familiar with pressure gauges and able to record readings in the appropriate log book.



Isolation suite ventilation system – example layout

When the suite is taken out of use, the logbook should be preserved for at least five years.

Other considerations

4.24 As far as practicable, access to domestic hot and cold water services and their associated thermostatic mixing valves should be via access panels in the lobby or corridor. Every effort should be made to avoid service and maintenance staff having to enter or pass through the bedroom when carrying out routine service and maintenance tasks.

Service and maintenance

4.25 Spectacle plates or gas-tight dampers should be used to seal the system, should the suite and/or its ventilation system require disinfection. A method statement should be prepared detailing the procedure. For further guidance on disinfection refer to 'Biological agents: Managing the risks in Laboratories and healthcare premises' by the Advisory Committee on Dangerous Pathogens, available from HSE. All works of service and maintenance should be subject to a permit to work.

Appendices

Appendix 1: Example room layouts – Use of single rooms for Isolation: Key Design Principles

Appendix 2: Acceptance testing of isolation suite

Appendix 1 : Example room layouts

Use of single rooms for Isolation: Key design principles

The room layouts in this Appendix are examples and are intended as a guide. Other room configurations are possible.

Current guidance (Scottish Health Planning Note 04: In-patient accommodation: Options for choice, May 2000) recommends that *"where not in a single-bed room each bedspace should not be less than 3.0m x 2.7m".* However interim guidance, issued on the 21st February 2007 by the Scottish Executive states that having regard to ergonomic criteria, primarily the space required for patient handling and other activities which take place in the immediate vicinity of the bed it is recognised that the minimum bedspace should not be less than 3.6m x 3.7m. It also states that when planning any new in-patient accommodation or any major refurbishments of existing accommodation it is recommended that the increased bedspace is adopted.

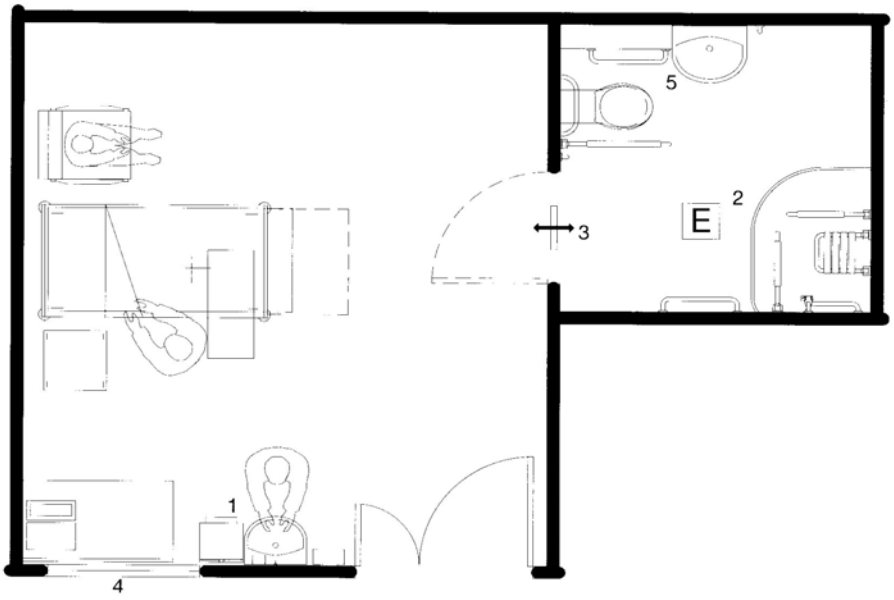
In planning for the construction or major refurbishment of healthcare facilities it is appropriate to provide an overall single occupancy room level of between 50% and 100%.

The appropriate level within that range is a matter for each individual NHSScotland Board to consider based on the following broad criteria:

- science-based decisions relating to the clinical and nursing care of patients and overall hygiene standards;
- value-based judgements about the nature of personal services and responsiveness to the local community and generational cultures;
- operational needs, for example managing volatility in demand or changing clinical needs and priorities; and
- the need to balance these against economic considerations.

Each Board may also want to give consideration to the patient group being treated.

Sheet 1: New build single room with en-suite facilities.



Minimum requirements:

1. Clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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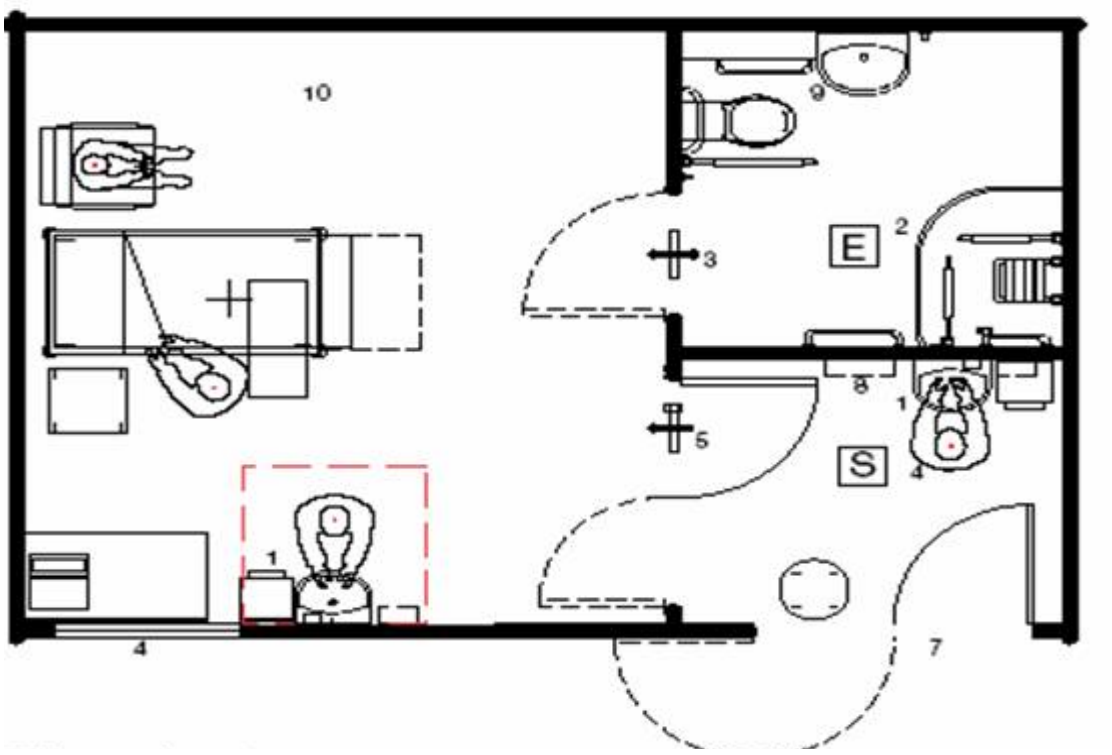
Sheet 2: New build single room with en-suite facilities and bed-access lobby (isolation suite)



Minimum requirements:

1. Clinical hand-wash-basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
7. Double door for personnel and bed access.
8 Disposable apron dispenser.
9. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.
10. Ceiling to be sealed solid construction, external window to be sealed.

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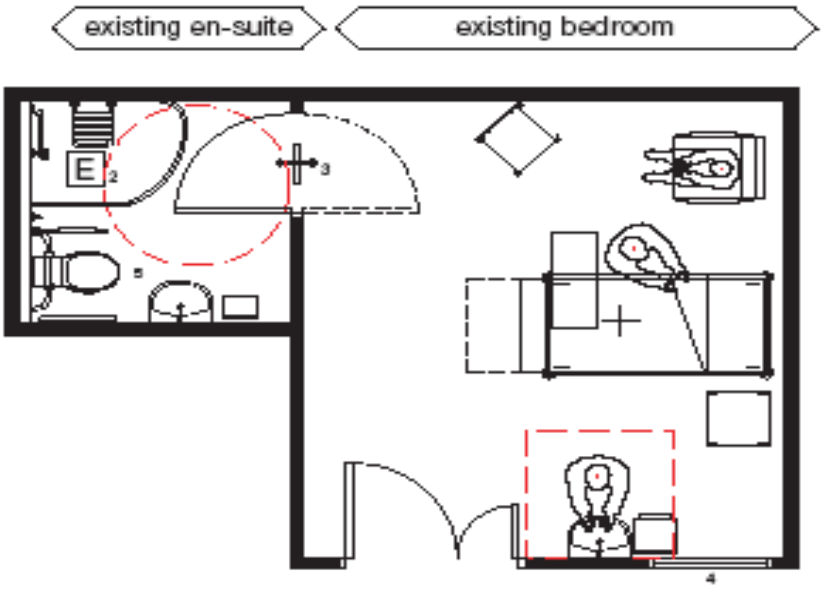
Sheet 3: Existing single room with en-suite facilities



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Upgrade existing extract fan.
3. Install transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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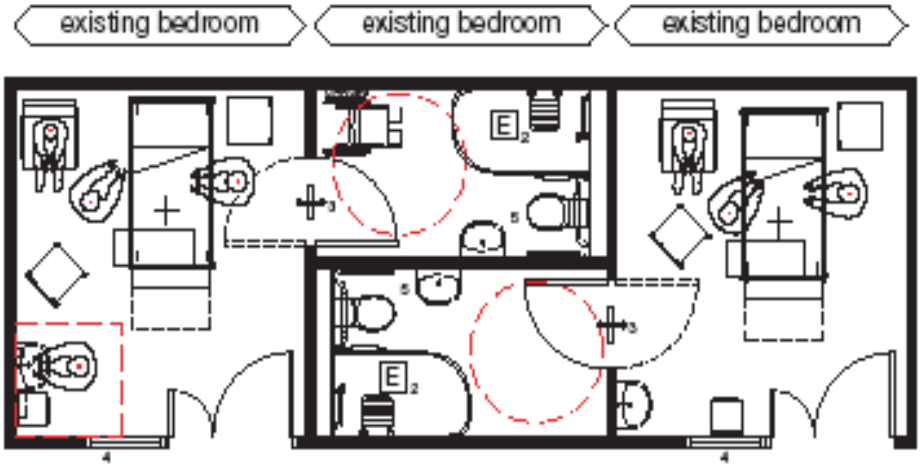
Sheet: 4 Single rooms without en-suite facility. Upgrading three existing single rooms to provide two single rooms with en-suite facilities



Minimum requirements to upgrade existing facilities:

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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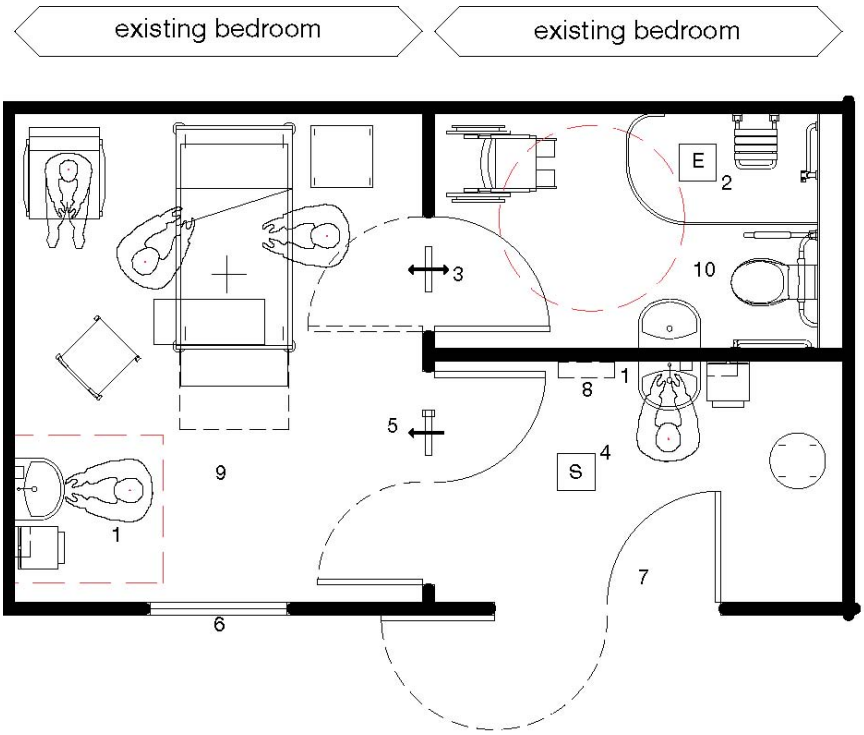
Sheet 5: Single rooms without en-suite facility. Upgrading two existing single rooms to provide one single room with en-suite facilities and bed access lobby



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow staff observation and patients views out.
7. Double door for personnel and bed access.
8. Disposable apron dispenser.
9. Upgrade ceiling to sealed solid construction, external windows to be sealed.
10. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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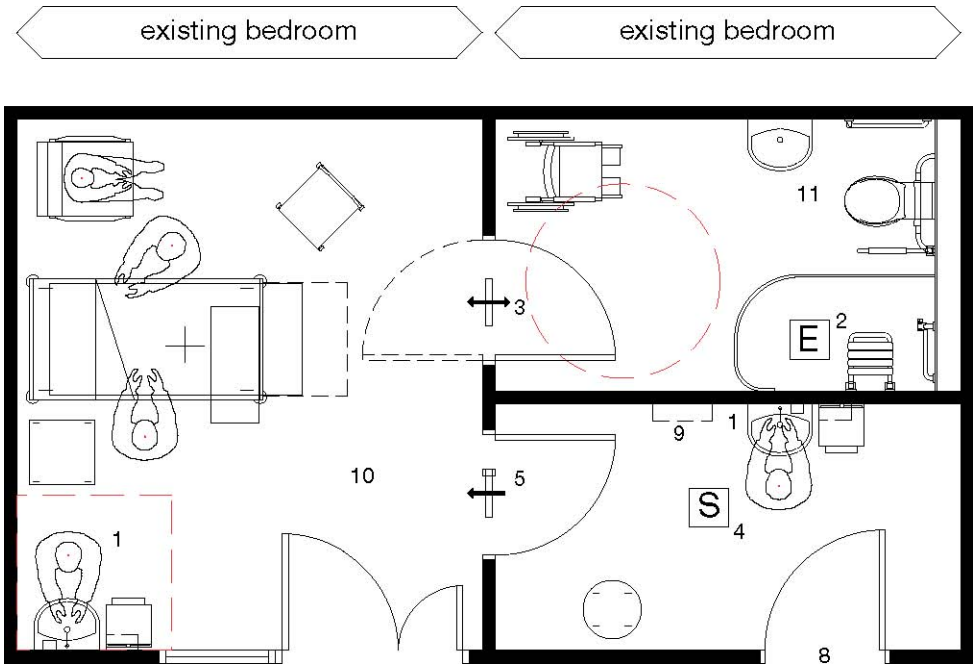
Sheet 6: Single rooms without en-suite facility. Upgrading two existing single rooms to provide one single room with en-suite facilities and personnel access lobby



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
7. Existing door and a half for bed access only must be kept locked and have seals to minimise air transfer.
8. Single door access via lobby.
9. Disposable apron dispenser.
10. Upgrade ceiling to sealed solid construction, external windows to be sealed.
11. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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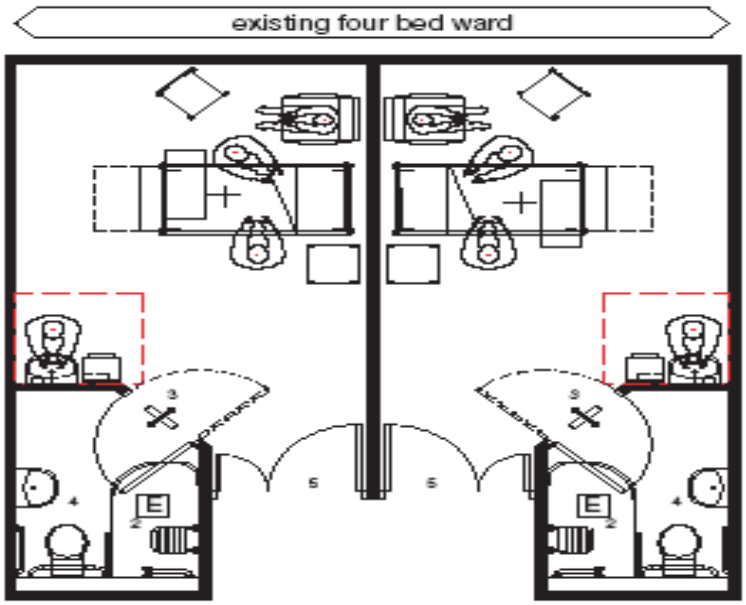
Sheet 7: Upgrading existing four bedded room to provide two single rooms with en-suite facilities.



Minimum requirements

1. Clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Transfer grille to en-suite door.
4. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.
5. Doors to be fully glazed, with integral privacy blinds, to allow staff observation and patients views out.

Appendix 2: Acceptance testing of isolation suite

Definitions

Isolation suite

Includes the entry lobby, patient's room, en-suite facility and any storage or other area directly accessible from the patient's or en-suite room.

Isolation suite envelope

The isolation room suite bounded by a solid floor, solid ceiling and full-height walls that separate it from any other adjoining space or the outside.

Validation – Isolation suite air permeability (leakage rate)

The suite will be considered fit for purpose if at a test pressure of +20 and –20 Pascals it has an average leakage rate of not more than 1 l/s of air per 1m^3 of envelope volume. The method of testing is set out below.

Rationale*:* To ensure effective isolation, it is important that air leakage to or from adjacent areas is kept to a minimum. Construction gaps should be minimised and service penetrations sealed before the suite is tested. The test pressures are significantly more than would be achieved under a ventilation fault condition within the isolation suite. When in operation, the patient's room and en-suite are designed to be at a neutral or slightly negative pressure so the actual leakage between adjoining spaces should be insignificant.

Validation

Filtration test standards

General and fine filter grades to BS EN 779:2002 should be visually inspected to ensure that they are free from tears or other damage at the time of installation. They should be a good fit in their housing, with no obvious gaps that could allow air bypass.

High Efficiency Particulate Air (HEPA) filters, where fitted, should be certified by their manufacturer for conformity to BS EN 1822:2000. When installed, their performance should be checked with a particle counter using the method set out in BS EN 1822:2000 for in situ aerosol testing.

Air permeability – Tests method

1. Establish the volume of the isolation suite envelope as defined above.
2. Turn off the suite supply and extract ventilation systems and those serving adjoining spaces. (Rationale: All adjoining spaces need to be at atmospheric pressure in order to establish the true leakage rate.)
3. Seal all supply and extract terminals.
4. Wedge all internal doors open.
5. Fit a temporary board seal and test fan in the lobby to corridor doorway.
6. Run the fan to maintain a positive test pressure of 20 Pascal for at least two minutes.
7. Measure the airflow rate of the fan.
8. Reverse the fan and run it to maintain a negative test pressure of 20 Pascal for at least two minutes.
9. Measure the airflow rate of the fan.
10. Average the two airflow readings obtained.
11. Calculate the leakage rate in l/s of air per m^3 of envelope volume. If the isolation suite envelope is correctly sealed the readings should be within 5% of each other.

Further details of the test method are contained in 'Testing buildings for air leakage', CIBSE, TM23, 2000.

Close all internal doors and, using the test fan, check that the pressure stabiliser opens at 10 Pascal and that it will carry the design airflow without flutter.

These tests should be carried out at initial commissioning and as necessary thereafter following works of refurbishment or when there is any doubt as to the actual performance standard of the suite.

System operating standard

The suite will be considered fit for purpose if, with the ventilation system operating and all doors closed, the following parameters are achieved:

- a positive pressure of between 10 and 12 Pascals between the entry lobby and the corridor;
- the patient's room has an air change rate of at least 10 per hour;
- the en-suite room is at a negative pressure with respect to the patient's room;
- a failure of either the supply or extract fan will be indicated at a designated nurse station and the estates department.

The suite should be tested following initial commissioning and thereafter re-tested at least annually for conformity with this operating standard.

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References

Acts and Regulations

Control of Substances Hazardous to Health (COSHH) Regulations 2002 and subsequent amendments, SI 2002 No 2677. The Stationery Office. http://www.opsi.gov.uk/si/si2002/20022677.htm

The Building (Scotland) Regulations 2004 and Amendment Regulations 2006, 2007, SI 2000 No 2531. The Stationery Office. http://www.hmso.gov.uk/legislation/scotland/ssi2004/20040406

British Standards etc

BS 8300: 2001 Design of buildings and their approaches to meet the needs of disabled people – Code of practice. British Standards Institute, London.

BS EN 779:2002 Particulate air filters for general ventilation. Determination of the filtration performance.

BS EN 1822-4:2000 High efficiency air filters (HEPA and ULPA). Determining leakage of filter element (scan method).

BS EN 1822-5:2000 High efficiency air filters (HEPA and ULPA). Determining the efficiency of filter element.

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Scottish Health Planning Note (SHPN) 04: 'In-patient accommodation: options for choice'. Health Facilities Scotland 2001.

Scottish Health Technical Memorandum 2015: 'Bedhead Services' Health Facilities Scotland 2001.

Scottish Health Technical Memorandum 2025: 'Ventilation in healthcare premises'.
Health Facilities Scotland, August 2001. (new edition forthcoming 2008, 'SHTM 03')

Scottish Health Technical Memorandum 2027: 'Hot and cold water supply, storage and mains services'. Health Facilities Scotland, December 2001. (Revised version SHTM 04 in preparation for publication in 2008).

Scottish Health Technical Memorandum 2040: 'The control of legionellae in healthcare premises: a code of practice'. Health Facilities Scotland December 2001. (Revised version in preparation for publication in 2008 within SHTM 04).

Other publications

The management and control of hospital acquired infection in acute NHS Trusts in England. National Audit Office, 2000.

Biological agents: Managing the risks in Laboratories and healthcare premises. Advisory Committee on Dangerous Pathogens, The Stationary Office.

http://www.hse.gov.uk/biosafety/biologagents.pdf

Testing buildings for air leakage. CIBSE, TM23, 2000.

Useful websites

Hospital Infection Society	http://www.his.org.uk
Infection Control Nurses' Association	http://www.icna.co.uk
Health Protection Agency	http://www.hpa.org.uk
Royal College of Nursing	http://www.rcn.org.uk
Health Facilities Scotland	http://www.hfs.scot.nhs.uk
Health Protection Scotland	http://www.hps.scot.nhs.uk

NHS National Services Scotland

SHTM 00
Best practice guidance for healthcare engineering

Policies and principles

Health Facilities Scotland
Engineering and Environment

February 2013

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Health Facilities Scotland

NHS National Services Scotland

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2.25 Scottish Health Technical Memorandum (SHTM) 07: Environment and sustainability (replaces Health Facilities Note 21 and HTM 2065 and 2075) 18

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Preface

About Scottish Health Technical Memoranda

Scottish Health Technical Memoranda (SHTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of SHTM guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building life cycle.

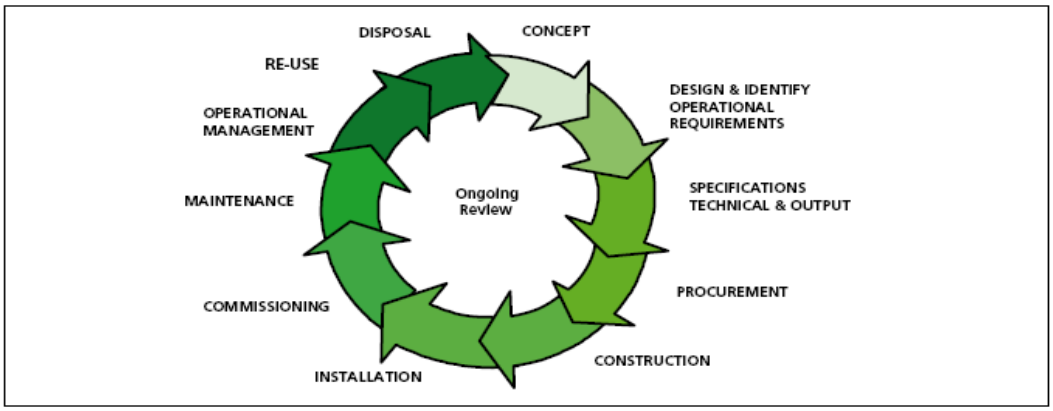

Figure 1: Healthcare building life cycle

Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Scottish (Engineering) Health Technical Memoranda (series) provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this series of documents to repeat unnecessarily international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Scottish Health Technical Memoranda guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of nine subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.

Structure of the Scottish Health Technical Memoranda (Engineering) suite

The series of engineering-specific guidance will ultimately contain a suite of eight core subjects pending a re-assessment of Firecode SHTMs 81-87.

Scottish Health Technical Memorandum 00: Policies and principles (applicable to all Scottish Health Technical Memoranda in this series)

Scottish Health Technical Memorandum 01: Decontamination

Scottish Health Technical Memorandum 02: Medical gases

Scottish Health Technical Memorandum 03: Heating and ventilating systems

Scottish Health Technical Memorandum 04: Water systems

Scottish Health Technical Memorandum 05: Reserved for future use

Scottish Health Technical Memorandum 06: Electrical services

Scottish Health Technical Memorandum 07: Environment and sustainability

Scottish Health Technical Memorandum 08: Specialist services

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

For example: Scottish Health Technical Memorandum 06-02 Part A will represent: Electrical Services – Electrical safety guidance for low voltage systems, Part A:

In a similar way Scottish Health Technical Memorandum 07-02 will simply represent: Environment and Sustainability - EnCO_2de.

All Scottish Health Technical Memoranda are supported by the initial document Scottish Health Technical Memorandum 00 which embraces the management and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.

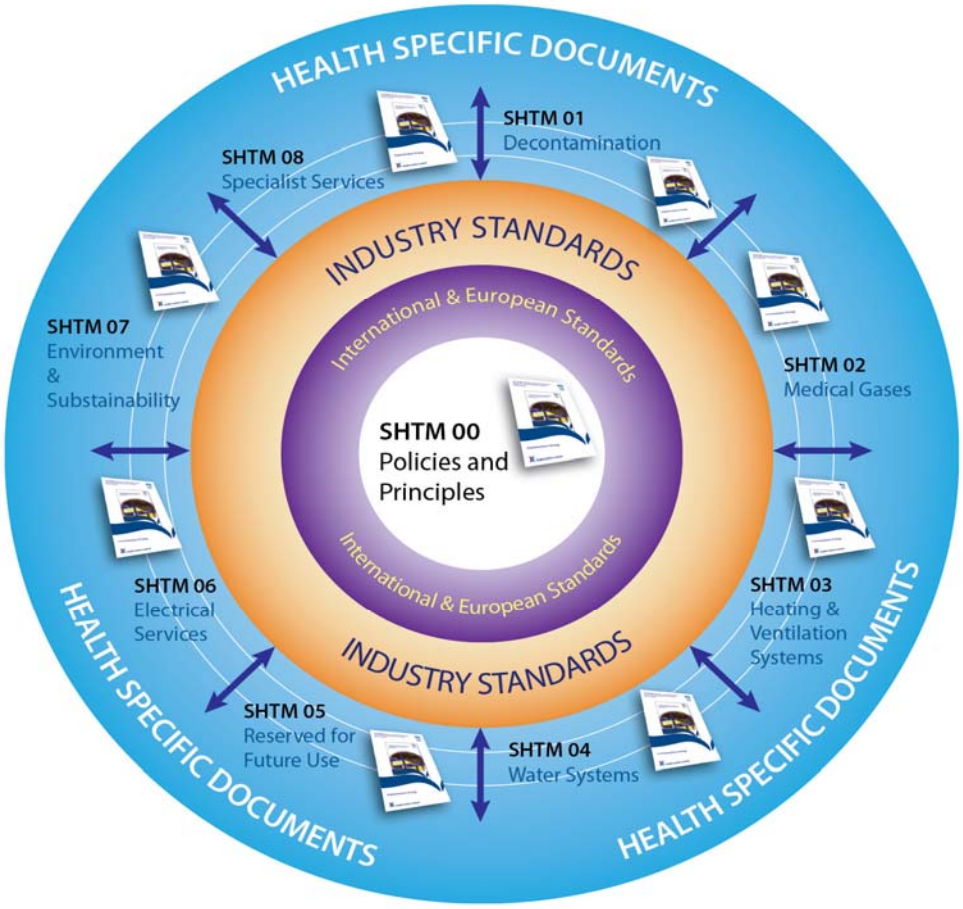

Figure 2: Engineering guidance

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Executive summary

This document gives best practice advice and provides a generic overview for Health Facilities Scotland's new suite of Scottish Health Technical Memoranda .

It is provided as a comprehensive guide to all issues relating to the management of engineering and technical service provision which can be applied to NHS and other healthcare facilities: that is, wherever NHS patients are treated.

Scope

Scottish Health Technical Memorandum 00, and the series it supports, provides comprehensive specialist advice and guidance on the design, installation and effective operation of a healthcare facility from an engineering technology perspective. While it is not intended to cover every possible scenario, for example the concept of hospital at home (in a domestic dwelling), the standards and principles it advocates may be appropriate to follow in all locations where healthcare is provided.

Aim of the guidance

The aim of Scottish Health Technical Memorandum 00 is to ensure that everyone concerned with the management, design, procurement and use of the healthcare facility understands the requirements of the specialist, critical building and engineering technology involved.

Regardless of procurement route, whether by traditional means or through a Public Private Partnership (PPP), it is essential that, as part of the briefing process, those involved in the provision of the facility are advised that all relevant guidance published by Health Facilities Scotland (HFS) is available electronically for purchase from HFS. In selecting technical advisers and preferred bidders, it is strongly recommended that their healthcare experience or credentials are thoroughly verified by the NHS Board. References should be obtained and followed up.

Only by having a knowledge of these requirements can the healthcare organisation's Board and senior managers understand their duty of care to provide safe, efficient, effective and reliable systems which are critical in supporting direct patient care. When this understanding is achieved, it is expected that (in line with integrated governance proposals) appropriate governance arrangements would be put in place, supported by access to suitably qualified staff to provide this 'informed client' role, which reflect these responsibilities.

By locally interpreting and following this guidance, NHS Boards and individual senior managers should be able to demonstrate compliance with their

responsibilities and thereby support a culture of professionalism, which instils public confidence in the capability of the NHS at local level.

Users of the guidance

Those providing NHS healthcare and operating facilities will be the main users of this document. However, other stakeholders will be interested and will expect that this best practice guidance is being followed.

Healthcare commissioners should expect that the facilities to which they refer patients should provide a safe, caring environment which aids a patient's recovery and does not expose them to undue risk. Therefore the resilience of critical engineering services and business continuity, linked to policies for emergency preparedness and the ability to respond to major incidents should be high on a provider organisation's agenda.

Structure

Within this document, each Section deals with a different aspect of engineering and technical management from an overview of commonly applicable statutes and legislation through to the training and development issues to consider when providing the necessary levels of professional and technical expertise.

- Section 2 provides an overview of the context of the Scottish Health Technical Memoranda suite;
- Section 3 (while not intending to be exhaustive) deals with commonly applicable statutory and legislative requirements;
- Section 4 considers appropriate professional and technical support;
- Section 5 looks at development of operational policies and advocates service-user involvement etc;
- Section 6 considers emergency preparedness etc and the ability of the organisation to continue to provide healthcare throughout emergency situations and to recover quickly;
- Section 7 provides guidance on staff training, systems and operation and maintenance procedures;
- Section 8 considers maintaining engineering systems to provide optimum performance and maximise the potential for critical service availability;
- Section 9 looks at design and access availability with regard to engineering services.

Recommendations

Scottish Health Technical Memorandum 00 recommends that Boards and Chief Executives, as accountable officers, use the guidance and references provided:

- when planning and designing new healthcare facilities or undertaking refurbishments;
- when developing governance systems which take account of risk;
- to establish principles and procedures which:
  - recognise and address both corporate and the individuals' responsibilities;
  - recognise the link between critical engineering systems and emergency preparedness capability;
  - reflect the important role which engineering polices and principles, as implemented by suitably qualified professional and technical staff, can have in support of direct patient care.

Once NHS Boards and Chief Executives have embraced the principles set out within this document and taken the necessary actions, their duty of care responsibilities are more likely to be fulfilled, as will their ability to maintain public confidence in the NHS at local level.

1. Introduction

Scope

1.1 Healthcare premises are dependent on the safe and secure function of critical engineering services, the application of sound environmental measures, and the support of key services. There are some common principles which apply across the full range of engineering guidance and support the wider interface of all healthcare-related equipment and its environment.

1.2 The concept of providing and maintaining safe and secure critical services carries a high priority and applies across the widest range of applications. It must apply to patients, staff and the general public: that is, *all users* of the healthcare environment.

1.3 In a similar way, the duty of care in operational performance can contribute to the overall efficiency and safety of a healthcare organisation. Accessibility to suitably qualified and competent staff is a key factor when considering governance arrangements.

1.4 Evidence suggests that a comfortable healthcare environment can have a strong influence on the healing cycle. This needs to be achieved in a sensitive way, with design having regard to the function and purpose of the specific and adjoining areas.

1.5 Staff and services must be resilient to ensure continuity of business and the safety of patients and staff, and be capable of providing a suitable response to maintain a level of healthcare in all circumstances.

Engineering governance

1.6 Responsibility and, more specifically, the duty of care within a healthcare organisation are vested in the board of management and its supporting structure.

1.7 Engineering governance is concerned with how an organisation directs, manages and monitors its engineering activities to ensure compliance with statutory and legislative requirements.

1.8 Systems and processes need to be in place, and supported by adequate resources and suitably qualified and trained staff.

1.9 Healthcare organisations should ensure that sound internal controls, safe processes, working practices and risk management strategies are in place to safeguard all their stakeholders and assets to prevent and reduce harm or loss.

Reviews

1.10 Management should conduct regular reviews of the effectiveness of the healthcare organisation's engineering structure and systems. The review should cover all controls, including strategic, operational, safety and engineering risk management.

Guidance

1.11 Scottish Health Technical Memoranda guidance provides a best-practice framework which aims to raise awareness and provide the confidence for strong management.

1.12 This document addresses the general principles, key policies and factors common to all engineering services within a healthcare organisation.

1.13 Key issues include:

- general health and safety;
- professional support;
- operational and training requirements;
- emergency preparedness;
- workforce planning and capability;
- maintenance.

1.14 To determine the right level of approach, which will often require an assessment of the risk and an evaluation of the factors that remain when reasonable and practical measures have been taken to minimise the elements giving rise for concern.

2. Overview of engineering services guidance

2.1 Within the overall Scottish Health Technical Memoranda guidance structure, there are eight specialist subjects supported by this core document. The specialist subject areas are detailed below.

Note: The sequence of numbering within each subject area does not necessarily indicate the order in which the SHTM will be published. However, the overall structure/number format will be maintained as described.

Scottish Health Technical Memorandum (SHTM) 01: Decontamination (replaces SHTM 2010, 2030 and 2031)

SHTM 01 - 01: The decontamination of reusable medical devices, Part A - Management and environment

2.2 The purpose of this guidance is to provide an overview and comprehensive advice, covering the general and regulatory environment for decontamination of reusable medical devices. It considers the key environment and management issues in this area including design, and operational management considerations. It outlines the 'best practice' for the philosophy of decontamination systems for the safety of patients and staff.

SHTM 01 - 01: Decontamination of reusable medical devices, Part B - Equipment

2.3 This document sets out the necessary arrangements for procuring and managing decontamination systems across the healthcare environment. The guidance is best practice and may encompass compliance of other industry legislation and standards.

2.4 It covers the design and pre-purchase considerations, validation and verification, and operational management of test equipment, washer-disinfectors and sterilisers.

Scottish Health Technical Memorandum (SHTM) 02: Medical gases (replaces Scottish Health Technical Memorandum 2022)

SHTM 02 - 01: Medical gas pipeline systems, Part A - Design, installation, validation and verification

2.5 The purpose of this guidance is to provide comprehensive, but not all-inclusive, advice on design considerations applicable to healthcare premises. It outlines the 'best practice' philosophy for systems where patient safety and well-being are of prime importance.

2.6 Guidance in this part covers piped medical gases, medical and surgical air, and medical vacuum installations. It applies to all medical gas pipeline systems installed in healthcare premises and anaesthetic gas scavenging disposal systems. Specifically, it deals with the issues involved in the design, installation, and validation and verification (testing and commissioning) of a medical gas pipeline system.

SHTM - 02: Medical gas pipeline systems, Part B - Operational management

2.7 The safe operation of a medical gas pipeline system relies on skilled staff who understand the system and who can liaise with clinical users to ensure continuing patient safety.

2.8 This document lists key personnel involved in the operation, maintenance and use of the system. This will include nominated medical and nursing staff, risk managers/fire safety officers, pharmacy staff and the quality controller for the site, and competent personnel (who may be in-house staff or contractors). The document also includes relevant drawings and schedules of plant, terminal units, area valve service units (AVSUs), alarms etc.

Scottish Health Technical Memorandum (SHTM) 03: Heating and Ventilating systems (replaces Scottish Health Technical Memorandum 2025)

SHTM 03 - 01 Heating and ventilating systems, Part A - (replaces SHTM 2025) Ventilation, design, installation, testing and validation

2.9 This document provides best practice guidance on the design and installation of ventilation systems and the close-control (mechanical cooling or air-conditioning) of general and ‘specialised’ healthcare environments.

SHTM 03:01 Ventilating systems Part B - (replaces SHTM 2025) Operational management and verification

2.10 This document sets out the necessary arrangements for managing healthcare ventilating and mechanical cooling systems across the majority of premises.

2.11 The sophistication of ventilating and mechanical cooling systems in healthcare premises is ever-increasing. Patients, staff and visitors have a right to expect that these systems will be designed, installed, operated and maintained to standards which will enable it to fulfil its desired functions reliably and safely. To this end, current legislation requires all parties involved to be aware of their individual and collective responsibilities.

Notwithstanding the above, it needs to be remembered that the provision of cooling outwith prescribed areas must be seen as a last resort after all other options have been examined, particularly where challenging energy target figures are to be imposed.

SHTM 04 - 01: The control of *Legionella*, hygiene, 'safe' hot water, cold water and drinking water systems, Part A - Design, installation and testing

2.12 Interruptions in water supply can disrupt healthcare activities. The design of systems must ensure that sufficient reserve water storage is available to minimise the consequence of disruption, while at the same time ensuring an adequate turnover of water to prevent stagnation in storage vessels and distribution systems.

To assist in assessing the implications of curtailment of water storage, a risk assessment should be carried out through liaison with the water supplier to verify robustness and condition of infrastructure from which supplies are to be derived, and records should be checked to assess frequency, duration and history of interruptions.

2.13 This document gives advice and guidance to healthcare management, design engineers, estates managers and operational managers on the legal requirements, design applications, maintenance and operation of hot and cold water supply, storage and distribution systems in all types of healthcare premises. It is equally applicable to both new and existing sites.

SHTM 04 - 01: The control of *Legionella*, hygiene, 'safe' hot water, cold water and drinking water systems, Part B - Operational management

2.14 This document sets out the necessary arrangements for managing healthcare water systems across the majority of premises. Current legislation requires all parties involved to be aware of their individual and collective responsibilities for the provision of wholesome, safe hot and cold water supplies, storage and distribution in healthcare premises.

2.15 The temperature control regime is the preferred strategy for reducing the risk from *Legionella* and other waterborne organisms in water systems. This requires monitoring on a regular basis. Recommended test frequencies are listed in the document.

2.16 For other water applications, such as hydrotherapy pools and provision to laundries etc (although briefly described in this publication); reference should be made to specific documentation.

SHTM 04 - 01: Water safety for healthcare premises, Part C – TVC testing

2.17 Although not strictly necessary, but favoured by many Heads of Estates, periodic TVC testing provides indication of trends and a change can give early warning of problems to come. This guidance sets out the procedures and protocols for testing to ensure consistency.

SHTM 04 - 01: The control of *Legionella*, hygiene, 'safe' hot water, cold water and drinking water systems, Part D – Water disinfection

2.18 Various forms of water disinfection are available. Some are only suitable for limited applications. This guidance sets out the benefits and draw-backs for those in common use.

SHTM 04 - 01: The control of *Legionella*, hygiene, 'safe' hot water, cold water and drinking water systems, Part E – Alternative materials and filtration

2.19 This guidance replaces Scottish Hospital Technical Note (SHTN) 2 which was originally published when copper tube corrosion first became manifest. It lists the various alternative materials approved for use in NHS Scotland premises and provides advise related to on-site filtration.

SHTM 04 - 01: The control of *Legionella*, hygiene, 'safe' hot water, cold water and drinking water systems, Part F – Chloraminated water supplies

2.20 The use of chloramination for water treatment is being pursued by the water authorities in place of chlorination. This has benefits for both the supplier and NHS Boards although there are implications for the likes of dialysis equipment. This guidance sets out the benefits and impacts.

SHTM 04 - 01: Water safety for healthcare premises, Part G – Written scheme exemplar

2.21 The Health & Safety Executive require the provision of Written Scheme for water services installations. This guidance sets out the procedures to be implemented and offers the framework for NHS Boards to adopt as templates for their production.

Scottish Health Technical Memorandum (SHTM) 05: Reserved for future use

2.22 Scottish Health Technical Memorandum 05 was to have been allocated to the replacement for the current series of Firecode guidance documents but the SHTM number is being held in reserve as Firecode SHTMs 81-87 have been updated and remain in use.

Scottish Health Technical Memorandum (SHTM) 06: Electrical services (replaces SHTM 2011, 2014, 2020 and 2021)

SHTM 06 - 01: Electrical services supply and distribution Part A – Design considerations (replaces SHTM 2007: Electrical Services supply and distribution, SHTM 2011: Emergency electrical services and absorbs SHTM 2014: Abatement of Electrical Interference).

2.23 The document is suitable for use with all forms of electrical maintenance work ranging from testing of plant, such as generators, to the periodic testing and inspection of the electrical network and final circuits.

2.24 Part A provides guidance for all work on the fixed wiring and integral electrical equipment used for electrical services within healthcare premises. The document should be used for all forms of electrical design work ranging from a new greenfield site to modifying an existing final sub-circuit. This document provides guidance to managers of healthcare premises on how European and British Standards relating to electrical safety such as the IEE Wiring Regulations BS 7671, the Building (Scotland) Regulations 2004 (and subsequent amendments) and the Electricity at Work Regulations 1989 can be used to fulfil their duty of care in relation to the Health and Safety at Work etc Act 1974.

SHTM 06: 01 Electrical services supply and distribution, Part B - Operational management (replaces SHTM 2007: Electrical services supply and distribution, SHTM 2011: Emergency electrical services and absorbs SHTM 2014: Abatement of electrical interference)

2.25 Part B provides guidance for all works on the fixed wiring and integral electrical equipment used for electrical services within healthcare premises. The document is suitable for use with all forms of electrical maintenance work ranging from testing of plant, such as generators, to the periodic testing and inspection of the electrical network and final circuits.

The document provides healthcare premises managers with guidance on the European and British Standards for Electrical Safety, such as the IEE Regulations BS 7671, the Building Regulations, and the Electricity at Work Regulations. Healthcare premises managers may be able to fulfil their duty of care in relation to the Health and Safety at Work etc Act by adopting the recommendations of this document. This SHTM recommends that designers and stakeholders review this part of SHTM 06-01 during the design process such that they are more aware of the maintenance activities required.

SHTM 06 - 02: Electrical safety guidance for low voltage systems

2.26 This Scottish Health Technical Memorandum gives operational guidance on electrical safety requirements for low voltage systems (up to 1 kV) in healthcare premises including management, professional and operational structure, safety procedures, testing, equipment and records.

2.27 Guidance is intended to assist in meeting the requirements of the Electricity at Work Regulations 1989, which detail the precautions to be taken against risk of death or personal injury from electricity in work activities.

SHTM 06 - 03: Electrical safety guidance for high voltage systems

2.28 This Scottish Health Technical Memorandum gives operational guidance on electrical safety requirements for high voltage systems (up to 11 kV) in

healthcare premises including management, professional and operational structure, safety procedures, testing, equipment and records.

2.29 Guidance is intended to assist in meeting the requirements of the Electricity at Work Regulations 1989, which detail the precautions to be taken against risk of death or personal injury from electricity in work activities.

Scottish Health Technical Memorandum (SHTM) 07: Environment and sustainability (replaces Health Facilities Note 21 and HTM 2065 and 2075)

(Scottish Health Technical Note (SHTN 3): NHS Scotland Waste Management Guidance)

2.30 This document consists of four parts:

- Part A: Best practice overview outlining NHS bodies' waste management responsibilities and best practice.

  A "practical" guidance document;
- Part B: Waste policy template providing example waste policy for all Health Boards to adopt and adapt as required;
- Part C: Waste management procedures template providing example waste procedures for all Health Boards to adopt and adapt as required;
- Part D: (forthcoming) comprising a compendium of regulatory requirements. and provides an overview of regulatory waste management requirements in Scotland.

  A "reference" document.

Note: This document incorporates aspects of HTM 07-01

SHTM 07 - 02: EnCO_2de - making energy work in healthcare (published April 2006)

2.31 This document replaces Encode guidance Parts I and II.

2.32 The purpose is to provide a primary source of guidance on managing energy use and carbon emissions in the healthcare sector. It aims to ensure that everyone involved in managing, procuring and using buildings and equipment gives due consideration to the implications of energy use and carbon emissions. It draws together best practice with the intention of putting energy at the heart of the health service.

SHTM 07 - 03: Transport management and car parking: best practice guidance for Boards

2.33 The purpose is to consider what measures NHS Boards can adopt when developing travel plans and managing transport and car parking, drawing on best practice to assist the NHS in a practical way. It aims to identify best practice in developing travel plans, give links to other assessment tools, provide a matrix from which to estimate a base level of car parking provision, point to external funding opportunities, and consider environmentally-friendly transport options.

Scottish Health Technical Memorandum (SHTM) 08: series of guidance which relates to building services systems or system components of a 'specialised' nature.

Purpose

2.34 Scottish Health Technical Memorandum 08 is the series of guidance, which relates to building services systems or system components of a 'specialised' nature.

2.35 A 'specialised' system can be either a specific stand-alone system utilised by the occupants for a specified task (for example pneumatic air tube systems or lifts), or systems interfaced or directly connected to engineering systems themselves (building & energy management control systems (BEMS).

2.36 The 'specialised' components are utilised in or in conjunction with the engineering systems to enable suitable operation (such as, sound or bed-head services).

SHTM 08 - 01: Acoustics (Replaces SHTM 2045)

2.37 This document outlines the principles and considerations associated with the control of noise generated by not only the various activities undertaken within healthcare premises but also the services which are required for these activities to be undertaken. The document is concerned with reducing both the interior noise environment affecting the exterior noise environment and vice-versa.

2.38 Noise from a certain activity within the premises should not appreciably intrude on activities taking place in adjacent areas. This may be avoided by either careful consideration of the positioning of rooms during design conception, or by provision of sufficient sound insulation.

2.39 This document provides not only the considerations for use at the design stage, but also outlines the routine maintenance of noise control hardware or acoustic treatment and the monitoring and recording of noise levels. The responsibilities of all parties involved are defined, either by brief explanation or by use of reference to specific legislation, standards and/or codes of practice.

SHTM 08 - 02: Lifts: (Replaces SHTM 2024)

2.40 This guidance sets out design and performance requirements together with safety and emergency procedures associated with traction, hydraulic and machine room-less lift installations. There is also a short section on escalators.

SHTM 08 - 03: Bedhead services: (Replaces SHTM 2015)

2.41 To be read in conjunction with SHTM 06-01 etc, this sets out design and performance requirements for bedhead services including power supplies, lighting, nurse call systems, patient monitoring, patient entertainment and medical gases pipeline systems.

SHTM 08 - 04: Pneumatic tube systems: (Replaces SHTM 2009)

2.42 This guidance sets out the design and performance parameters for pneumatic tube installations updated to reflect the latest technology and practice.

SHTM 08 - 05: Automatic controls: (Replaces SHTM 2005)

2.43 Published in four parts (A-D) this guidance sets out design and performance requirements for automatic controls installations and building management systems including innovations such as wireless technology.

SHTM 08 - 06: Pathology laboratory gas installations:

2.44 A new SHTM comprising a companion volume to SHTM 02-01 specifically concentrating on gases for laboratories.

Scottish Health Technical Memorandum (SHTM) 04-02: Water systems: Emerging technologies. Subdivided as follows:

SHTM 04-02: Part A Solar water heating

SHTM 04-02: Part B Rainwater harvesting

SHTM 04-02: Part C Grey water recovery

2.45 This guidance advises caution in the application of these technologies in the light of minimising healthcare associated infection but gives advice on practical issues.

3. Statutory and legislative requirements

Health and safety in the UK

3.1 Current health and safety philosophy was developed following the Report of the Robens Committee 1972 which resulted in the Health and Safety at Work etc Act 1974.

3.2 The standards of health and safety in the UK are delivered through a flexible enabling system introduced in 1974 by the Health and Safety at Work etc Act 1974 and are typified by the Management of Health and Safety at Work Regulations 1999.

3.3 The Health and Safety at Work etc Act 1974 leaves employers freedom to decide how to control the risks which they identify, that is, to look at what the risks are and to take sensible measures to tackle them. The Act is part of criminal law, and enforcement is by the Health and Safety Executive and Local Authority. Successful prosecution can result in fines or imprisonment.

Regulations are law, approved by Parliament. These are usually made under the Health and Safety at Work etc Act following proposals from the Health & Safety Commission. Regulations identify certain risks and set out specific actions which must be taken.

Approved Codes of Practice give advice on how to comply with the law by offering practical examples of best practice. If employers follow the advice, they will be doing enough to comply with the law.

Approved Codes of Practice have a special legal status. If employers are prosecuted for a breach of health and safety law, and it is proved that they did not follow the relevant provisions of an Approved Code of Practice, they will need to show that they have complied with the law in some other way, or a court will find them at fault.

Standards (British or European), institutional guides and industry best practice play a large part in how things should be done. They have no direct legal status (unless specified by Regulations). However, should there be an accident; the applied safety practices at the place of work would be examined against existing British or European Standards. It would be difficult to argue in favour of an organisation where safety was not to the described level.

Guidance is issued in some cases to indicate the best way to comply with Regulations, but the guidance has no legal enforcement status.

Some statutory and legislative requirements in the UK

3.4 There are numerous statutory and legal duties to which owners and occupiers of premises must adhere. These are continually changing in the light of new evidence and experience. Reference should be made to these documents at the time of application.

3.5 The following are some of the commonly cited legislation in the UK and current at the time of publication. The list is not exhaustive but is intended to demonstrate the range of issues which should be considered. All references to guidance legislation standards should be compared to those current at the time of application. Latest published guidance always takes precedence.

3.6 Only the primary Acts and main Regulations are cited here. Most of these Acts and Regulations have been subjected to amendment subsequent to the date of first becoming law. These amending Acts or Regulations are not included in this list.

- Health and Safety at Work etc Act 1974;
- Factories Act 1961 (as amended);
- The NHS and Community Care Act 1990;
- Consumer Protection Act 1987;
- Disability Discrimination Act 2005 (DDA);
- The Management of Health and Safety at Work Regulations 1999;
- Workplace (Health, Safety and Welfare) Regulations 1992;
- Provision and Use of Work Equipment Regulations 1998;
- Manual Handling Operations Regulations 1992;
- Personal Protective Equipment at Work Regulations 1992;
- Health and Safety (Display Screen Equipment) Regulations 1992;
- Confined Spaces Regulations 1997;
- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR 95);
- The Working Time (Amendment) Regulations 2002;
- Control of Substances Hazardous to Health Regulations (COSHH) 2002;
- Health and Safety (First-Aid) Regulations 1981 and Miscellaneous Amendments 2002;
- Health and Safety (Consultation with Employees) Regulations 1996;
- Health and Safety Information for Employees Regulations 1989;
- Health and Safety (Safety Signs and Signals) Regulations 1996;
- Employers' Liability (Compulsory Insurance) Regulations 1998 and (Amendment) Regulations 2004;

- The Health and Safety (Training for Employment) Regulations 1990;
- Safety Representatives and Safety Committees Regulations 1977;
- Control of Asbestos at Work Regulations 2006.

Electrical

- Electricity Act 1989;
- Electricity Safety, Quality and Continuity Regulations 2002;
- Electricity at Work Regulations 1989;
- BS 7671:2008 (IEE Wiring Regulations, 17th Edition);
- The Electrical Equipment (Safety) Regulations 1994;
- The Plugs and Sockets etc (Safety) Regulations 1994;
- The Radio Equipment and Telecommunications Terminal Equipment Regulations 2000 and Amendment 2003;
- Electromagnetic Compatibility Regulations 2005.

Mechanical

- Supply of Machinery (Safety) Regulations 1992 and Supply of Machinery (Safety) (Amendment) Regulations 1994;
- Lifting Operations and Lifting Equipment Regulations 1998 (LOLER);
- Gas Appliances (Safety) Regulations 1995;
- Gas Safety (Installation and Use) Regulations 1998;
- The Lifts Regulations 1997;
- Noise at Work Regulations 2005;
- The Pressure Systems Safety Regulations 2000;
- The Pressure Equipment Regulations 1999 and (Amendment) Regulations 2002;
- Simple Pressure Vessels (Safety) Regulations 1991;
- The Construction (Design and Management) Regulations 2007;
- The Construction (Health, Safety and Welfare) Regulations 1996;
- The Building (Scotland) Regulations 2004.

Environment

- The Environmental Protection Act 1990;
- The Control of Pollution (Amendment) Act 1989;
- The Waste Management Licensing Regulations 1994 (as amended);
- Environmental Protection (Duty of Care) Regulations 1991;

- The Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations 1991;
- Special Waste Amendment (Scotland) Regulations 2004;
- Pollution Prevention and Control (Scotland) Regulations 2000;
- The Special Waste Regulations 1996;
- Clean Air Act 1993;
- Environmental Protection (Prescribed Processes) Regulations 1991;
- Trade Effluent (Prescribed Processes and Substances) Regulation 1989 Amended 1990, 1992;
- Controlled Waste Regulations 1992 Amendment 1993;
- Environment Act 1995;
- Packaging (Essential Requirements) Regulations 2003;
- Control of Pollution (Oil Storage) (Scotland) Regulations 2003;
- The Landfill Tax Regulations 1996 and Landfill Tax (Qualifying Material) Order 1996;
- Chemicals (Hazard Information and Packaging for Supply) Regulations 2002;
- The Planning etc. (Scotland) Act 2006;
- The Control of Pollution Act 1974 and (Amendment) Act 1989;
- Producer Responsibility Obligations (Packaging Waste) Regulations 2007;
- Waste Electrical and Electronic Equipment Directive 2002;
- The Water Environment and Water Services (Scotland) Act 2003;
- The Water Byelaws (Scotland) 2000;
- Control of Lead at Work Regulations 2002;
- Control of Pesticides Regulations 1986;
- Noise and Statutory Nuisance Act 1993.

Radiation

- Ionising Radiations Regulations 2004 (IRR99);
- The Radioactive Substances Act 1993 (RSA93);
- Ionising Radiation (Medical Exposure) Regulations 2000;
- Radioactive Materials (Road Transport) Regulations 2002;
- Medicines (Administration of Radioactive Substances) (Amendment) Regulations 2006.

Fire

- The Fire (Scotland) Act 2005 as Amended;
- The Furniture and Furnishings (Fire) (Safety) Regulations 1988;
- Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) 2002.

Food

- The Food Safety Act 1990;
- The Food Safety (General Food Hygiene) Regulations 1995;
- The Food Safety (Temperature Control) Regulations 1995.

Public Health

- Public Health (Infectious Diseases) Regulations 1988;
- Medicines Act 1961.

3.7 This list demonstrates the complex services which exist within a healthcare organisation. A further brief description of each piece of legislation is given in Appendix 1 of this document.

Risk and/or priority assessment

3.8 In carrying out design, operational and management evaluation, a consistent method of assessment should be engaged to ensure adequate information, consultation and appraisal is undertaken across the whole range of influences.

3.9 Although some elements of a particular assessment may be complex (for example whole-life costing, net present value, patient criticality, resilience etc), it is important to keep the collective assessment as simple as possible.

3.10 One method is to establish an evaluation matrix which allows information across two scales to be represented in an easily understood way which helps users come to a particular decision.

3.11 Both scales are graded from lowest to highest such that a combination of the assessments can be represented.

3.12 For example, an event analysis may appear as below: mapping the likelihood of an event happening and the severity of the effect.

3.13 In a similar way, a cost/benefit matrix may be constructed or a risk/design measure assessment made.

3.14 A more detailed example of applied risk assessment may be found in the Department of Health's (2005) 'A risk-based methodology for establishing and managing backlog'.

The Matrix shown below has been adopted for use in SCART, Statutory Compliance Audit and Risk Tool.

Likelihood / Severity	Negligible (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Rare (1)	Low (1x1)	Low (1x2)	Low (1x3)	Low (1x4)	Medium (1x5)
Unlikely (2)	Low (2x1)	Low (2x2)	Medium (2x3)	Medium (2x4)	High (2x5)
Possible (3)	Low (3x1)	Medium (3x2)	Medium (3x3)	High (3x4)	High (3x5)
Likely (4)	Low (4x1)	Medium (4x2)	High (4x3)	High (4x4)	Very High (4x5)
Almost Certain (5)	Medium (5x1)	High (5x2)	High (5x3)	Very High (5x4)	Very High (5x5)

Adapted from the AS/NZ 4360 Standard Risk Matrix and NHS QIS Risk Matrix

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4. Professional support

4.1 Managers of healthcare property and services need technical and professional support across a range of specialist services. This support should be embedded into the structure and responsibility framework of the organisation to ensure an adequate approach for each of the areas covered by the healthcare-specific technical engineering guidance.

4.2 Within the Scottish Health Technical Memoranda, a range of measures are discussed to meet the needs of each service. This Section considers the principles, standards and common features which will be applicable as a core approach.

Management and responsibility

4.3 Healthcare organisations have a duty of care to patients, their workforce and the general public. This is to ensure a safe and appropriate environment for healthcare. This requirement is identified in a wide range of legislation.

4.4 At the most senior level within an organisation, the appointed person should have access to a robust structure which delivers governance, assurance and compliance through a formal reporting mechanism.

Scottish Health Technical Memoranda guidance structure

4.5 Following the SHTM guidance review, seven specialist topics have been initially identified while that on Fire Safety remains to be tackled:

- decontamination;
- medical gases;
- heating and ventilation;
- water;
- electrical services;
- environment and sustainability;
- Specialist services.

4.6 Within each topic, specific duties and responsibilities are defined. See Figure 2 in the Preface for structure and relationships.

Management structure

4.7 To engage and deliver the duties required, a healthcare organisation may consider the structure shown in Figure 3. In following this structure, healthcare

organisations may consider that the necessary professional and technical resilience is available to provide a robust service.

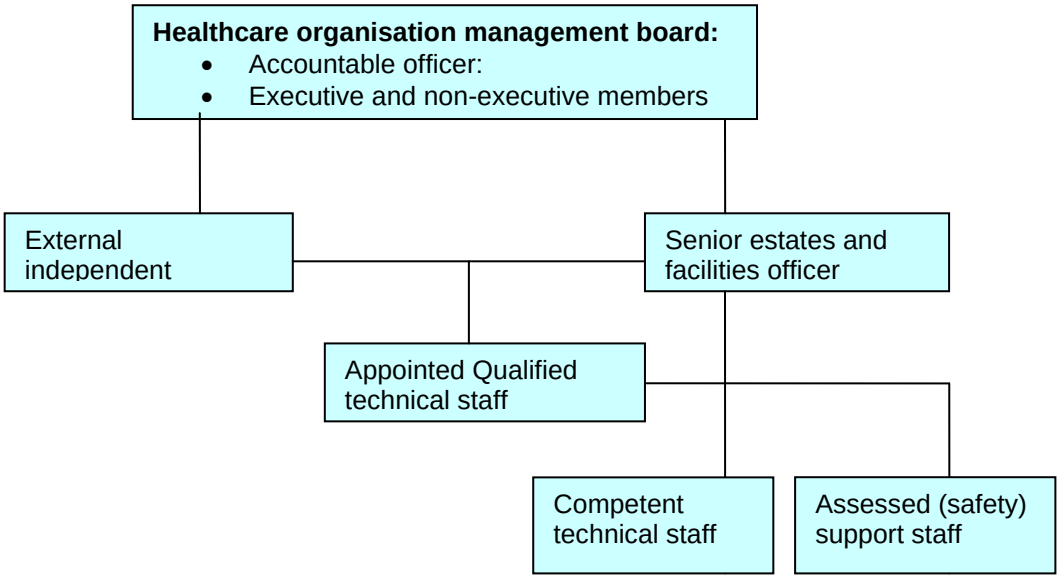

Figure 3: Management structure

Professional structure

4.8 While a Chief Executive and the NHS Board carry ultimate responsibility for a safe and secure healthcare environment, it can be assigned or delegated to other senior executives.

4.9 It may not be generally possible to maintain a senior executive with specialist knowledge for all professional services. External support may therefore be required.

4.10 An independent adviser for audit purposes, assessment and operational advice may also be required.

4.11 The structure shown in Figure 4 represents a professional approach to delivery of a specialist service.

4.12 Within a specific service, other support staff for safety, quality and process purposes may be required.

4.13 Within certain healthcare organisations, some elements of specialist services are not present (high voltage electrical, decontamination, medical gas pipelines etc). In this case, an appropriate level of external professional support should be considered.

4.14 It is possible for several organisations to share the same professional staff either individually or collectively; however, it is usual for the Authorising Engineer role to remain independent of the organisation, with particular regard to the critical audit process.

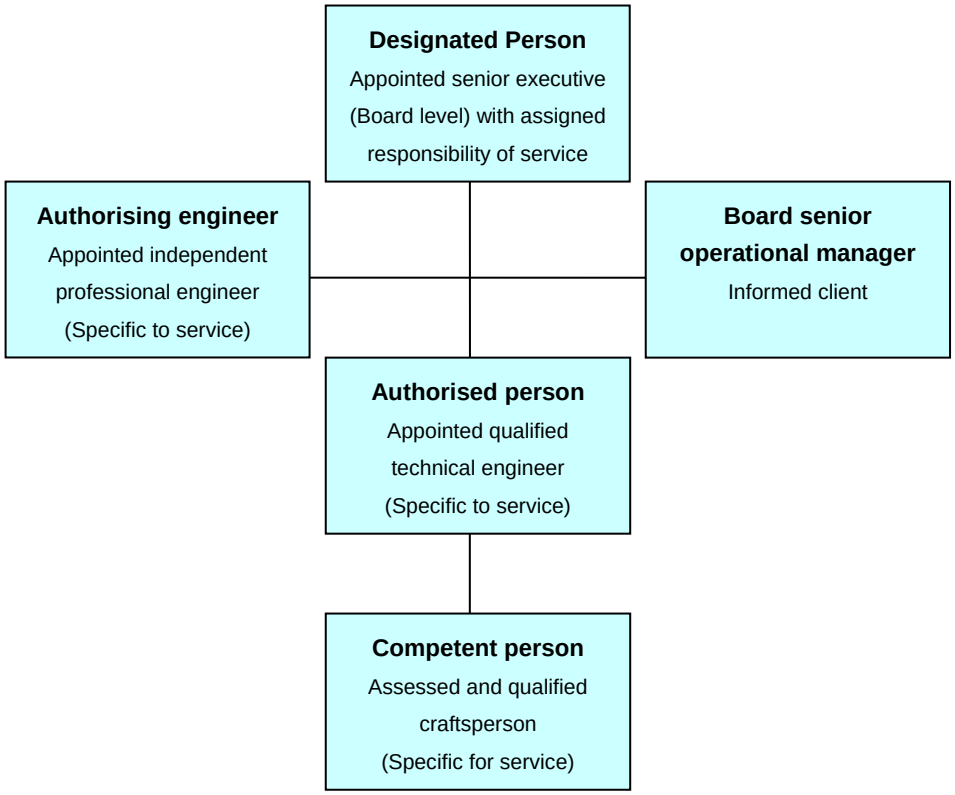

Figure 4: Professional structure

Roles and responsibilities

Designated Person (DP)

4.15 This person provides the essential senior management link between the organisation and professional support, which also provides independence of the audit-reporting process. The DP will also provide an informed position at NHS Board level.

4.16 The DP will work closely with the Senior Operational Manager to ensure that provision is made to adequately support the specialist service.

NHS Board Senior Operational Manager (SOM)

4.17 The SOM may have operational and professional responsibility for a wide range of specialist services. It is important that the SOM has access to robust, service-specific professional support, which can promote and maintain the role of the 'informed client' within the healthcare organisation. This will embrace both the maintenance and development of service-specific improvements, support the provision of the intelligent customer role and give assurance of service quality.

Authorising Engineer (AE)

4.18 The AE will act as an independent professional adviser to the healthcare organisation. The AE should be appointed by the organisation with a brief to provide services in accordance with Scottish Health Technical Memoranda guidance. This may vary in accordance with the specialist service being supported.

4.19 The AE will act as assessor and make recommendations for the appointment of Authorised Persons, monitor the performance of the service, and provide an annual audit to the DP. To carry out this role effectively, particularly with regard to audit, it is preferable that the AE remains independent of the operational structure of the NHS Board.

Authorised Person (AP)

4.20 The Authorised Person has the key operational responsibility for the specialist service. The person will be qualified and sufficiently experienced and skilled to fully operate the specialist service. He/she will be nominated by the AE and be able to demonstrate:

- his/her application through familiarization with the system and attendance at an appropriate professional course;
- a level of experience;
- evidence of knowledge and skills.

4.21 An important element of this role is the maintenance of records, quality of service and maintenance of system safety (integrity).

4.22 The AP will also be responsible for establishing and maintaining the roles and validation of Competent Persons, who may be employees of the organisation or appointed contractors.

4.23 Larger sites may need more than one AP for a particular service. Administrative duties such as record-keeping should be assigned to specific APs and recorded in the operational policies.

Competent Person (CP)

4.24 This person provides skilled installation and/or maintenance of the specialist service. The CP will be appointed, or authorised to work (if a contractor), by the AP. He/she will demonstrate a sound trade background and specific skill in the specialist service. He/she will work under the direction of the AP and in accordance with operating procedures, policies and standards of the service.

Variation by service

4.25 The particular detailed roles and responsibilities will vary between specialist services, and the guidance given in the appropriate SHTM should be followed to

ensure that the necessary safe systems of working are established and maintained.

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5. Operational policy

General

5.1 The healthcare organisation's management board is responsible for setting overall operational policy, and it is the Designated Person, as the senior executive, who has responsibility for implementation.

5.2 The Scottish Health Technical Memoranda series should enable an organisation to be aware of the issues relative to a particular service and support any operational policy which has to be prepared.

5.3 It is acknowledged that some organisations have separate procedures which are referenced within the operational policy under the control of other specific departments.

5.4 Where the operation of engineering services is vital to the continued functioning of the healthcare premises, operation and maintenance may require special consideration; therefore, improving resilience within the critical engineering systems should be considered. When preparing briefing for new or refurbishment projects, consideration will require to be given to the options of having backup provision as an integral part of purchased equipment or whether designers have to make specific allowance for this.

Operational considerations

5.5 The operational policy should ensure that users are aware of the capacity of the specific system and any particular limitations.

5.6 A maintenance policy which pursues and expects the good upkeep of plant and equipment by regular inspection and maintenance is evidence of best practice.

5.7 All safety aspects of operation associated with particular plant or equipment should be clearly understood by operational staff.

5.8 Nursing, medical and other staff should be aware of the purpose of any alarm systems and of the course of action to be taken in the event of an emergency occurring.

5.9 Staff responsible for engineering plant operation should be aware of the activities necessary to ensure the continued safe operation of the system and what action to be taken in an emergency.

5.10 The Authorised Person responsible for engineering services should take a lead in explaining to users the function of the system, and organise adequate information and training about the system.

5.11 Maintenance and safety are two closely related subjects. General safety is largely dependent on good standards of maintenance being attained and staff safety disciplines being exercised.

Records/drawings

5.12 The organisation should have accurate and up-to-date records and/or drawings. These should be readily available on site, in an appropriate format, either electronically or in hard copy for use by any Authorised Person responsible for engineering services. They form part of Written Schemes as required by the Health & Safety Executive and set out in their Approved Code of Practice L8. In a PPP situation where maintenance is undertaken by consortia FM Provider, all such information should be provided for NHS Board access on a 'read-only' basis.

5.13 A unique reference number should identify the equipment. This should correspond to that shown on the records/drawings.

5.14 The records/drawings should indicate the type and make of the equipment.

5.15 Database systems could be used to link plant reference numbers to locations on drawings and detailed records of the plant and its maintenance.

5.16 A schematic diagram of the installation should also be available and displayed in each plant room or service area, scheduling key components.

5.17 When additions or alterations are to be made to existing installations, the Authorised Person responsible for engineering services should ensure that the current as-fitted information is available in an acceptable format. On completion of the work, the records/drawings should be updated and the service alterations noted and dated.

Security

5.18 All means of service isolation, regulation and control (except those in plant rooms) should be secured in such a way that they can be fixed in the 'normal' position.

5.19 In the case of those components which may have to be operated in an emergency, the fixing method should be capable of being overridden.

5.20 All plant rooms should be kept locked, suitably signed and under access control.

5.21 A procedure in the operational policy for controlling access, including in the event of an emergency, should be established.

5.22 Adequate means of engineering plant isolation and safe working areas should be provided for all operational and maintenance contingencies to allow temporary plant where required and safe working around equipment.

Monitoring of the operational policy

5.23 The Designated Person is responsible for monitoring the operational policy to ensure that it is being properly implemented. This should be carried out on a regular basis, and the procedure for such monitoring should be set out in the operational policy.

5.24 The responsibility for monitoring specific aspects may be delegated to appropriate key personnel. For example, the responsibility for monitoring the implementation of the permit-to-work procedure would normally be delegated to the Authorised Person. The details of such delegation shall be set out in the operational policy.

Contractors

5.25 All contractors should comply with the organisation's safety procedures. This should be clearly stated in the operational policy.

5.26 Work should only be carried out by suitably qualified contractors within the range of design, installation, commissioning or maintenance of services as appropriate. Evidence of current registration should be by sight of the appropriate certificate of registration.

5.27 The operational policy should set out the responsibilities for monitoring the work of contractors. The Authorised Person responsible for the specific engineering services would normally co-ordinate this. The 'call-out' procedures for a contractor, particularly in the event of a fault or an emergency, should be set out in the operational policy.

Medical equipment purchase

5.28 The Authorised Person responsible for engineering services must be consulted during initial discussions on the purchase of any significant piece of medical equipment which will be connected to the engineering services. This will be in terms of high electrical running or start-up loads, requirement for clean electrical supplies, and provision of uninterruptible power supplies (UPS), high heat gains or needs for process cooing water. This is to ensure that the systems have sufficient capacity and can continue to deliver the required service.

5.29 The policy should state the procedures to be followed and the personnel who need to be consulted before a new item of medical equipment is connected to an engineering service.

6. Emergency preparedness and contingency planning

Introduction

6.1 Under the Civil Contingencies Act 2004, certain NHS organisations (as category 1 responders) e.g. Scottish Ambulance Service, geographical NHS Boards in Scotland, Health Protection Agency (but not Health Protection Scotland) are required to assess the risk of an emergency occurring and the impact on business continuity.

6.2 The organisation should sustain plans for the purpose of minimising the impact from such emergencies, maintaining services and protecting patients and staff.

6.3 Healthcare organisations should contribute and receive information through their local strategic co-ordinating group (SCG), which exchanges views and knowledge across a wide range of services within a local community.

Note: In all aspects of emergency and operational planning, Health Boards should ensure engagement with the emergency planning officer and local security management lead.

Wider specific NHS guidance on the management of non-clinical business continuity in healthcare facilities can be found in 'The National Health Service in Scotland Manual of Guidance: responding to emergencies'.

6.4 Healthcare organisations may encounter such scenarios as:

- unplanned interruption to a utility supply (gas, water, electricity etc);
- unexpected equipment and service distribution failures (telephones, water pipework, medical gases etc);
- a civil incident (act of terrorism, civil disturbance etc);
- an environmental incident (floods, transport incident, storm damage etc).

6.5 Such failures or incidents, when they occur, can have an impact on all aspects of healthcare services, including patient care, staff comfort, and health and safety.

6.6 Failures in essential support systems may lead to patient evacuation and the temporary closure of wards, which could have a major impact on the public's confidence in a healthcare organisation.

6.7 Additionally, dependent on the scale or nature of the incident, the ability of the organisation to continue an acceptable level of healthcare services may itself be compromised.

6.8 It is the responsibility of the healthcare organisation's management to ensure that their premises comply with all legislation. (See Appendix 1 for a summary of commonly cited health and safety guidance documents.) Additionally, when considering the implications of, for example, an incident associated with terrorism, reference should also be made to 'The National Health Service in Scotland Manual of Guidance: responding to emergencies'.

6.9 Planning for such emergencies can help to reduce the impact. By developing an emergency plan, healthcare organisations should be able to restore systems to normal as quickly as possible after an emergency, using safe working methods and making the best use of available resources.

6.10 Plans need to be regularly tested and updated to meet changing circumstances.

6.11 Emergency and contingency planning cannot be carried out in isolation.

6.12 All arrangements should be agreed through consultation and dialogue.

6.13 Individual services or departments should be encouraged to accept responsibility for contingency arrangements. This is particularly important for services provided through associated contracts (via PPP partners, commercial business, service level agreements etc).

6.14 Essential-service contingency plans should not be confused with major incident plans (although the two should be consistent):

- major incident plans generally are outward looking and deal with the healthcare organisation's response to a public incident for which an immediate high level of healthcare is required;
- contingency planning is generally inward looking and deals with actions needed to maintain a healthcare facility in a safe and operational status under adverse conditions.

6.15 It is possible that some features from both plans may be needed for a complex incident, but lines of responsibility should be clearly defined and understood at all times.

Creating an emergency plan

6.16 All plans should be documented and supported by as much information as possible. This should be kept up-to-date and under constant review.

6.17 It is important to define the area to which the plan will apply. This will usually be by site rather than individual buildings to avoid repetition of procedures and to embrace the wider service issues.

6.18 From an understanding of the area and the healthcare activity that takes place, all the estates services and facilities which exist in the range of buildings on-site should be considered.

6.19 Table 1 gives a broad list of suggested topics for consideration. It is not a comprehensive list and may not be applicable to all sites, but it should act as a prompt to establish the ‘services list’.

Systems	Services	External Influence
Main electricity supply	Catering – patients and staff	Mains water contamination
Standby generators	Key clinical departments (A&E, theatres, critical care etc)	Air pollution
UPS and other batteries	Estates and facilities management (including engineering, APs, CPs etc)	Flooding
Mains water	Transport	Mains sewage treatment failure
Hot water	Portering	Transport routes and infrastructure
Treated water	Administration support	Infestation
Heating and ventilation	Patient information	Civil disturbance
Steam	Cleaning	Explosion
Critical cooling	Waste disposal	Evacuation
Pneumatics	Laundry	Terrorism incidents
Building Management System	Medical supplies	Communications
Drainage	Fuel supplies	
Surface/foul/waste	Water drainage	
Fuel supplies	Security	
Gas/oil/other		
Communications		
Telephones (fixed)		
Mobile		
Paging		
Electronic		
IT and Patient information system		
Lifts		
Sterilization and decontamination		
Medical gases		
Fire alarms		

Table 1: Suggested systems and services for consideration when creating an emergency plan

System resilience, planning and design

6.20 Resilience of the various systems and services (for example water and fuel) is ideally provided at the design stage of a healthcare facility. This could include:

- priority allocation of the site by local utility suppliers which provide alternative routes, for site supply, should parts of the external infrastructure be damaged or contaminated;
- resilient internal infrastructure systems which provide flexibility in services supplies to buildings;
- provision of alternative fuel sources, with appropriate storage capacity on-site (for example, fuel oil as back-up to natural gas, for boiler plant);

- enhanced levels of on-site standby capacity for electricity supplies by the use of CHP systems, the sizing of standby generator plant, and flexible electrical distribution systems;
- appropriate monitoring and storage capacity for, for example, water supplies.

6.21 Planning and designing for resilience whenever the opportunity arises, that is, when new sites/buildings or departments are being considered and when major refurbishments are taking place, is a key responsibility of the Health Board.

6.22 This will require a clear understanding of the critical operational service requirements and the type and level of ongoing service needs in the event of an emergency/incident.

6.23 Prerequisite information should be provided at the planning and design stage to enable an appropriate level of resilience to be built in. For this purpose, close liaison should take place between the organisation's emergency planning lead and the estates and facilities professionals at the earliest possible stages.

6.24 Of particular importance in times of emergency are all forms of communication systems. Email, mobile phones, advanced telephone/telemedicine and patient data systems may all require a detailed analysis of the effect of failure or loss.

6.25 Proposed changes to any communication system should ensure that consideration is given to the requirements of emergency plans and communication-service resilience before decisions are taken.

6.26 These considerations should also include home/mobile communication systems for key staff who will be required in the event of an emergency or adverse incident.

Services and priorities

6.27 Maintaining services is an essential function of business continuity and must be a priority within a contingency plan. Alternative sources of catering, laundry, waste disposal, transport etc need to be confirmed, and all lines of communication and supply chains regularly tested.

6.28 It is also necessary to discuss and establish the priorities of clinical services within the plan. These will move from life-critical functions (operating theatres, critical care areas, neonatal intensive care units, emergency care) through diagnostic services (imaging, laboratories) and on to clinical support (blood, sterile services, pharmaceutical supplies, medical gases etc).

6.29 Prioritised but flexible, estates and facilities services which underpin clinical priorities will provide a good platform for the organisation to cope with the impact of emergencies and speed up recovery to provide normal business continuity.

External impact

6.30 External influences are perhaps the most difficult element of contingency planning due to the wide range of scenarios that could be presented. Consequently, scenario planning for every eventuality is very unlikely.

6.31 However, some of the most likely scenarios and the key issues arising should be examined, evaluated and, where possible, tested to ensure that some form of response is in place for that eventuality, for example loss of major utility, external communication links etc.

Security

6.32 Areas of clinical concern, for example radiology, pathology, may require enhanced access control, and staff and contractor screening, in accordance with the 'Security Management Framework for NHS Boards in Scotland'.

6.33 Adverse incidents may present exceptional requirements to control security, access, patient and staff safety etc. Planning should ensure that measures are available and understood which may include additional staff resources (drawn from non-critical roles) for entry/exit control, increased awareness and communications, defined management responsibility etc.

Responsibility

6.34 If the issue or incident remains predominantly an estates or facilities issue, action should be coordinated through the estates and facilities management (EFM) structure. However, if the cause and/or effect escalates into a more major event, and a major incident is declared, the lines of responsibility should revert to the major incident plan structure.

6.35 Accountability must be maintained within the healthcare organisation's structure. The Chief Executive and NHS Board members must be aware of the proposed contingency plans, although it is likely that operational managers will implement the actions.

6.36 The structure of different organisations will mean that staff with varying levels of experience and expertise could be called upon to deal with estates and facilities emergencies.

6.37 Written emergency operational procedures should therefore be easily understood by those people expected to use them. For example, if the management structure is such that emergencies associated with engineering services will always be handled by a qualified and experienced engineer, the emergency operational procedure may be highly technical.

6.38 In many cases, however, standby staff who may be the first to attend an emergency will not have the technical knowledge to make appropriate decisions. If this is the case, emergency operational procedures should be detailed and specific, and should include instruction on where and how to seek

assistance from a more experienced colleague at any stage. This instruction should normally include more than one route and more than one level of management (that is, it should have some communication resilience).

Staff functions

6.39 Whether employed directly by NHS Boards or by PPP consortia FM Providers, individuals who are responsible for different parts of the emergency process should be identified, notified and trained accordingly. Key personnel will include:

- communications manager;
- incident manager;
- resource manager;
- emergency procedure manual owner.

Communications manager

6.40 This is a vital responsibility which should be assigned to someone who has a wide range of knowledge about the site and the infrastructure. It may also be necessary to co-ordinate between departments, media, public, emergency services, and other healthcare managers and providers.

Incident manager

6.41 This will probably be the most senior Operational Manager available.

Resource manager

6.42 This role is necessary for emergency procurement, contact with external support, and maintaining a record of staff on site. It is important to ensure that staff welfare requirements are also considered and included in the plans.

Emergency procedure manual owner

6.43 For each key role identified, there should be a specific copy of the manual, and individual departments should have a copy assigned to a named individual whose role it is to maintain and review the details to ensure they remain valid.

Testing the plan

6.44 Small elements of the plan should be exercised in order to familiarise staff and to test procedures.

6.45 Larger and more wide-ranging exercises should be carefully planned to ensure that control is maintained and that reversion to status quo is easily achieved. An alternative is to carry out a ‘table-top’ exercise where a scenario approach is tested and staff are challenged to deal with the issues that arise.

6.46 These approaches should engage all staff involved in contingency and emergency planning for the healthcare organisation so that all lessons learned can be shared across all services and used to update the plans.

7. Training, information and communications

General

7.1 All personnel employed in the operation and maintenance of critical engineering services, including maintenance personnel and operators, should receive adequate, documented training. Personnel should not commence their duties until this training has been completed and detailed operating instructions have been provided.

7.2 As a minimum, training should include:

- the prime function for the operation and maintenance of the critical engineering service;
- operational policies;
- safety provisions;
- first-aid (as appropriate);
- emergency procedures;
- use of respiratory equipment (as appropriate);
- duties to be performed;
- actions in the event of a fire;
- problems and hazards that can arise from failing to follow the agreed operating, monitoring and maintenance procedures;
- the permit-to-work system and safety procedures in use (when appropriate);
- the danger of making unauthorized modifications, alterations or additions to the critical engineering service, as well as the possible legal consequences;
- the procedure to be followed if it is suspected that the system is no longer operating correctly.

Building occupiers

7.3 The engineering services and their functions and operation should be explained to the building occupiers. This will assist in understanding the safe operation and capability of the particular system when changes are being considered.

Service and maintenance staff

7.4 Training of all staff involved with the operation or maintenance of the engineering services is essential to realise the optimum use of facilities and the safety of staff, patients and the public.

The required workforce (as defined by service and operational needs)

7.5 All staff involved, irrespective of employer, need to be adequately trained and competent to undertake the work expected of them. This is especially pertinent to work on critical engineering systems and services where errors may have significant implications.

7.6 Consequently, a process needs to be developed which regularly checks that the workforce is competent and suitably trained to cover all aspects of the work required. The following issues may require consideration:

- analysis of maintenance profile (review of existing practice);
- assessment of emergency repair experience (to inform staff profile);
- planned and first-line maintenance of equipment (to determine essential skills);
- recruitment and retention experience (to understand the likely labour pool available);
- skills gap (determined by an analysis);
- potential/ideal staff profile (as if setting up a new structure);
- possible training (to meet the above if not available from in-house arrangements).

7.7 From this type of assessment, it should be possible to determine the service shortfalls relative to loss of staff for which a natural replacement is not readily available, and the skill shortages of existing staff and the skill shortage for equipment or systems installed etc.

7.8 The resulting analysis may give rise to either a training need for existing staff or a need for a staff/structure review with possible training implications. It may also identify a service, which may be more cost-effectively provided by an outsourced contract.

7.9 While it is important to address the staff profile by trade or service, it may be useful for an organisation to link the outcome with other service profiles. This may indicate some common issues, economies of scale for training needs, useful feeder groups and a better general overview of the service, which can be used to inform a priority assessment.

Improving the workforce profile

7.10 Many of the traditional training routes no longer provide the level of opportunity relevant to the healthcare sector; at the same time, skills and competences needed are becoming more and more specific to the healthcare sector.

7.11 One challenge is to encourage more young people to enter the services sector of healthcare organisations under specific programmes such as the modern

apprenticeship scheme where skills can be delivered to meet a specific need. Another is to develop a multi-skilled approach to service delivery. In each case, training and development will be an important factor in the solution.

7.12 With an understanding of the existing workforce profile, a training plan may be established to meet the short, medium and long-term requirements that are needed to satisfy the organisation's requirements.

7.13 The cost of training and the cost of apprenticeships can be difficult to secure. When presented as part of an overall assessment with, at least, a medium-term plan, it can deliver cost-efficient provision of services meeting the future need of the organisation.

7.14 Training and the quality of service are inter-linked. Taking full advantage of multi-skilling and flexible working practices will begin to deliver the cost and performance efficiencies required from the services.

Criteria for operation

7.15 Maintenance staff should be trained in all relevant maintenance procedures.

7.16 The depth of training will depend on the level of required maintenance, but it should at least draw attention to any risks and safety hazards arising due to maintenance activities.

7.17 Other personnel who monitor plant or who carry out routine plant maintenance should be trained in:

- understanding the visual displays;
- acknowledging and canceling alarms;
- taking required actions following alarm messages;
- obtaining the best use of the system.

7.18 Training (including refresher training) will need to be repeated periodically in order to cater for changes in staff or the systems.

7.19 Records of the training provided should be kept up-to-date.

7.20 On completion of training, employees should be assessed by an Authorised Person to ensure that the training programme has been understood and that they are competent to undertake the work required.

8. Maintenance

General

8.1 Healthcare organisations should make available to maintenance personnel originals of commissioning data, as-fitted drawings, manuals etc, and records of any changes implemented since commissioning.

8.2 Schedules of routine maintenance activities, suggested spares lists, and operational information should be readily available. This should be achieved by the use of computer-based systems to maintain plant databases, maintenance requirements and records.

8.3 Monitoring of data from the critical engineering services enables faults to be rectified at an early date.

8.4 The actual frequency of any particular maintenance activity and the need for planned preventive maintenance of the critical engineering services should be determined and continually assessed throughout its operation. This is to avoid unnecessary routine maintenance while ensuring the services remain safe and available.

8.5 The initial frequency of maintenance will depend on the manufacturer's recommendations and the circumstances of application.

8.6 Record sheets should be completed for all maintenance actions.

Maintenance contractors

8.7 Organisations may arrange for the appointment of a contractor to provide a maintenance service and emergency breakdown support should directly-employed staff not be suitably qualified or available.

8.8 Initial maintenance of equipment is particularly important to establish validation of warranties. Responsibility for this can be focused effectively by including the first 12 months maintenance in the supply contract. If maintenance is to be provided by the supplier/installer, it will be advantageous to detail the costs in the initial tender invitations.

8.9 The maintenance contractor may not be the equipment provider, services manufacturer or the installation contractor. Clear understanding needs to be established as to who is responsible for what, and what maintenance service will be provided.

8.10 Management should be satisfied that the contractor responsible for the regular maintenance of the engineering services employs staff who:

- understand the extent and nature of the healthcare to which the service relates;
- are competent to do the work and have had the necessary training;
- have a knowledge of the installed system;
- maintain a current awareness of the manufacturers' equipment, including computer hardware and software;
- have access to modern diagnostic equipment;
- have good technical support;
- are supported by an adequate supply of spares.

8.11 Records of service reports and attendance dates (both scheduled and achieved) should always be available.

Maintenance policy

8.12 A maintenance policy that pursues and expects the good upkeep of equipment by regular inspection and overhaul is a sign of good management. An appreciation of safety, at all times, by operational staff should be encouraged.

Tools

8.13 Special tools to carry out the necessary basic level of breakdown, maintenance or overhaul should be held in stock.

8.14 Instrumentation and tools which are classified as safety tools should always be available on site, and their position known to those who may need to use them.

Instructions

8.15 It is essential that practical training is given to all operational and maintenance staff to ensure that work routines, operational procedures, and correct application of the safety procedures and rules are implemented.

8.16 Initial and, where appropriate, ongoing training should be given by the manufacturer to all technical staff as part of the contract requirement, and should be based on the operating and maintenance manuals, which themselves should be supplied as part of the contract.

Maintenance frequency

8.17 The frequency of maintenance will be influenced by several operating factors, such as information supplied by manufacturers. This information should be used to maintain the operational integrity of an item of plant or equipment.

8.18 Planned preventive maintenance (or maintenance at fixed intervals irrespective of a service need) should be balanced against the application of breakdown maintenance. The best approach may be a mix of both, depending upon local factors and circumstances.

Maintenance planning

8.19 Irrespective of the scale of operation, maintenance programmes are essential to ensure that all the critical engineering service equipment is checked, inspected, tested, repaired or replaced at the appropriate time. This makes sound economic sense, as it enhances the operational life span of the equipment and maximises the potential for its availability for use.

8.20 To ensure that an organised maintenance programme is carried out economically, it should be supported by a reporting system of 'defect and failure'. Classifications of urgency would allow for those defects requiring extensive plant isolation and shutdown to be slotted into the overall planned maintenance programme to minimise disruption.

Original commissioning tests

8.21 It is strongly recommended that the original tests are checked and/or witnessed by suitably qualified staff on behalf of the client and signed off by both client and contractor.

8.22 These tests generate the contractually agreed records of the original commissioning procedures related to particular items of equipment or plant. They must be accurate, retained and kept in a safe place. Reference to these documents should be made from copies, as they represent the history of the equipment or plant. The originals should not be handled for reference purposes in confirming tests or in discussion, the exception being as legal documents.

Original and amended drawings

8.23 As with test records, these drawings have contractual significance, being the original as-built form.

8.24 They are legal documents showing the assembly and construction of a system, and healthcare organisations should ensure that complete and accurate drawings are handed over to them prior to acceptance of the work.

8.25 These drawings, with dated amendments made during the construction phase up to final acceptance, should not be amended. Where subsequent changes are made, these should be entered on separate amended drawings and noted to indicate the date and reference as appropriate.

Functional tests

8.26 Functional tests are a practical demonstration of the operation of an item of equipment or plant. The commissioning functional test record sheet should be

preserved for future reference. It will be the comparative reference for all future maintenance tests throughout the life of the item of equipment or plant.

8.27 The frequency of such routine tests can depend on the use of the equipment as represented by the running hours or operations. Experience may well dictate this requirement on the basis of routine and specific time-checks.

Inspections prior to re-commissioning

8.28 Before any engineering service equipment or plant is put back into service following a period of maintenance, a thorough inspection of all operational controls, protection settings, alarms and indications should be carried out. This would normally be the responsibility of the person undertaking the work, the Competent Person, or the Authorised Person.

Planned maintenance programme

General

8.29 The planned maintenance programme should be designed according to the following principles:

- where the correct functioning of important components is not necessarily verified by the periodic tests prescribed for the critical engineering service, those components should be regularly tested, and reference to testing them should be included in the schedules of maintenance tasks. This applies, for example, to door interlocks that may only be required to perform their safety function when presented with an abnormal condition;
- the maintenance programme should include, at appropriate intervals, those tasks such as lubrication and occasional dismantling of particular components (such as pumps), the need for which is indicated by normal industry best practice, manufacturer's advice and experience. Apart from those tasks, the maintenance programme should concentrate on verifying the condition of the critical engineering service and its components by means of testing and examination without dismantling. Parts that are working correctly should not be disturbed unnecessarily;
- maintenance should be carried out under a quality system such as BS EN ISO 9000. Spares fitted to critical engineering services constructed under a quality system should be sourced from the manufacturer or a similarly approved quality system.

Design of a planned maintenance programme

8.30 The planned maintenance (PM) programme supplied by the manufacturer should be used where it is available. If no manufacturer's programme can be obtained, a programme should be drawn up in consultation with the Authorised Person and the maintenance person.

8.31 Although the manufacturer may carry out certain inspection and maintenance procedures under the terms of his guarantee, these may not constitute a full PM programme. The user or their representative should therefore ensure that the complete PM programme is carried out by the maintenance person during the guarantee period.

8.32 The user or their representative should also implement any reasonable instructions given by the manufacturer during this period. Failure to carry out maintenance tasks and periodic tests could affect safety.

8.33 A set of procedures should be developed for each critical engineering service, containing full instructions for each maintenance task.

8.34 It is important that maintenance is planned so that any plant or equipment is out of service for as little time as possible.

8.35 Where practicable, maintenance should be scheduled immediately to precede any periodic tests.

Review of the planned maintenance programme

8.36 The PM programme, procedures and records should be reviewed at least once a year by the user and the maintenance person in association with the Authorised Person. To do this, it is necessary to keep systematic records of all work done, so that judgement can be made in consultation with the manufacturer on what changes, if any, to the PM programme would be best.

8.37 The review should aim to identify:

- any emerging defects;
- any changes required to the maintenance programme;
- any changes to any maintenance procedure;
- any additional training required by personnel concerned with maintenance;
- whether records have been completed satisfactorily, signed and dated.

9. Engineering services

Management of access to engineering services

9.1 Healthcare organisations have the responsibility to ensure that all service installations are specified, designed, installed, commissioned and maintained (including future upgrade) with consideration for services modifications and dismantling during the life of the building. This responsibility is not diminished in PPP projects.

9.2 To satisfy these requirements, it is recommended that organisations:

- designate a person responsible to co-ordinate or oversee all engineering services to ensure that the services do not have any adverse effects on each other, the structure and personnel safety;
- ensure that a project file is available for all new projects, alterations or extensions, regardless of the size of the project. The file should contain specifications, drawings, and maintenance information including access and safe disposal at the end of its useful life;
- ensure that adequate space is provided for installation and maintenance staff and appropriate access to services;
- adequately brief the designers on the current and future maintenance policies;
- ensure that any new work, alterations or modifications do not restrict existing access to plant and equipment.

9.3 Details of any asbestos survey must be made available to the design team and any contractors prior to carrying out any work.

9.4 The Control of Asbestos at Work Regulations 2006 includes duties to protect those who come into contact with asbestos unknowingly or accidentally. The survey report should include details of any asbestos-containing materials, their condition and location, and when they were last inspected.

9.5 A zoning policy allocating particular zones for specific services should be agreed early in the design stage. The policy should also allocate crossover zones, minimum separation distances and shielding requirements in the event of it not being possible to meet these requirements.

9.6 Before putting any engineering systems into service, the installation should be inspected, and it should be verified that access is available for commissioning, maintenance, and future upgrading.

9.7 It should also be verified that there are adequate provisions made for additional services and dismantling during the life of the system.

Development planning

9.8 It is essential to ensure that both the engineering and architectural aspects are developed in harmony from project inception. This should ensure that systems are safely integrated in terms of location, distribution and future developments, and that service resilience is planned from the start.

9.9 The architectural design must permit sufficient space for services. Provision of extra space to allow for future development is considered as best practice.

9.10 Accurate and detailed drawings are essential for providing space requirements. However, these may not be available at the early design stage. An estimate of space requirements may have to be made on preliminary drawings in order to avoid costly revisions.

Distribution requirements

9.11 An assessment of the distribution requirements should be considered, taking into account communication, area, plant and distribution. This must be related to the specific size and shape of the building etc.

9.12 Accommodation of vertical services will be decided at an early design stage. The information may be in the form of total area requirements to be divided later as design progresses.

9.13 Resilience and flexibility of services distribution should be included at an early stage.

9.14 Departments that require heavily-loaded services should be grouped together and located near to the distribution centre if possible. This avoids large runs and therefore distribution losses. Dependent on the building design, it may be advantageous for services to follow the main communication routes.

9.15 The Energy Centre is usually the first plant room whose location is determined on site. This allows the main service routes to be determined. The next step would be to determine areas required for other plant rooms including, for example, those at rooftop level.

9.16 Consideration should be given to maximising the flexibility of engineering services to allow the maximum possible changes in the use of hospital departments.

9.17 In multi-storey buildings:

- restricted flexibility is achieved when there is a small number of large vertical ducts with provision for horizontal space above ceiling level and below structural members; the number of vertical service ducts will be a function of the limitation of void spaces to accommodate horizontal distribution of ventilation ductwork and other electrical and piped services. Each vertical duct should contain service space for future additional ducting

but, in briefing this, designers should be given a suggested percentage or rationale behind this requirement.

- generally, more flexibility is achieved by a large number of smaller vertical ducts with ceiling spaces for horizontal distribution as necessary;
- the omission of space above ceilings produces the least flexible arrangement.

9.18 Convenient access should be provided to all service spaces.

9.19 In single-storey buildings:

- sufficient headroom should be allowed for installation and maintenance purposes;
- if a service trench is provided, where practicable, removable covers should be provided over the complete length of the trench.

Access

9.20 Access to services should be considered at every stage of both the architectural and engineering design process.

9.21 The frequency of access required should be the main factor considered.

Frequent access:

- immediate access is required for plant, valves, switches and other controls requiring frequent attention for safe operation and maintenance;
- if enclosed, the access should be by door or panel;
- adequate clearance should be provided for ease of working.

Intermittent access:

- items that require access at intervals (for example monthly) can be provided by means of floor traps, removable panels in walls, false ceilings and so on. It is recommended that access panels be fitted by means of retained quick-release mechanisms rather than screws and cups.

Renewal or modification of service:

- most, if not all, services may require modification or renewal during the useful life of the building. Accommodation should be planned for this to occur, taking into account weight, size and configuration of the item. During non-emergency renewals, it may be possible to remove doorframes, windows, partitions and other non-structural items. The renewal or modification of minor items does not usually create problems except where piping or cable lengths are restrictive;

- the destruction of finishes to open up a trench or vertical duct or existing access could be more economic than the provision of expensive but rarely-used permanent access. Costs versus savings must be considered with regard to the cost of inconvenience/disruption to functions incurred at the time of replacement.

Working in confined spaces

9.22 A confined-space permit-to-work system should be established, and personnel trained in the use of the system.

9.23 The system should address the following points:

- assessment of the task to be undertaken;
- identification of the potential risks/hazards;
- ventilation;
- air quality testing, prior to entry and continuously during access requirements;
- provision for special tools and lighting;
- working methods;
- implementation of the working methods;
- monitoring of compliance of the system;
- actions in case of emergency;
- communication;
- First-aid.

Appendix 1: Summary of key legislation

The following paragraphs give a wider explanation of the itemised legislation listed in paragraph 3.6. They are not a definitive summary, but are intended to explain more fully the broad content. Reference should be made to the current full documents if consideration of the legislation is thought appropriate.

Health and Safety at Work etc Act 1974

1. This is the prime piece of UK general safety legislation, and gives Government ministers the legal powers to enact Regulations.

All employers, including healthcare organisations, have a general duty under the Health and Safety at Work etc Act 1974 to ensure, so far as is reasonably practicable, the health, safety and welfare of their patients, employees and visitors and members of the public who may be affected by workplace activities.

These duties are legally enforceable, and the Health and Safety Executive has successfully prosecuted employers including health authorities and trusts for breaches of this statute. It falls upon owners and occupiers of premises to ensure that there is a management regime for the proper design, installation and maintenance of plant, equipment and systems. It is important to note that failure to have a proper system of work and adequate control measures can also constitute an offence even though an incident has not occurred.

Key requirements are:

The duties of employer to:

- issue each employee with a safety policy statement;
- provide a safe system of work;
- give adequate training and supervision;
- provide for the health, safety and welfare of all (employees, contractors and public) those affected by their business.

The duties of employees to:

- use equipment provided correctly;
- work in accordance with the organisation's policies;
- be responsible for their own acts and omissions;
- co-operate with their employer.

Factories Act 1961

2. The Factories Act 1961 and the Offices, Shops and Railway Premises (Hoists and Lifts) Regulations 1968 require that every power-driven lift should be of

good mechanical construction, sound material and adequate strength etc. The act refers to maintenance and thorough examination by an Authorised Person (Lifts) every six months, and states that a report of the result of every such examination should be prepared.

The NHS and Community Care Act 1990

3. Section 60 of the NHS and Community Care Act 1990 removed Crown immunity from the NHS and specified Health Service bodies from 1 April 1991 with only a few exemptions. This Act brings the local authority and the Health and Safety Executive into play and puts the NHS into a comparable position to any other organisation.

Consumer Protection Act 1987

4. The aim of the Consumer Protection Act 1987 is to help to safeguard the consumer from products that do not reach a reasonable level of safety. The main areas dealt with can be described as product liability and consumer safety.

The Act allows injured persons to sue producers, importers and 'own-branders' for death, personal injury or losses on private property, and the injured party must be able to show that on the balance of probabilities, the defect in the product caused the damage.

Defective products are defined as being those where the safety of the product is not such as persons generally are entitled to expect. On the other hand, a product will not be considered defective simply because it is of poor quality or because a safer version is subsequently put on the market.

Disability Discrimination Act 2005

5. The Disability Discrimination Act (DDA) was first enacted in 1995 to end the discrimination that people with disabilities face. The provisions introduced by the 2005 Act have been enforceable since December 2006. It extended the scope of part 3 of the 1995 Act to include the functions of public authorities. It created new duties for providers of premises and transport services. It protects people with disabilities in:

- employment;
- access to goods, facilities and services;
- the management, buying or renting of land or property;
- education.

Public authority functions:

Since December 2006, Part 3 of the 1995 Act has applied to the functions carried out by a public authority. The original DDA did not apply to the exercise of certain functions by public authorities (such as arrests by the police) as these do not constitute the provision of a service to the public. The provisions relating

to 'public authority functions' only apply where other parts of the 1995 Act do not already apply (section 21B (7)).

The Management of Health and Safety at Work Regulations 1999

6. Employer's duties include:

- making assessments of risk to the health and safety of their employees and acting upon risks they identify, so as to eliminate or reduce them;
- appointing competent persons to oversee workplace health and safety;
- providing employees with information and training on occupational health and safety;
- operating a written health and safety policy.

Workplace (Health, Safety and Welfare) Regulations 1992

7. The main provisions require employers to provide:

- adequate lighting, heating, ventilation and workspace, to be kept in a clean condition;
- staff facilities: toilets, washing and refreshment;
- safe passageways (for example preventing slipping and tripping hazards).

Provision and Use of Work Equipment Regulations 1998

8. The main provisions require employers to:

- ensure the safety and suitability of work equipment for the purpose for which it is provided;
- properly maintain the equipment, irrespective of its age;
- provide information, instruction and training on the use of equipment;
- protect employees from dangerous parts of machinery.

Manual Handling Operations Regulations 1992

9. The main provisions require employers to:

- so far as is reasonably practicable, avoid the need for employees to undertake any manual handling involving risk of injury;
- make assessments of manual handling risks, and try to reduce the risk of injury (the assessment should consider the task, the load, and the individual's capability);
- provide workers with information on the weight of each load.

Personal Protective Equipment at Work Regulations 1992

10. The main provisions require employers to:

- ensure that suitable personal protective equipment (PPE) is provided "*wherever there are risks to health and safety that cannot be adequately controlled in other ways".* The PPE must be 'suitable' for the risk in question, and include protective facemasks and goggles, safety helmets, gloves, air filters, ear defenders, overalls and protective footwear";
- provide information, training and instruction on the use of this equipment.

Health and Safety (Display Screen Equipment) Regulations 1992

11. The main provisions apply to display screen equipment (DSE) 'users' (defined as workers who 'habitually' use a computer as a significant part of their normal work). This includes people who are regular users of DSE equipment, or rely on it as part of their job. This covers their use DSE for an hour or more continuously, and/or you are making daily use of DSE.

Employers are required to:

- make a risk assessment of workstation use by DSE users, and reduce the risks identified;
- ensure DSE users take 'adequate breaks';
- provide regular eyesight tests;
- provide health and safety information;
- provide adjustable furniture (desk, chair etc);
- demonstrate that they have adequate procedures designed to reduce risks associated with DSE work.

Confined Spaces Regulations 1997

12. The Confined Spaces Regulations 1997 require employers firstly to avoid the need to enter a confined space. Where this is not possible, they must:

- carry out an assessment of the risks associated with entering a confined space and draw up a safe system of work;
- limit entry to the confined space to employees who are competent for confined space work and who have received suitable training;
- verify, prior to entry, that the atmosphere in the confined space is safe to breathe;
- provide any necessary ventilation;
- make sure that suitable rescue arrangements are in place before anyone goes into the confined space. These rescue arrangements should not involve risks to the safety of the people intended to carry out the rescue.

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR 95)

13. These Regulations set out the responsibilities for employers, the self-employed or those in control of work premises to report certain injuries, diseases and dangerous occurrences.

The following events must be reported by the quickest possible route (normally telephone).

If there is an accident connected with work and:

- any person is killed;
- member of the public is taken to hospital;
- a specified major injury or work-related disease (certified by a doctor) occurs to a person at work;
- any specified type of dangerous occurrence occurs, whether or not injury results.

Report the following events within ten days:

- if a person injured at work is absent from work or unable to do their normal work for more than three consecutive days (including non-work days);
- If a doctor notifies you that your employee suffers from a work-related disease.

Prosecution may follow for failing to notify the relevant authority of any of the above.

Examples of major injuries:

- fracture other than to fingers, thumbs or toes;
- amputation;
- dislocation of the shoulder, hip, knee or spine;
- loss of sight (temporary or permanent);
- loss of consciousness.

Examples of dangerous occurrences:

- failure of load-bearing parts of lifts and lifting equipment;
- explosion, collapse or bursting of any pressure vessel or associated pipework;
- electrical short-circuit or overload causing fire or explosion.

The Working Time (Amendment) Regulations 2002

14 The Regulations implement two European Union (EU) Directives on the organisation of working time and the employment of young workers (under 18 years of age). The Regulations cover the right to annual leave, to have rest breaks, and they limit the length of the working week.

Key protections include:

- a 48-hour maximum working week. Employers have a contractual obligation not to require a worker to work more than an average 48-hour week;
- four weeks paid holiday;
- minimum daily rest periods of 11 hours, unless shift-working arrangements have been made that comply with the Regulations;
- 20-minute daily rest breaks after six hours work, with young workers entitled to 45 minutes if more than 4½ hours are worked;
- a weekly rest period of 24 hours every seven days.

Control of Substances Hazardous to Health Regulations (COSHH) 2002

15. The COSHH legislation puts specific responsibilities on the employer as follows:

- they must assess the possible risks to health that may occur due to exposure to the substance before it is used;
- they must ensure prevention or practical control to exposure;
- they have a duty to ensure that the control measures are used, adequately maintained, and that they are examined and tested;
- they should monitor exposure and carry out health surveillance;
- they should ensure that their employees are informed of the hazards, instructed, and that they are given adequate training;
- the employer should review the risk assessment on a regular basis.

Too often, the first control measure that the employer adopts is the use of PPE (personal protective equipment). That is not to say that PPE cannot be used in tandem with the other control measures, should the risk assessment find it necessary. **PPE does not remove the hazard**. The hierarchal ladder of control measures as follows:

Prevent exposure by:

- eliminating the substance;
- substitution with a substance less hazardous to health.

Control exposure by:

- total enclosure of the process, therefore removing exposure;

- limiting the area of contamination;
- the use of LEV (local exhaust ventilation);
- dilution ventilation;
- reducing the period of exposure;
- providing suitable PPE.

The COSHH Regulations relate to any substance irrespective of its form including, gas, solid, dust, liquid, vapour, aerosol or micro organisms. Furthermore, substances not deemed to be detrimental to health can cause problems if not used correctly.

Health and Safety (First-Aid) Regulations 1981 and Miscellaneous Amendments 2002

16. These Regulations require an employer to provide adequate and appropriate equipment facilities and first-aid to be given to their employees if they are injured or become ill at work.

The Health and Safety Executive guidance states there is no mandatory list of items that must be included in a first-aid kit - the contents will depend on the employer's overall assessment of need.

The minimum requirements for first-aid for any workplace are:

- a suitably stocked first-aid kit/container;
- a person appointed to take charge of first-aid arrangements;
- information for all employees on first-aid arrangements.

Health and Safety (Consultation with Employees) Regulations 1996

17. Under these Regulations, all employees must now be consulted by their employers on health and safety matters. Employers can consult employees individually or through representatives elected by groups of employees in their place of work.

In general, the consultation should cover such aspects as:

- changes at work which may substantially affect the health and safety of people at work, such as changes in systems of work, procedures or equipment;
- the employer's compliance with the requirement to appoint competent persons to assist in meeting health and safety legislation;
- information resulting from risk assessments on likely risks and dangers, measures to control or eliminate such dangers, and what employees own actions should be if confronted by risk or danger;

- the consequences for health and safety standards of the introduction of new technology.

Health and Safety Information for Employees Regulations 1989

18. These Regulations require employers to provide their employees with certain basic information concerning their health, safety and welfare at work. This information is contained in both a poster and a leaflet approved by the Health and Safety Executive. Employers can comply with their duty by either displaying the poster or providing employees with a copy of the leaflet.

Some of the more recent changes to the poster are:

- removal of references to repealed duties under the Factories Act 1961 and the Offices, Shops and Railway Premises Act 1963;
- reference to the main duties under some of the more recent legislation;
- drawing attention to the duty to consult employees or their representatives on health and safety;
- The inclusion on the poster of two further information boxes which the employer is encouraged to complete as appropriate in order to personalize the information. These give details of the names and locations of employee, health and safety representatives, and the names of competent persons appointed by the employer together with their health and safety responsibilities.

Health and Safety (Safety Signs and Signals) Regulations 1996

19. These Regulations specify minimum requirements for safety signs at work. They implement a European Directive aimed at encouraging the standardisation of safety signs throughout Europe.

Safety signs are not a substitute for other methods of controlling risks, such as engineering controls and safe systems of work.

Fire safety signs are also covered in these Regulations.

Employers' Liability (Compulsory Insurance) Regulations 1998 and (Amendment) Regulations 2004

20. All employers need liability insurance unless they are exempt under the Employers Liability (Compulsory Insurance) Act. The following employers are exempt:

- most public organisations including government departments and agencies, local authorities, police authorities and nationalized industries;
- health service bodies, including NHS trusts, health authorities, primary care trusts and Scottish Health Boards;

- some other organisations which are financed through public funds, such as passenger transport executives and magistrates courts committees;
- family businesses. However, this exemption does not apply to family businesses which are incorporated as limited companies.

Further exemptions from the need to have employers' liability insurance are listed at section 3(1) (a) and section 3(1) (b) of the Employers' Liability (Compulsory Insurance) Act 1969, and Schedule 2 to the 1998 Regulations.

Employers must insure against liability for injury or disease sustained by an employee in the course of their employment. The sum to be insured is not less than £5 million. The certificate of insurance must be displayed in an appropriate location.

Health and Safety (Training for Employment) Regulations 1990

21. These Regulations extend the health and safety legislation to all those receiving 'relevant training' as defined by the Regulations. This includes government training schemes and students and pupils on work experience.

These Regulations extend 'work' in the Health and Safety at Work etc Act 1974 to include 'relevant training'. Those in training will be treated as employees of the immediate training provider.

For health and safety purposes, training for employment means that participants in many of the government's schemes will be employees, unless the training is provided by an educational establishment as defined by the Regulations.

Recent reforms in the Health Service mean that teaching institutions are now separate establishments from hospitals. However, the trainees spend much time in the associated hospital on educational visits. If these visits are purely for observation, it is unlikely they are 'relevant training' but if the trainees help with the work of the hospital, assisting doctors at clinics or in caring for patients, this might be 'relevant training', and the hospital, as the immediate provider, would have duties under section 2 of the Health and Safety at Work etc Act 1974.

Safety Representatives and Safety Committees Regulations 1977

22. If an employer recognizes a trade union and that trade union has appointed, or is about to appoint, safety representatives under the Safety Representatives and Safety Committee Regulations 1977, the employer must consult those safety representatives on matters affecting the group or groups of employees they represent. Members of these groups of employees may include people who are not members of that trade union.

Control of Asbestos at Work Regulations 2006

23. The Control of Asbestos at Work Regulations deals with the management of risk from asbestos in non-domestic buildings and requires duty holders (landlords, lessees, owners) to:

- take reasonable steps to find materials in premises likely to contain asbestos, and to check their condition;
- presume that materials contain asbestos unless there is strong evidence to suppose they do not;
- make a written record of the location and condition of asbestos and presumed asbestos-containing materials, and keep the record up-to-date;
- assess the risk of the likelihood of anyone being exposed to these materials;
- prepare a plan to manage that risk and put it into effect to ensure that:
  - any material known or presumed to contain asbestos is kept in a good state of repair;
  - any material that contains or is presumed to contain asbestos is, because of the risks associated with its location or condition, repaired or, if necessary, removed;
  - Information on the location and condition of the material is given to anyone potentially at risk.

Electrical

Electricity Act 1989

24. The primary legislation governing the electricity supply industry in Great Britain is the Electricity Act 1989 and the Utilities Act 2000. The 2000 Act established the Gas and Electricity Markets Authority – the office of which is known as Ofgem, the principal duties of which include:

- protect the interests of consumers by, wherever possible, promoting effective competition in generation, transmission, distribution or supply;
- secure reasonable demand for electricity is met;
- have regard to the interests of the disabled and sick, the elderly, those on low incomes and those in rural areas.

Electricity Safety, Quality and Continuity Regulations 2002

25. These Regulations revoke the Electricity Supply Regulations 1988 and all subsequent amendments. The requirements are separated into broad equipment categories and include:

- protection and earthing;
- substations;
- underground cables and equipment;
- overhead lines;
- generation;

- supplies to installations and other networks.

They impose requirements regarding the installation and use of electric lines and apparatus of suppliers of electricity, including provisions for connections with earth. These Regulations are administered by the Engineering Inspectorate of the Electricity Division of the Department of Energy, and may impose requirements which are in addition to those of the Electricity at Work Regulations.

Electricity at Work Regulations 1989

26. These Regulations apply to all workplaces and the electrical equipment used in them. They require precautions to be taken against the risk of death or personal injury from the use of electricity in work activities and commercial premises.

They impose duties in respect of:

- systems, electrical equipment and conductors;
- competence of persons working on or near electrical equipment.

The employers and self-employed people must make sure that everything that uses or carries electricity in the workplace is safe, that employees do not interfere with or abuse anything electrical that has been supplied for their use, or bring into the workplace anything electrical that is unsafe.

Employees must be instructed to report any damaged electrical equipment to their supervisors immediately and to not carry out any electrical work themselves, unless competent and authorised by the employer.

One of the most important elements of electrical safety is the need for routine visual inspections of electrical equipment. The visual checking of electrical leads to appliances, for example, should be made a part of every employee's work habits.

To achieve compliance with the Regulations, organisations need to make arrangements to make sure that all portable electrical appliances are safe to use. The items may already be high-risk, for example electrical drills, or the danger may be increased by using them in a high-risk environment such as wet conditions. These items particularly must be inspected by a competent person on a regular basis.

It is recommended that a record of all maintenance, including test results, is kept for each appliance.

BS 7671:2008 (IEE Wiring Regulations, 17th Edition)

27. The IEE Wiring Regulations (now called BS 7671 'Requirements for electrical installations') are an all-encompassing set of documents that give both technical and practical guidance on the installation and maintenance of electrical services.

While not being encompassed in an Act of Parliament, the Regulations do have sufficient recognition to make it unthinkable to install electrical services that do not comply with the Regulations. Their primary purpose is to ensure that all electrical installations are safe.

The Regulations are in seven parts, supported by various amendments, as follows:

- Part 1 ‘Scope, objects and fundamental requirements for safety’;
- Part 2 ‘Definitions’;
- Part 3 ‘Assessment of general characteristics’;
- Part 4 ‘Protection for safety’;
- Part 5 ‘Selection and erection of equipment’;
- Part 6 ‘Special installations or locations – particular requirements’;
- Part 7 ‘Inspection and testing’.

In addition, the 17th Edition has a number of publications called ‘guides’ which include much material previously to be found in appendices. These guides must be considered to form part of the Regulations.

Electrical Equipment (Safety) Regulations 1994

28. These Regulations replace the Low Voltage Electrical Equipment (Safety) Regulations 1989 and impose additional requirements on manufacturers. The rules cover electrical equipment designed or adapted for use between 50 and 1000 Volts ac or 75 and 1500 Volts dc. Electrical equipment manufacturers whose equipment falls within the scope of the Regulations must:

- CE marks the equipment, or the packaging, instruction sheet, or guarantee that accompanies the equipment. Components that are themselves ‘electrical equipment’ must also carry CE marking;
- issue a Declaration of Conformity that confirms in writing that the product complies with the requirements of the Regulations;
- compile technical documentation, which must be kept for ten years.

Plugs and Sockets etc (Safety) Regulations 1994

29 These Regulations require domestic plugs in the UK to be independently certificated as complying with BS 1363. Domestic socket-outlets, adaptors, fuse-links etc are required to meet the relevant British Standard. Additionally, the Regulations require most domestic electrical appliances to be pre-fitted with a compliant standard plug.

Radio Equipment and Telecommunications Terminal Equipment Regulations 2000 and Amendment 2003

30. This applies to radio equipment and telecommunications terminal equipment, ensuring that relevant products meet certain minimum essential requirements concerning health and safety, electromagnetic interference, and radio spectrum requirements.

Electromagnetic Compatibility Regulations 2005

31. These Regulations apply to almost all electrical and electronic appliances, and regulate radio interference from electrical equipment. For the purposes of being able to test whether or not equipment complies with the Regulations, tests are divided into five classes:

- radiated emissions - checks to ensure that the product does not emit unwanted radio signals;
- conducted emissions - checks to ensure the product does not send out unwanted signals along its supply connections and connections to any other apparatus;
- radiated susceptibility - checks that the product can withstand a typical level of electromagnetic pollution;
- conducted susceptibility - checks that the product can withstand a typical level of noise on the power and other connections;
- electrostatic discharge - checks that the product is immune to a reasonable amount of static electricity.

Mechanical

Supply of Machinery (Safety) Regulations 1992 and Supply of Machinery (Safety) (Amendment) Regulations 1994

32. These Regulations place duties on those who supply machinery and safety components, including manufacturers, importers and others in the supply chain. They set out the essential requirements which must be met before machinery or safety components may be supplied in the UK.

There are basically three steps to dealing with the requirements:

- the responsible person should ensure that machinery and safety components satisfy the relevant essential health and safety requirements of the Supply of Machinery (Safety) Regulations and that, where appropriate, relevant conformity assessment procedures have been carried out;
- the responsible person must issue a declaration of conformity (or a declaration of incorporation) which is issued with the finished product so that it is available to the user. This will contain various details such as the manufacturer's address, the machinery type and serial number, and the harmonized European or other standards used in design;

- when the first two steps have been satisfactorily completed, the responsible person or person supplying or assembling the final product should affix the CE marking if they are satisfied it is safe.

Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)

33. In general, these Regulations require that any lifting equipment used at work for lifting or lowering loads is:

- strong and stable enough for particular use and marked to indicate safe working loads;
- positioned and installed to minimize any risks;
- used safely: that is, the work is planned, organised and performed by competent people;
- subject to ongoing thorough examination and, where appropriate, inspection by competent people.

Gas Appliances (Safety) Regulations 1995

34. These Regulations apply to domestic and commercial gas appliances used for cooking, heating, hot water production, refrigeration, lighting or washing (with no limit on power), excluding appliances which have a normal operating temperature above 105°C. Appliances for use in industrial processes on industrial premises are specifically excluded.

Gas Safety (Installation and Use) Regulations 1998

35. These Regulations cover safe installation, maintenance and use of gas systems and appliances in domestic and commercial premises.

Lifts Regulations 1997

36. These Regulations apply to lifts permanently serving buildings and constructions, and specified safety components. All lifts and safety components placed on the market from 1 July 1999 in the UK, including imports, will have to:

- be safe (in the case of a safety component, enable the lift in which it is installed to be safe);
- meet the relevant essential health and safety requirements in their design, construction and installation;
- satisfy the appropriate conformity assessment procedure set out in the Regulations;
- carry CE marking;
- be accompanied by an EU declaration of conformity.

Additional duties include:

- liaise between installers of lifts and those responsible for work on the building or construction;
- keep lift shafts free of extraneous piping, wiring and other fittings;
- keep the supply of relevant information to those who are entitled to it.

Noise at Work Regulations 2005

37. These Regulations impose a duty on employers to reduce risk of damage to hearing of employees from exposure to noise. They require employers to assess the noise to which employees may be exposed.

Usually the important factors are:

- the noise level given in decibels (dBA);
- exposure – how long employees are exposed to the noise (not only daily but over a number of years).

If in doubt, it is important to have the noise exposure to workers assessed by a competent person, tell the workers of the findings, reduce the noise as far as reasonably practicable, and implement ear protection measures that are required. Routine monitoring of the situation should follow.

Pressure Systems Safety Regulations 2000

38. These Regulations revoke and replace the Pressure Systems and Transportable Gas Containers Regulations 1989. These Regulations apply to all plant/systems which contain a relevant fluid (steam, gas under pressure and liquids under pressure which become gases upon release to the atmosphere) at a pressure greater than 0.5 bar above atmospheric. Certain small vessels, where the combination of the internal volume and pressure of the vessel is less than 250 bar litres, are exempt from some parts of the Regulations.

The Regulations require users to:

- establish the safe operating limits of the plant;
- have a suitable written scheme drawn up or certified by a competent person for the examination at appropriate intervals of:
  - most pressure vessels,
  - all safety devices,
  - any pipework which is potentially dangerous;
- arrange to have examinations carried out by a competent person at the intervals set out in the scheme;
- provide adequate operating instructions (including emergency instructions) to any person operating it (for example operating manual supplemented by on-the-job training and supervision for new staff);
- ensure the pressure system is maintained in good repair;

- keep adequate records of the most recent examination and any manufacturer's records supplied with the new plant;
- distinguish between installed or mobile systems and whether owner or user is responsible.

The Pressure Equipment Regulations 1999 and (Amendment) Regulations 2002

39. These Regulations apply to the design and construction aspects of pressure equipment intended to contain a gas or liquid at 0.5 bar gauge or above. Assemblies of such equipment (that is, a pressure system) are also covered.

Simple Pressure Vessels (Safety) Regulations 1991

40. The legislation harmonises national laws of member states across the European Union regarding the design, manufacture and initial conformity of simple pressure vessels which are intended to contain air or nitrogen at a gauge pressure between 0.5 and 30 bar gauge.

Simple pressure vessels cannot be placed on the European market unless they meet the requirements of this legislation.

Before being placed on the market, vessels must bear the CE conformity marking.

The vessel or data plate must bear, in addition to the CE marking, at least one of the seven additional inscriptions described in the Regulations.

The Construction (Design and Management) Regulations 2007

41. These Regulations are intended to improve management of safety during construction work. They establish high standards in the management and control of construction activity from concept to commissioning, rather than imposing detailed engineering requirements. In particular, they emphasise the need to take account of health and safety aspects during initial planning to ensure that these considerations are built into the scheme.

The health and safety requirements identified at the design and planning stage must be set down in a safety plan. This must be further developed during the construction phase. When the project is complete, a safety file must be provided which contains the detailed information about the structure and equipment within it, so the end-user can manage health and safety properly during subsequent use, construction and maintenance activity.

The Regulations apply to construction work on structures, but both the definitions are extremely broad:

- **Construction**: these include alteration, installation, commissioning, assembly, conversion, repair, renovation, maintenance, demolition, exploration etc. It should be noted particularly that the term can apply to

work on mechanical, electrical and telecommunications installations fixed within or to a structure;

- **Structure**: these include any building, railway, shaft, bridge, pipe, sewer, gasholder, road, cable, pylon etc.

The Regulations apply if more than four persons will be involved in the construction work at any one time. The project requires notification to the Health and Safety Executive if it will exceed 30 days or involve more than 500 person-days of work.

One of the requirements of the legislation is a safety plan. This is a statement of the arrangements made in order to achieve satisfactory standards of health and safety during construction. It should be prepared at the pre-tender stage and be part of the documentation used in the tender process which results in the selection of the Principal Contractor. The purpose is to identify known hazards associated with the project and to invite prospective contractors to say what arrangements they will make to deal with them.

Another requirement of the legislation is to have a health and safety file. This file is a record of information for the end-user, focusing on health and safety. It should identify significant health and safety risks associated with the structure and the equipment it contains. It should contain 'as built' drawings and plans.

The legislation imposes a duty on various participants, including:

- client;
- planning supervisor;
- designer;
- principal contractor.

Several or all of these roles can be performed by the same person and can be performed in-house. The essential fact is that each of the roles must be performed by competent persons.

Construction (Health, Safety and Welfare) Regulations 1996

42. These Regulations consolidate, modernise and simplify three sets of Regulations.

Most of the duties are already found in existing Regulations, but they have been updated and adapted to take account of modern working practices. Examples of the duties covered are:

- requirements to ensure a safe place of work and safe means of access to and from a place of work;
- preventing people falling from a height;
- preventing accidental collapse of new or existing structures;
- preventing accidental collapse of the ground both in and above excavations;

- identifying and preventing risk from underground cables and other services.

Training for work which could cause injury.

The new provisions applying to construction sites are:

- providing safe traffic routes;
- preventing and controlling emergencies such as fire and explosion.

Building (Scotland) Regulations 2004 and subsequent Amendments

43. Building Regulations are legal requirements aimed at achieving adequate standards for the construction of domestic, commercial and industrial buildings. They are laid down by Parliament and are supported by separate documents containing practical and technical guidance on compliance, which are known as Approved Documents. These are produced in different parts.

Building Regulations have three purposes:

- to ensure the health and safety of people in and around buildings;
- the conservation of energy;
- Access and facilities for people with disabilities.

Environment

Environmental Protection Act 1990

44. To prevent the pollution from emissions to air, land or water from scheduled processes, the concept of integrated pollution control has been introduced. Authorisation to operate the relevant processes must be obtained from the enforcing authority which, for the more heavily polluting industries, is HM Inspectorate of Pollution. Control of pollution to air from the less heavily polluting processes is through the local authority. Regulations also place a duty of care on all those involved in the management of waste, be it collecting, disposing or treating controlled waste which is subject to licensing.

Control of Pollution (Amendment) Act 1989

45. This Act covers the registration of waste carriers and controls fly-tipping. Waste carriers are obliged to register with the Scottish Environment Protection Agency (SEPA).

Waste Management Licensing Regulations 1994 (as amended)

46. These Regulations sit under the 1990 Environmental Protection Act. They make it an offence to treat, keep or dispose of controlled waste except under and in accordance with a waste management licence. Certain activities are exempt from the requirement for licensing, but these exemptions require to be

registered with the waste regulation authority – The Scottish Environment Protection Agency (SEPA).

The Waste Management Licensing (Amendment) Regulations 1995 and the Waste Management Licensing (Amendment No 2) Regulations 1995 provide exemptions for carrying out certain activities relating to scrap metal and waste motor vehicles, and other transitional exemptions.

The Waste Management Regulations 1996 relate to transitional provisions for certificates of technical competence in the management of waste treatment plants and also add exemptions relating to the storage of certain materials.

Environmental Protection (Duty of Care) Regulations 1991

47. These Regulations impose requirements on those who import, produce, carry, keep, treat or dispose of controlled waste, or act as a broker, and as such have a duty of care under the Environmental Protection Act 1990. The Regulations require that the transferor and the transferee of the waste should complete and sign a transfer note as the waste is transferred, and make and retain copies. The transfer note must identify and describe the waste in question and state its quantity, how it is stored, the time and place of transfer, and the name and address of the transferor and the transferee. Breach of the duty of care or of these Regulations is a criminal offence.

Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations 1991

48. These Regulations cover the registrations required for certain waste carriers, brokers and dealers by the local environmental regulator. These controls, together with the Duty of Care, are designed to prevent fly-tipping (illegal waste disposal). Organisations or individuals that want to transport, deal in and/or arrange the disposal or recovery of controlled waste, whether in liquid or solid form, are required to register with their environmental regulator. The carriage of an organisation's own wastes does not usually require registration, unless it is construction or demolition waste. Waste carriers who operate in Scotland must register with the Scottish Environment Protection Agency (SEPA).

The Special Waste Amendment (Scotland) Regulations 2004 (updated 2005) to the Special Waste Regulations 1996

49. Regulations 2, 2A and 2B of the Special Waste Amendment (Scotland) Regulations provide full definitions of 'special waste'. The Regulations define and regulate the movement of hazardous waste in Scotland from the point of production to the point of disposal or recovery. These Regulations, among other things, require the producers of hazardous waste to notify by means of consignment notes the Scottish Environment Protection Agency (SEPA) and to provide unique codes to be applies to the consignment notes that accompany the waste when transported. See SHTN 3: 'NHS Scotland Waste management guidance".

The Waste Management Licensing Amendment (Scotland) Regulations 2006

50. The List of Wastes Regulations combined with the Hazardous Waste Regulations (above), implement the requirements of the Hazardous Waste Directive and the European Waste Catalogue Codes.

The List of Wastes effects the regulation of waste and hazardous waste and in particular for the purposes of:

- the determination of whether a material or substance is a waste or a hazardous waste, as the case may be;
- the classification and coding of waste or hazardous waste. The different types of waste in the List of Wastes Regulations are fully defined by the six-digit code for the waste and the respective two-digit and four-digit chapter headings.

Pollution, Prevention and Control (Scotland) Regulations 2000

51. These Regulations apply to installations or mobile plant that complies with set criteria or limits, for the purpose of achieving a high level of protection of the environment taken as a whole by, in particular, preventing or, where that is not practicable, reducing emissions into the air, water and land. This will require that some businesses need a permit from the Scottish Environment Protection Agency (SEPA) before they can operate. Such situations in healthcare may include provision of an ‘energy centre’ or the operation of an on-site incinerator.

Clean Air Act 1993

52. This Act deals with the emission of smoke from agriculture, industrial burning, industrial furnaces, railway engines and ships. The best practicable means must be used to reduce emissions, and furnaces are required to be fitted with plant for arresting grit and dust. Chimney heights are also specified.

The Act is enforced by local authorities, who can prosecute organisations or their employees.

The Act also specifies maximum concentrations of lead and sulphur in motor fuel.

Environmental Protection (Prescribed Processes) Regulations 1991

53. This legislation defines the substances that must be controlled when released to a particular environmental medium.

Trade Effluent (Prescribed Processes and Substances) Regulation 1989. Amended 1990, 1992

54. These Regulations prescribe the substances and processes which are treated as ‘special category effluent’. Stringent controls apply to such effluents.

Prescribed processes include those processes discharging chlorinated effluents.

Controlled Waste Regulations 1992. Amendment 1993

55. These Regulations cover the wastes which are to be treated as controlled waste under the categories of household, industrial and commercial wastes.

Most wastes from industry and commerce are controlled wastes – one notable exception being radioactive waste.

Environment Act 1995

56. The Environment Act 1995 creates a system whereby local authorities must identify, and if necessary arrange for the remediation of, contaminated sites in their areas.

Each local authority must inspect its area from time to time in order to identify contaminated land, and must keep a register of such land.

Packaging (Essential Requirements) Regulations 2003

57. These Regulations implement Directive 94/62/EC on packaging and packaging waste, which relates to the essential requirements to be satisfied by packaging. The Regulations apply to all packaging placed on the market in the UK, and are enforced by trading standards officers of local authorities.

The Regulations place a responsibility on any company that introduces packaging onto the marketplace to ensure that it is minimal, safe, and is either reusable, or recoverable, or recyclable.

Water Environment (Oil Storage) (Scotland) Regulations 2006

58. These Regulations are more stringent than the Control of Pollution (Oil Storage) (England) Regulations 2001. They require persons having custody or control of oil, or who store oil, to carry out certain works and take precautions and other steps for preventing pollution of any controlled waters. It is a criminal offence to fail to comply with these Regulations but there are exemptions including single private dwellings where less than 2500 litres is stored and buried tanks outwith buildings.

Landfill Tax Regulations 1996 and Landfill Tax (Qualifying Material) Order 1996

59. These Regulations apply to all waste going to landfill. Tax is chargeable by weight on all types of waste. Two rates are applied: inert wastes are those which do not give off methane or other gases and do not have the potential to pollute underground water.

Lists of wastes are found in Annex A of the Landfill Tax (Qualifying Material) Order 1996. Those liable for tax are the licence holders for the landfill site.

Chemicals (Hazard Information and Packaging for Supply). Regulations 2002

60. These Regulations describe the requirements for the labelling of substances to indicate risks to health, safety and the environment. Preparations classified as dangerous for the environment should be assigned the symbol N. Some substances that pose no particular human health and safety problem nevertheless require to be labelled dangerous for the environment.

The Planning etc. (Scotland) Act 2006

61. This Act requires a local authority to assess the environmental effects of certain development projects, and to consult the Scottish Environment Protection Agency before granting planning permission.

Control of Pollution Act 1974 and (Amendment) Act 1989

62. The Control of Pollution Act 1974 (CPA) gives powers to local authorities to set noise criteria within the local environment. The local authority therefore has the power to serve notices on those responsible for causing noise amounting to a nuisance.

Producer Responsibility Obligations (Packaging Waste) Regulations 2005

63. A company involved in the production and sale of packaging or packaging materials has an obligation as a producer under the Regulations where thresholds are exceeded. A producer can be a manufacturer, converter, packer/filler, seller or importer of packaging or packaging material. The obligations can be discharged individually or by joining a registered scheme.

Waste Electrical and Electronic Equipment Directive 2002

64. The Waste Electrical and Electronic Equipment (WEEE) Directive was agreed in 2003, together with the related Directive on Restrictions on the use of certain hazardous substances in electrical and electronic equipment (RoHS).

The WEEE Directive applies to a huge range of products. It aims to minimise the impact of electrical and electronic equipment on the environment during their lifetimes and when they become waste. It focuses on collecting, treating, recycling and recovering waste electrical and electronic equipment.

From July 2006, the RoHS Directive will ban the placing on the EU market of new electrical and electronic equipment containing more than agreed levels of certain prescribed substances. Manufacturers will need to make sure that their products and their components comply in order to be able to offer their products for sale.

The Water Environment and Water Services (Scotland) Act 2003

65. The Water Environment and Water Services (Scotland) Act 2003 will enable Scottish Ministers to implement the EC Water Framework Directive in Scotland.

The Bill was introduced into the Scottish Parliament on 18 June 2002 and received Royal Assent on 5 March 2003.

For the first time the Act establishes a planning system for the water environment with SEPA as the lead authority working alongside the public, private and voluntary sectors.

The Act ensures that all human activities that can have a harmful effect on the water environment can be controlled by establishing a framework for co-ordinated controls on water abstraction and impoundment engineering works near watercourses, and all forms of pollution to water.

For further information:
http://www.opsi.gov.uk/legislation/Scotland/acts2003/20030003.htm

The Scottish Water Byelaws 2004

66. The Scottish Water Byelaws 2004 were made to prevent the waste, misuse, undue consumption, contamination or erroneous measurement of drinking water. The Regulations set requirements for the design, installation and maintenance of plumbing systems and water fittings. They are enforced by Scottish Water.

Control of Lead at Work Regulations 2002

67. The primary aim of the Control of Lead at Work Regulations 1998 is to control risks to health caused by exposure to lead (in the form of lead dust or fumes or lead alloys) where that lead is liable to be inhaled, ingested or absorbed through the skin.

Control of Pesticides Regulations 1986

68. The Control of Pesticides Regulations 1986 and the Control of Pesticides (Amendment) Regulations 1997 regulate the sale of pesticides. The Regulations are supported by an approved code of practice that includes guidelines for the safe storage of pesticides and details of training and certification requirements.

The sale or supply of pesticides must be under the control of someone that holds a ‘nominated storekeeper’ certificate from the British Agrochemical Standards Inspection Scheme, which also maintains a register of suppliers.

Noise and Statutory Nuisance Act 1993

69. The Noise and Statutory Nuisance Act 1993 is not directly relevant to healthcare premises, but will be to associated activities. It covers nuisances arising from vehicle and building alarms, loudspeakers and other noise in public areas.

Radiation

Ionising Radiations Regulations 2004 (IRR99)

70 These Regulations place duties and responsibilities for radiation safety and the setting up of local rules and procedures. They identify the role of a radiation protection adviser (RPA) and a radiation protection supervisor (RPS). They classify different types of personnel and restrict the exposure through design and safe systems of work. They specify various dose limits, equipment, notification of incidents, and routine inspection and testing of equipment.

Radioactive Substances Act 1993

71. This Act consolidates earlier legislation including the Radioactive Substances Act 1960. It requires those keeping and using radioactive materials to register with the Environment Agency, and those disposing of radioactive wastes or accumulating them for subsequent disposal to be authorised.

Ionising Radiation (Medical Exposure) Regulations 2000

72. These Regulations revoke the 1988 version and are concerned with exposure of patients and research activities. They lay down basic measures for the health and protection of individuals against dangers of ionising radiation in relation to medical exposure.

The Regulations impose duties on those responsible for administering radiation to protect persons undergoing medical exposure, whether as part of their own medical diagnosis or treatment or as part of occupational health surveillance, health screening, voluntary participation in research or medico-legal procedures.

Radioactive Materials (Road Transport) Regulations 2002

73. These Regulations detail the requirements of transporting radioactive substances. The Regulations are concerned with the following:

- package design should be such that the risk of any radioactive contamination or external radiation hazard should be kept to a minimum;
- all shipments should be traceable to the sender;
- good quality assurance should produce public reassurance.

A47168969

Medicines (Administration of Radioactive Substances) (Amendment) Regulations 2006

74. These Regulations relate to nuclear medicine. Certificate holders are only authorised to administer these medicines. They cover nuclear medicine scanning, nuclear medicine therapy, some pathology tests and Brach therapy.

Fire

Fire (Scotland) Act 2005 as amended

75. The Fire (Scotland) Act 2005 received Royal Assent on 1 April 2005. Parts 1, 2, 4 and 5 of the Act commenced in August 2005. Part 3 introduces a new fire safety regime for non-domestic premises and is due to come into force on 1 October 2006 and will replace the Fire Precautions Act 1971 and the Fire Precautions (Workplace) Regulations 1997, as amended. (http://www.Scotland.gov.uk/Topics/Justice/Fire/19077/FireAct)

Fire certificates will no longer be required after 1 October 2006 and the new fire safety regime will be based on the principle of risk assessment similar to the Fire Precautions (Workplace) Regulations.

Furniture and Furnishings (Fire) (Safety) Regulations 1988

76. This legislation relates to the supply of furniture and furnishings. It is intended to ensure that furniture and furnishings are fire-resistant and will not produce harmful, noxious smoke in the event of a fire.

All furniture or furnishings supplied must be marked with a label to show that they comply with the Regulations. Any furniture manufactured in the UK since March 1989 must comply. The following items are covered by the Regulations:

- furniture for private use in a dwelling, including children's furniture;
- sofas and chairs;
- beds, headboards and mattresses;
- sofa-beds and futons;
- nursery furniture;
- garden furniture which is also suitable for use inside;
- scatter cushions and seat pads;
- pillows;
- loose and stretch covers for furniture.

The following items are exempt:

- bed linen (including duvets and pillowcases);

- loose covers for mattresses;
- curtains;
- carpets.

Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002

77. These Regulations set minimum standards for the protection of workers and others from the risk of fire or explosions related to dangerous substances. Petrol and LPG are amongst those substances deemed to be dangerous.

The Regulations require that risks arising from those dangerous substances are comprehensively risk-assessed and recorded.

Food

Food Safety Act 1990

78. The Food Safety Act 1990 aims to protect consumers by preventing illness from the consumption of food and by preventing them from being misled as to the nature of the food they are purchasing. The Act has similarities to the Health and Safety at Work etc Act 1974, which deals with the concept of hazards and risk.

Food Safety (General Food Hygiene) Regulations 1995

79. These Regulations cover:

- general requirements for food businesses, for example cleanliness, structural requirements, facilities such as water supply, ventilation, drainage etc;
- further requirements such as personal hygiene and staff training;
- obligations on proprietors, that is, a risk assessment.

Food Safety (Temperature Control) Regulations 1995

80. These Regulations cover all types of food businesses, ranging from a mobile food caterer to a 500-bedroom hotel. This includes food that is sold publicly or privately, for profit or fund-raising.

There are a number of stages in the food production chain which are subject to the Regulations:

- preparation;
- handling;
- processing;

- packaging;
- manufacturing;
- storage;
- transporting;
- selling;
- distribution;
- supplying.

Public Health

Public Health (Infectious Diseases) Regulations 1988

81. The Public Health (Infectious Diseases) Regulations 1988 require that a properly appointed officer shall inform the Chief Medical Officer for Scotland, as the case may be, of any serious outbreak of any disease which to his knowledge has occurred in his/her district.

Medicines Act 1961

82. Medical gases are classified as medicinal products under the Medicines Act and are therefore subject to the same procurement and quality procedures as all other medicinal products.

Health Facilities Scotland

NHS National Services Scotland

Appendix 2: Exemplar procedures

Introduction

1 The following procedures have been prepared by HFS Board Estates and Facilities Management (EFM) personnel to meet the needs of their own organisations.

2 They are not intended to be appropriate or definitive for all sites, but they provide examples of the types of format which may be used, and the different levels of technical content which may be appropriate on different sites.

3 These procedures cover:

- electricity supply failure;
- water contamination;
- piped medical gas failure.

4 Further procedures will be required within a healthcare organisation and a regular review is important to ensure that directives, staff and equipment remain current.

Procedure for electricity supply failure

Operational procedure reference no: ……..

Hospital location: ……..

Healthcare description (A&E, CCU, Ward 6 etc): ……..

Key areas of equipment likely to be

Lighting, medical equipment, fixed and/or mobile computers and associated equipment, other non-medical equipment (catering, waste disposal etc), communication systems (telephones, nurse call etc), heating and ventilation.

Risk assessment

This procedure is linked to the overall hospital site procedure for failure of electricity supply and departmental risk assessment register. This document should be reviewed on a regular basis and especially if any alterations to equipment function, staff and responsibility take place.

Aims

This emergency procedure is intended to highlight the key issues that may arise at departmental level in the event of electrical power failure. It is appreciated that this may be the result of a full site power failure, but it may also be the result of a local failure for which notification will be necessary. The main aim is to provide a structured approach to the safety of patients and staff and to minimise the risk associated with an electrical failure.

Identification of failure

This may be indicated by the failure of key observable elements, for example lighting and computer displays, but may also be indicated by alarm signals from monitored supply panels on medical equipment, services and systems.

Major supply failure

In the event of an obvious full electrical failure, do not wait for the restoration of supplies by generator, but immediately take action.

Staff should safely complete or suspend any procedure being undertaken and prioritise their attention on the most critical equipment and/or patients. Local standby supplies and equipment-based systems should be checked. Where necessary, manual intervention should be started to ensure the safety of patients.

When supply is restored by generator, staff should ensure that all essential equipment is functioning correctly and, where necessary, transfer equipment or patients on to essential supplies.

On restoration of the normal supply, staff should check that all systems and equipment have reset to normal.

Continued supply failure

If full supply loss should continue for several minutes, immediately contact the hospital duty manager via the switchboard. The switchboard will also contact the duty engineer for attention.

Within the department, prioritise duties to ensure safety of patients and take preventative measures, where possible, to minimise the workload.

In the event that it is identified as a local failure, contact the duty manager to gain further staff support from other adjacent unaffected areas, or arrange to move the most critical patients to other departments.

Partial supply failure

If only part of the department's electrical system fails, it is unlikely that standby systems will restore supplies in the immediate term. First, minimise the risk to patients and identify the extent of the failure. Contact the switchboard, who will alert the duty engineer and duty manager. Continue to monitor the situation and move critical equipment and/or patients to fully supported areas where possible.

Awareness and training

Electrical supply failure is one of the most wide-ranging impacts on the normal running of a department. It is likely that staff will be engaged in the regular testing of the standby systems, but further local awareness should be engaged to ensure that all staff is aware of the departmental issues and the effects of a longer-term and full failure. Where possible, this should be carried out at the workplace, but with minimum impact on patients. Senior managers should liaise with the estates engineer to arrange simulation and practical support.

Emergency procedures should be an essential part of new staff induction to the department to ensure all local issues are fully understood.

Review procedure

From incident experience and training evaluation, this procedure and any supporting information should be reviewed and amended as necessary to ensure the document remains up-to-date and definitive for the department.

This document was first issued on: …….. (Date)

Amendments (Brief details and date) ……

……

Plan approved and accepted by: ……...

Senior manager ……

Head of department: ……

Procedure for water contamination

Operational procedure reference no: .....

Other relevant procedures: Engineering scheme to provide piped fresh water supplies

Scope

The following procedure is designed to instruct and advise on the operational requirements for dealing with contamination of the water supply. It is not considered a definitive guide as the particular circumstances of the incident will ultimately determine the course of action taken. It will attempt to highlight the responsibilities of estates staff, clinical staff and on-call administrators.

Causes

Water may become contaminated in a number of ways, including:

- contamination of the incoming water supply to the hospital site;
- contamination due to substances inadvertently or maliciously added to the water storage systems;
- contamination caused by the corrosion or decay of materials in contact with the water supply, for example rusting metal and dead animals;
- cross-contamination of water supply due to the effect of a process carried out on site by staff or contractors where the safety devices are inadequate or non-existent, for example cross-contamination due to siphon age from drains and stagnant water;
- misoperation/failure of water treatment plant;
- migration between domestic hot and cold water services.

Effects

The possible effects of contamination are varied, and will depend on the severity and degree of the contamination. However, further investigation should be carried out if:

- staff complain about the taste of the drinking water;
- the water is discoloured;
- the water has a distinctive smell (this could be the result of chemicals (for example chlorine), acid, sewage or decaying matter);
- the water appears normal but people using it have become sick.

Investigation and response

The size of the affected area must first be ascertained. This will give some indication of the extent of the problem and may help to identify the source of the contamination.

The following actions may or may not require to be taken, depending on whether part of or the whole water system has been contaminated:

- inform the senior staff of affected departments to cease using the water;
- contact the local water authority. The contamination may have originated from the main water incoming supplies; there is likely to be an obligation not to contaminate the public water network;
- take samples as necessary to determine the nature of the contamination;
- once the extent has been determined, an assessment should be undertaken as to the nature of the contamination. The use of microbiology staff is recommended;
- isolate the affected area from the main supply to prevent further contamination;
- take samples at various points within the affected area(s) for future analysis;
- contact on-call or emergency administrative staff and advise them to arrange a supply of fresh water for areas requiring it;
- dependent on the nature of contamination, the cause may be obvious or easily located. If this is not possible, carry out a systematic investigation of water supply systems;
- if the cause of the contamination is located, isolate the contamination and carry out necessary works to resolve the situation;
- inform medical staff of the nature of the contamination and await advice on the clinical effect before restoring the water supply to the area;
- thoroughly flush all pipework (run taps, flush toilets, bidets etc) until further analysis shows no trace of contamination;
- when the water quality is restored and confirmed by medical or microbiology staff, allow normal use to continue.

Further work

- study how the contamination has occurred and carry out preventative work if possible to avoid recurrence;
- review the operational procedure for the incident and modify as necessary;
- note the date and time of the incident, action taken and by whom, for future reference.

Relevant drawing nos: .....

Additional information

……

……

……

……

……

Plan approved and accepted by:

Board member: .....

Risk assessment

This document is linked to risk assessment no..... It should incorporate existing controls contained in the risk assessment and should be modified if any changes to the risk assessment are made.

Procedure for piped medical gas failure

Operational procedure reference no: .....

Hospital location: .....

Plant or system description: .....

Systems in use:

Oxygen ref ..... Nitrous oxide ref .....

Nitrous oxide/oxygen ref..... Medical air ref.....

Aims

The aim of this emergency procedure is to provide guidance and a structured approach to the management response in the case of a major failure in supply of piped medical gases, and to safeguard patients at risk from any such failure.

Identification of the source and nature of failure

This will normally be indicated by an alarm actuation at one of the following locations:

- telephone exchange;
- porter's lodge;
- boiler room;
- main corridor;
- ward 1;
- ward 2;
- ward 3.

On actuation of the alarm, the hospital switchboard must be contacted with a description of the alarm legend. The switchboard operator will immediately contact the Duty Engineer or Duty Authorised Person (responsibility allocated in the medical gas pipeline system (MGPS) operational policy) for the initial response and investigation of the fault, and will follow switchboard procedures.

The situation will be assessed by the Duty Engineer and categorised accordingly as a minor or major failure of the system.

Minor failure, not life-threatening

The Duty Engineer will contact the Authorised Person to have repairs carried out in accordance with Scottish Health Technical Memorandum 02-01, and inform the Duty Senior Manager of the cause and outcome of the situation. Permits-to-work will be issued in accordance with Scottish Health Technical Memorandum 02-01 as above.

Major failure of supply

If a major failure of supply has occurred, the following procedure is to be followed by the Duty Engineer, who will carry out the initial assessment and arrange for the following personnel to be contacted:

Authorised Person, Senior Manager, Senior Pharmacist, Senior Nurse, Senior Medical Officer/Surgeon

The situation will be re-assessed by the Senior Manager and a decision taken as to whether the major incident plan is also implemented and brought into operation, together with the procedures outlined in this document.

Damage control

The cause and result of the damage to the system should be investigated by the Duty Engineer/Authorised Person.

Drawings and schematics should be readily available.

Steps should be taken to limit the amount of disruption, and a temporary supply should be secured by either valving or capping of damaged areas to enable emergency supply banks to cope during repairs. Failing this, sufficient portable cylinders should be provided at the point of use.

Following damage limitation, valve-off the damaged section where possible and ensure back-up supply banks are functioning.

Team members' attendance should be confirmed. They should assemble at a predetermined location where control will be handed from the Duty Engineer/Duty Estates Manager to the responsible Senior Manager.

The areas of responsibility for the various team members are outlined, but this list is by no means exhaustive and should be further developed in the light of knowledge as the incident develops.

Areas of responsibility

Telephonist

- first-line communications;
- initial co-ordination of response;
- assists with all communications and logs calls and responses.

Senior Manager

- coordination of all team members;
- recovery strategy and repair coordination;
- documentation.

Senior Pharmacist

- ordering and procurement of gases;
- purity checks on reinstatement of supply.

Senior Medical Officer, Surgeon/Senior Nurse

- clinical prioritisation of supply requirements;
- liaison with doctors and nursing staff;
- movement of patients where necessary;
- advice to other team members on clinical criteria.

Duty Engineer/Authorised Person

- initial response and co-ordination;
- damage limitation and securing supply;
- diagnosis and repair of failure;
- provision of temporary supplies (pipeline);
- testing and verification on reinstatement;
- recommissioning and documentation.

Designated Manager, Hotel Services

- provision of portering staff for moving and changing cylinders;
- liaison with other team members for manpower requirements;
- organisation of patient transport where needed;
- organisation of transport for support services;
- liaison with outside agencies and press.
- communications.

Debriefing

Following return to normality, a team debriefing should be held to review the emergency procedure and update or correct any apparent weaknesses.

Review procedure

This procedure will be reviewed following any change in personnel, equipment, materials and environment or following any change. It will be reviewed at regular intervals not exceeding 12 months.

Training and information

All staff involved will receive adequate training and instruction to enable them to carry out these procedures with confidence during an emergency. This training will be recorded in the log attached, and updated on a regular basis.

Amendments.....(brief details and date)

Plan approved and accepted by:

Board member: .....

Risk assessment.....

This document is linked to risk assessment no ..... It should incorporate existing controls contained in the risk assessment and should be modified if any changes to the risk assessment are made.

Operational Checklist	Define ownership of the problem?	Will patient/public/staff safety/care be affected?	Risk of fire outbreak, or reduced fire-fighting ability?	Consider impact on electricity supply?	Consider impact on gas supply?	Consider Impact on water supply?	Consider impact on drainage?	Consider impact on other services?	Increased risk of *Legionella*?	Consider impact on site security? Impact on fire alarms?	Will medical gases be affected?	Is there an impact on clinical waste?	Agree responsibility boundaries	Clinical department procedures?	Control of Infection Team involvement?	Do public relations need to be addresses?	Consider Service Level Agreements with purchasers?	Involve commercial services?	Record Board personnel contact details?	Locate supply of specialist equipment?	Locate approved subcontractors?	Record specialist contractor contact details?	Keep records of actions taken?
Air conditioning																							
Air pollution																							
Asbestos																							
Building management system																							
Boilers																							
Clinical waste																							
Domestic hot Water																							
Drainage																							
Electricity Supply failure																							
Explosions																							
Extreme Weather																							

Health Facilities Scotland

NHS National Services Scotland

Operational Checklist	Define ownership of the problem?	Will patient/public/staff safety/care be affected?	Risk of fire outbreak, or reduced fire-fighting ability?	Consider impact on electricity supply?	Consider impact on gas supply?	Consider Impact on water supply?	Consider impact on drainage?	Consider impact on other services?	Increased risk of *Legionella*?	Consider impact on site security? Impact on fire alarms?	Will medical gases be affected?	Is there an impact on clinical waste?	Agree responsibility boundaries	Clinical department procedures?	Control of Infection Team involvement?	Do public relations need to be addresses?	Consider Service Level Agreements with purchasers?	Involve commercial services?	Record Board personnel contact details?	Locate supply of specialist equipment?	Locate approved subcontractors?	Record specialist contractor contact details?	Keep records of actions taken?
Fire																							
Flooding																							
Gas																							
Heating																							
Incinerators																							
Infestations																							
Kitchens																							
Laboratory failures																							
Lifts																							
Medical engineering equipment																							
Operating theatres																							
Piped medical gases																							

Operational Checklist	Define ownership of the problem?	Will patient/public/staff safety/care be affected?	Risk of fire outbreak, or reduced fire-fighting ability?	Consider impact on electricity supply?	Consider impact on gas supply?	Consider Impact on water supply?	Consider impact on drainage?	Consider impact on other services?	Increased risk of *Legionella*?	Consider impact on site security? Impact on fire alarms?	Will medical gases be affected?	Is there an impact on clinical waste?	Agree responsibility boundaries	Clinical department procedures?	Control of Infection Team involvement?	Do public relations need to be addresses?	Consider Service Level Agreements with purchasers?	Involve commercial services?	Record Board personnel contact details?	Locate supply of specialist equipment?	Locate approved subcontractors?	Record specialist contractor contact details?	Keep records of actions taken?
Paging																							
Refrigerators																							
Sewage plant																							
Sterilization																							
Telephones																							
Transport incidents																							
Water contamination																							
Water supply																							
Water Treatment																							

Sample procedure Matrix

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NHS National Services Scotland

Scottish Health Planning Note 04

In-patient Accommodation: Options for Choice
Supplement 1: Isolation Facilities in Acute Settings

Health Facilities Scotland
Engineering and Environment

September 2008

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1. Introduction

Context

1.1 Healthcare Associated Infection (HAI) is a burden on the NHS. It affects an estimated one in ten NHS hospital patients each year (DH, 2003) at an annual cost of £1bn (National Audit Office, 2000).

1.2 Many patients with an infection require physical isolation. However, often patients cannot be isolated because of a shortage of single rooms and isolation suites.

1.3 The key to effective isolation on acute wards is the provision of single rooms with en-suite sanitary facilities. Single rooms reduce the risk of cross-infection for non-airborne diseases and help to lower the incidence of HAI. Most patients on acute wards can be isolated in single rooms with en-suite facilities. All single rooms in new-build hospitals should have en-suite facilities so that they can be used to isolate patients for a variety of reasons and not just for infection control purposes.

Purpose of the guidance

1.4 This Supplement to SHPN 04: 'In-patient accommodation: options for choice', provides guidance on the facilities required for isolating patients on acute general wards.

1.5 For infection control purposes, a single room without en-suite is better than no single room at all. However, the guidance in this Supplement is based on best practice, and describes how a single room can be enhanced to provide an effective isolation facility for patients on acute general wards. The Supplement has two aims:

- to set a standard for new-build facilities;
- to provide Health Boards wishing to convert existing accommodation with simple design options that can be implemented relatively quickly and cost-effectively.

1.6 This guidance:

- explains how a single room with en-suite sanitary facilities can be enhanced to provide effective isolation for patients with infections that could be transmitted within healthcare;
- describes how an enhanced single room with en-suite facilities and a ventilated lobby can provide an isolation suite for patients who have airborne infections or who need to be protected from them;

- can be used for both new-build schemes and the upgrading of existing accommodation.

1.7 The guidance also contains examples of room layouts.

1.8 The guidance on isolation suites in this Supplement is based on a validated design model. The aim of this Supplement is to provide practical guidance on how to provide isolation facilities that are simple to use and meet the needs of the majority of patients on acute general wards.

1.9 Information about how good design can prevent cross-infection in healthcare premises generally is provided in SHFN 30 Version 3: 'Infection control in the built environment: design and planning' and Healthcare Associated Infection-System for Controlling Risk in the Built Environment (HAI-SCRIBE). SHPN 04 Supplement 1 should be read in conjunction with SHFN 30 and HAI-SCRIBE.

Exclusions

1.10 This Supplement does not describe the specialist facilities required in infectious disease units or on wards where severely immuno-compromised patients are nursed. Guidance for these facilities will follow in a further Supplement to SHPN 04.

2. Operational policies and planning principles

The need to isolate patients

2.1 Historically, isolation in general wards has been provided in single rooms, sometimes without en-suite facilities. Rooms without en-suite facilities often cannot be used to isolate patients effectively.

2.2 Ventilated isolation suites with en-suite facilities have also been provided. They may have a ventilation system that provides a positive pressure in the room to protect the patient from infection, or a negative pressure to prevent a patient from infecting others, or the ventilation may be switchable from positive to negative. These rooms rely on staff being able to assess the type of ventilation required when a patient arrives on the ward and, for switchable systems, knowing how to select the correct ventilation mode. Patients can be put at risk by user error if the ventilation mode is not set correctly.

2.3 The provision of isolation rooms which are switchable from positive to negative air pressure is no longer recommended because of the risk of cross contamination in the event of the setting being incorrect.

2.4 There are four main reasons for caring for patients in single rooms:

- patient susceptibility to infection from other sources;
- where a patient presents an infection risk to others;
- non-medical, for example patient preference;
- clinical but not infection-related.

In terms of infection control, only patients in the first two categories require isolation. Patients in the latter two categories can be cared for in standard single en-suite rooms.

Isolation facilities

2.5 In order to simplify the use of isolation facilities, this Supplement proposes two room designs for isolating patients in acute general settings:

- enhanced single room with en-suite facilities;
- enhanced single room with en-suite facilities and ventilated bed access lobby (isolation suite).

Enhanced single room with en-suite facilities

2.6 An enhanced single room with en-suite sanitary facilities having extract ventilation is a simple, cost-effective way to provide isolation, and will meet the needs of most patients on general wards.

2.7 The room does not require any specialist knowledge or action by the nursing staff to operate it. When not being used for isolation the room can be used for general nursing.

2.8 See Section 3 for detailed design guidance.

Enhanced single room with en-suite facilities and ventilated lobby (isolation suite)

2.9 An enhanced single room with a positive pressure ventilated bed access lobby and en-suite facilities with extract ventilation provides both source and protective isolation.

2.10 The positive pressure lobby ensures that air from the corridor does not enter the isolation room, and that air from the room does not escape into the corridor. This simple design enables the suite to be used for both source and protective isolation without the need for switchable ventilation or special training for staff. It also provides safe isolation for patients whose exact condition is unknown.

2.11 See Section 3 for detailed design guidance.

Advantages

2.12 Both rooms are suitable for caring for patients not in isolation but who require a single room for other reasons. In addition, both room designs are simple in concept, by default safe in operation, and do not require the nursing staff to have any specialist ventilation knowledge.

Creating pleasant environments

2.13 Some patients with infections need to stay in isolation in hospital for long periods of time. The number of visitors they receive and the length of time they can spend with them may be restricted. This means that patients who are already vulnerable, but not necessarily physically severely incapacitated, will be confined to the room for sometimes several weeks and can experience long periods of boredom.

2.14 Accommodation for these patients should be stimulating and as comfortable as possible. Designers should try to achieve a balance between the need for a clean environment and the comfort of patients. There are a number of publications that describe in detail, evidence that supports the concept that a therapeutic environment has a positive effect on a patient's general feeling of well-being, reduces the length of stay for many patients, reduces depression,

confusion and aggressive episodes and significantly increases a patient's level of satisfaction with the overall quality of their care.

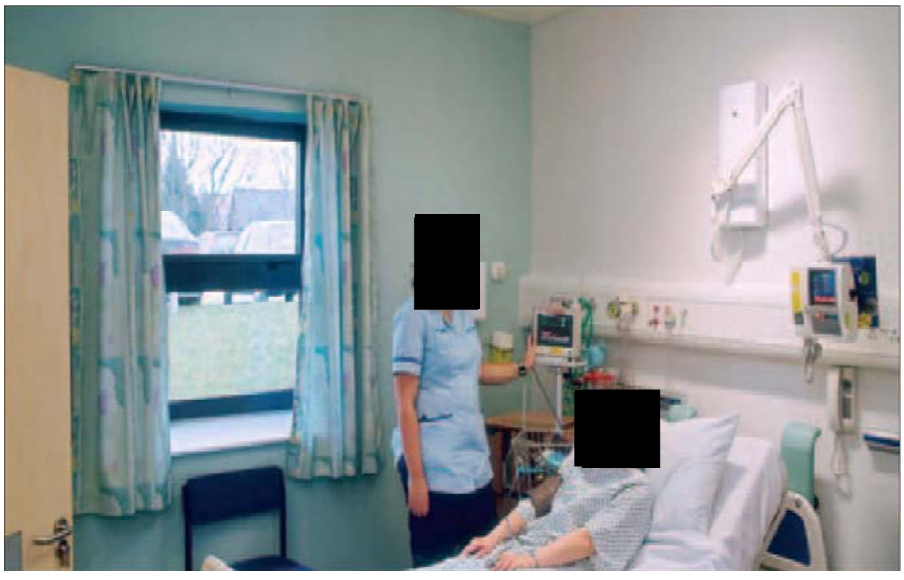
2.15 If patients are to stay in an isolation suite, it is important that they are able to see staff from their beds. Staff should also be able to see the patient in case of emergency. This reduces the psychological problems of isolation. Observation windows should have integral privacy blinds which can be controlled by both staff and patients. The sense of containment can also be reduced by providing outside views using windows with low sills.

Record keeping

2.16 Where staff are required to record lobby air pressures as part of the local COSHH assessment, facilities for completing and storing log books should be provided in the lobby.

Maintenance and cleaning

2.17 Guidance on the maintenance and cleaning of materials and finishes is contained in SHFN 30: Infection Control in the Built Environment: design and planning, planning teams should also refer to the 'Monitoring Framework for NHSScotland National Cleaning Services Specification-Guide for NHS Managers'. All surface finishes must be washable and moisture-resistant. This does not include emulsion paint.



Single Room

En-Suite Bathroom

3. Design guidance

New build isolation facilities

Enhanced single room with en-suite facilities

3.1 The design for a new-build enhanced single room with en-suite facilities is shown in Appendix 1 Sheet No 1: Example room layouts.

3.2 The general specification for single rooms is provided in SHPN 04 (2000). The enhancements and modifications recommended for isolating patients are:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers including alcohol hand rub dispensers, and disposable towel holders;
- a foot operated lidded bin for disposing of paper towels and other non-clinical items;
- suitable extract to the en-suite bathroom;
- transfer grille in en-suite door;
- en-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control (see paragraph 3.20);
- external windows should be openable, but with a fixed maximum opening width for safety. They should also be lockable. Internal windows should be fixed;
- observation window in corridor wall with integral privacy blinds that can be controlled by both patients and staff;
- all windows, including observation windows, should be low enough to provide a view for patients lying in bed.

Enhanced single room with en-suite facilities and ventilated bed-access lobby (isolation suite)

3.3 The design for a new-build enhanced single room with en-suite facilities and ventilated lobby, with bed access through the lobby, is shown in Appendix 1 Sheet No 2 Example Room layouts.

3.4 The ventilated bed access lobby ensures that:

- air entering the bedroom is the clean ventilation supply from the lobby. Air from the corridor is blocked by the ventilation supply in the lobby, that is, the patient in the bedroom is protected from air from the corridor;

- potentially contaminated air from the bedroom is prevented from escaping into the corridor by the ventilated lobby, so the patient will not present a risk of infection to others.

As the lobby simultaneously prevents unfiltered air entering the room and potentially contaminated air escaping from it, the room can be used by both infectious patients and those at risk of infecting others.

3.5 The use of personal protective equipment (PPE) will be determined by local infection control policy. Facilities for putting on and removing PPE, and washing hands, are provided in the lobby. The risk of contaminants being dislodged from used PPE by the ventilation system and blown out into the corridor is considered negligible. However, a hand-wash basin and pedal operated lidded bin are also provided in the bedroom close to the exit door so that PPE can be removed in the bedroom should local policy require.

3.6 The benefits of the isolation suite are that it is simple in concept, requires no specialist knowledge by healthcare staff to operate it, and can also be used for general nursing. In addition, if the ventilation system fails the layout of the suite still ensures a degree of protection.

3.7 The general specification for single rooms is provided in SHPN 4. The enhancements and modifications recommended for isolating patients are:

In the bed access lobby:

- a clinical hand-wash basin with non-touch, fixed temperature mixer tap (see paragraph 3.20);
- wall-mounted soap dispensers, disinfectant hand rub dispensers, and disposable towel holders;
- wall-mounted plastic apron and glove dispensers and storage for other clean PPE items;
- a clinical waste bin for disposal of used PPE;
- a bin for disposing of paper towels and other non-clinical items;
- storage for room cleaning equipment;
- a suitable air supply;
- In the isolation room;
- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers, including alcohol hand rub dispensers, and disposable towel holders;
- a clinical waste bin for disposal of used PPE;
- observation window in corridor wall with integral privacy blinds;
- a pressure stabiliser above bedroom door.

In the en-suite bathroom:

- suitable extract system to the en-suite bathroom;
- transfer grille in the en-suite door;
- en-suite WC to be non-touch flush and wash basin to have single tap with flow and temperature control (see paragraph 3.20).

For the suite as a whole:

- sealed, solid ceiling;
- windows to the exterior and interior to be locked shut and sealed;
- recessed luminaire rated IP44;
- where the configuration of the building permits (e.g. roof space above) consideration should be given to accessing luminaires from above for lamp changing. This will avoid the need for maintenance staff to access isolation facilities to undertake this activity.

3.8 Heating and cooling of the isolation suite will normally be provided via the ventilation system.

3.9 The provision of a two-way intercommunication system between the patient's bedroom and the nurses' base should be provided (see SHTM 2015: 'Bedhead Services').

Converting existing facilities

3.10 The majority of patients requiring isolation can be cared for in enhanced single rooms with en - suite facilities that have an extract system. Only a small number of patients will need an isolation suite.

3.11 Acute general hospitals can create enhanced single en-suite rooms and isolation suites by converting bays and adapting existing single room accommodation. The layout of existing facilities may impose constraints on design, however, and planning teams will sometimes have to resolve the conflict between what is desirable and what is achievable.

3.12 For Health Boards wanting to convert existing accommodation into isolation facilities, the easiest and least expensive option is to adapt existing single rooms with en-suite sanitary facilities. However, where existing single rooms do not have en-suite facilities, Health Boards will need to reconfigure the accommodation (see paragraph 3.16).

Converting a single room with en-suite facilities

3.13 The standard furnishing and fitment requirements for a single room are described in SHPN 04: 'In-patient accommodation: options for choice'.

3.14 The additional requirements for isolation of a single en-suite room are:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- wall-mounted hand hygiene dispensers including alcohol hand rub dispensers, and disposable towel holders;
- a foot operated lidded bin for disposing of paper towels and other non-clinical items;
- suitable extract to the en-suite bathroom;
- transfer grille in en-suite door;
- en-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control;
- external windows should be openable, but with a fixed maximum opening width for safety. They should also be lockable;
- observation window in corridor wall with integral privacy blinds that can be controlled by both patients and staff;
- all windows, including observation windows, should be low enough to provide a view for patients lying in bed.

3.15 A typical layout for converting an existing single room with en-suite facilities is shown in Appendix 1 Sheet No 3: Example room layouts.

Converting a single room without en-suite facilities

3.16 In an existing building it may be possible to modify three adjacent single bedrooms into two enhanced single bedrooms each with en-suite facilities - see Appendix 1 Sheet 4: Example room layouts.

3.17 The requirements for disabled access, as set out in sections 4.2 and 4.7 of The Building (Scotland) Regulations, should be met.

Creating an enhanced single room with en-suite facilities and ventilated bed access lobby (isolation suite)

3.18 When converting a single room into an enhanced single room with en-suite and ventilated lobby, any suspended ceiling must be replaced with a sealed solid ceiling. If a single room has a suspended ceiling to permit access to overhead services, a Health Board should install a sealed ceiling with sealable access hatches or move the services.

3.19 The additional requirements for upgrade to an isolation suite are as follows:

In the bed access lobby:

- a clinical hand-wash basin with non-touch, fixed temperature mixer tap (see paragraph 3.20);

- wall-mounted soap dispensers, disinfectant hand rub dispensers, and disposable towel holders;
- wall-mounted plastic apron and glove dispensers and storage for other clean PPE items;
- a clinical waste bin for disposal of used PPE;
- a bin for disposing of paper towels and other non-clinical items;
- storage for room cleaning equipment;
- a suitable air supply.

In the bedroom:

- a clinical hand-wash basin, with non-touch, fixed temperature mixer tap (see paragraph 3.20) adjacent to the exit door;
- a clinical waste bin for disposal of used PPE;
- non-opening observation window in corridor wall with integral privacy blinds;
- a pressure stabiliser above the bedroom door into the lobby;
- In the en-suite bathroom;
- suitable extract system to the en-suite bathroom;
- transfer grille in the en-suite door;
- en-suite WC to be non-touch flush and wash basin to have single tap with flow and temperature control (see paragraph 3.20).

For the suite as a whole:

- sealed, solid ceiling;
- windows to the exterior and interior to be locked shut and sealed;
- recessed luminaire rated IP44;
- where the configuration of the building permits (e.g. roof space above) consideration should be given to accessing luminaires from above for lamp changing, This will avoid the need for estates staff to access isolation facilities to undertake this activity.

3.20 Point of use oversink, non-touch, fixed temperature water heaters may be used as an alternative to ‘fixed temperature mixer taps’.

3.21 The provision of a two-way intercommunication system between the patient’s bedroom and the nurses’ base should be provided (see SHTM 2015: ‘Bedhead services’).

3.22 An option for reconfiguring two existing single rooms to provide one enhanced single room with en-suite facilities and ventilated lobby, with bed access through the lobby, is shown in Appendix 1 Sheet 5: Example room layouts. Where space restrictions mean bed access through the lobby is not possible, an

alternative layout gives bed access directly to the bedroom from the corridor shown in Appendix 1 Sheet 6: Example room layouts. In this case the lobby would be sized for personnel access only.

Converting a multi-bed bay

3.23 An existing four-bed bay may be converted to provide two enhanced single rooms with en-suite facilities in Appendix 1 Sheet 7: Example room layouts.

3.24 In this configuration it is not possible to provide a normal observation window. As observation is critical, however, one option would be to provide fully-glazed lobby and bedroom doors, with integral privacy blinds, to enable observation from the corridor and to provide a view out for the patient.

Hand rub dispenser

4. Engineering requirements

Engineering design philosophy

4.1 This Section describes the ventilation system philosophy for an isolation suite with a patient's bedroom, en-suite sanitary facilities and ventilated lobby. A methodology for validation of the performance standard is given in Appendix 2.

4.2 The isolation suite and its ventilation system are based on a validated design. The engineering guidance given in this Section aims to provide a practical, 'fail-safe' design solution for isolating patients on acute general wards.

4.3 The ventilation system is designed on the basis that all its constituent parts, as described in Table 1, work together to form an integrated system. For example, air to the suite is supplied at high level in the lobby, with extract in the en-suite bathroom. This ensures good airflow through the entire isolation suite. Similarly, the volumetric airflow rate in the lobby is determined by the number of air changes required in the patient's bedroom. Modifying or failing to provide one element of the system will jeopardise the performance of the system as a whole.

Basic design parameters

4.4 The patient's bedroom is to have 10 air changes per hour. The entry lobby is to be at +10 Pascals with respect to the corridor. The en-suite room is to have at least 10 air changes per hour and be at a negative pressure with respect to the patient's bedroom. Table 1 gives nominal design values calculated for rooms of the size stated. The air change rates and pressure differentials below should be maintained when filters are dirty. Variable-speed control of fan motors would be an acceptable method of flow control, within the normal operating range of the fan's speed.

Room	Parameter	Nominal Design Values
Lobby	Room volumes Bed access lobby (5m2 x 2·7m) Personnel access lobby (4m2 x 2·7m)	 13·5 m^3 10·8 m^3
	Pressure differential to corridor	Nominally 10 Pascals
	Supply air flow (for a room of this size)	Bed access lobby - 238 l/s Personnel access lobby - 208 l/s
	Air change rate	Bed access lobby – 63 per hour Personnel access lobby – 69 per hour
Isolation Room	Room volume (19m2 x 2.7m)	51.3m^3
	Pressure differential to corridor	Nominally zero
	Room air flow (for a room of this size)	158 l/s
	Air changes rate	10 per hour
En-suite	Room volume (6m2 x 2·7m)	16·2m^3
	Pressure differential to isolation room	Negative
	Extract air flow (for a room of this size)	158 l/s (If extract is fitted in the isolation room this reduces to 45 l/s in the en-suite with 113 l/s extract in the isolation room)
	Air change rate	At least 10 per hour

Table 1: Isolation Suite – Ventilation Parameters

Note: In this example the design parameters are based on SHPN 04: 'In-patient accommodation: options for choice'. The en-suite is sized to comply with BS 8300 accessibility requirements.

The airflow rates quoted do not include any allowance for construction leakage. This has been set at 1 l/s of air per 1m^3 of suite envelope volume (see Appendix 2).

Where immuno-compromised patients are to be accommodated, such as in transplant units or specialist cancer units, there could be a need for positive pressure isolation rooms.

Isolation Suite

Ventilation – general

4.5 Ideally each suite should have its own dedicated supply and extract system. If two or more suites share a ventilation system there will be an inevitable increase in the complexity of the system and a corresponding reduction in reliability and serviceability. Further complications will occur when individual suites have to be isolated for deep cleaning following occupation. Routine maintenance of the ventilation system will result in complete closure of all suites

that it serves. For these reasons it is strongly recommended that each suite should have its own ventilation system. However, refer also to paragraph 4.8.

4.6 The object should be to keep the ventilation systems as simple as possible. Standby fans or motors are not required for either supply or extract. This is because the system as designed is robust enough to withstand fan failure without significantly compromising the level of protection. A flow sensor should be fitted to each system that will alarm on fan failure at a designated nurse station and the estates department.

4.7 Ductwork should be kept as direct and simple as possible. In order to facilitate duct cleaning, volume control devices and other obstructions in the distribution ducts should be avoided. Supply and extract flow rates should, where possible, be set by terminal and duct size design. In the unlikely event that volume control devices are required, iris dampers are the preferred type.

4.8 In a high-rise building a common supply and extract system may be the only feasible solution. In this case, run and standby fans would be required for the extract and a duplicate supply unit may be considered necessary. The supply and extract branches to each isolation suite should be fitted with spring-close gas-tight dampers. This will permit individual suites to be shut down for cleaning and maintenance. The common supply and extract systems will need to be controlled to ensure a constant volume in each isolation suite branch regardless of the number in use. The overall design should ensure that short-circuiting couldn't occur between isolation suites.

Fire strategy

4.9 The isolation suite is intended to be built as a single fire compartment. The positive pressure in the lobby will deter smoke originating in the corridor from entering the room. Smoke from a fire in the room will be contained within the suite and extracted via the en-suite extract. Due to this. the ventilation system serving the isolation facility should be kept running in the event of a fire.

4.10 Fire rated ductwork should be provided such that ducts can be considered an extension of the isolation suite. Fire dampers, where the ducts penetrate walls and floors, will not then be required.

4.11 A motorised smoke/fire damper should be fitted at the discharge of the supply air handling unit (AHU). The damper should close in the event of an AHU or intake fire under the control of a smoke detector mounted in the AHU.

Extract ventilation

4.12 An extract terminal should be fitted at high level in the en-suite room. An additional terminal may be fitted in certain circumstances at low level adjacent to the bedhead in the bedroom. The clinical requirement for this should be verified and such requirements would probably relate to highly infectious patients.

4.13 A transfer grille should be fitted at low level in the door between the bedroom and en-suite room.

4.14 The extract duct should be fitted with a spectacle plate or gas-tight damper so that the system can be sealed to allow the isolation suite to be disinfected. The plate or damper should be fitted at the inlet of the extract fan. This will also permit isolation of the extract fan for service and maintenance.

4.15 The extract fan unit should be located outside the building so that all ductwork within the building is under negative pressure. Access and cleaning hatches should only be fitted where absolutely necessary. If fitted they should be of the sealed type and marked with a bio-hazard symbol. If the fan has to be located inside the building it should be as close as practicable to the outside. The extract fan motor should be mounted out of the air stream and should be capable of being changed without withdrawing the impeller or opening up the ductwork. The extract fan should draw its power from the essential electrical system.

4.16 Extract filters will not be required provided that the fan can discharge in a safe location 3 m above the building height. If extract filters are fitted they should be in a 'safe change housing' outside the building on the suction side of the fan. Extract filters, where fitted, should be of H14 grade. Even if filtered, extract air must not be re-circulated.

4.17 Extract ductwork, the fan and discharge stack must be clearly marked to identify the isolation suite that they serve. Service, maintenance, cleaning and filter change of the system will be subject to a 'Permit to Work'.

Supply ventilation

4.18 The supply AHU should comply in all respects with the minimum standards set out in SHTM 2025:'Ventilation in Healthcare Premises'. (*This SHTM is under review and is listed for replacement by SHTM 03*). Heating and cooling should be provided, but not humidification. The fire/smoke damper fitted in the discharge from the AHU should close on plant shutdown and/or airflow failure, sealing the AHU from the distribution ductwork. This will prevent any reverse airflow and permit routine maintenance or system disinfection. The supply fan should draw its power from the essential electrical system.

4.19 The supply AHU and distribution ductwork must be clearly marked to identify the isolation suite that they serve. Access and cleaning hatches should only be fitted where absolutely necessary. They should be of the sealed type and marked with a bio-hazard symbol. Service, maintenance, cleaning and filter change of the system will be subject to a permit to work.

4.20 A G3 pre-filter and final filter should be fitted in the AHU. The lobby air supply terminal should be of a type into which a HEPA filter can be fitted. While it is not envisaged that a HEPA filter will be routinely required, this arrangement will allow for subsequent fitting when appropriate with the least disturbance. A

sealable upstream DOP injection test point will be required in the supply duct so that, if a HEPA filter is fitted, it can be challenge tested on installation.

4.21 A pressure stabiliser of the balanced blade type, set to operate at 10 Pascals, should be fitted above the door between the lobby and the bedroom. The stabiliser should be visible so that its correct operation can be seen. It should be of a style that will operate silently, and be correctly sized and positioned so that it does not cause a draught that would be uncomfortable for patients.

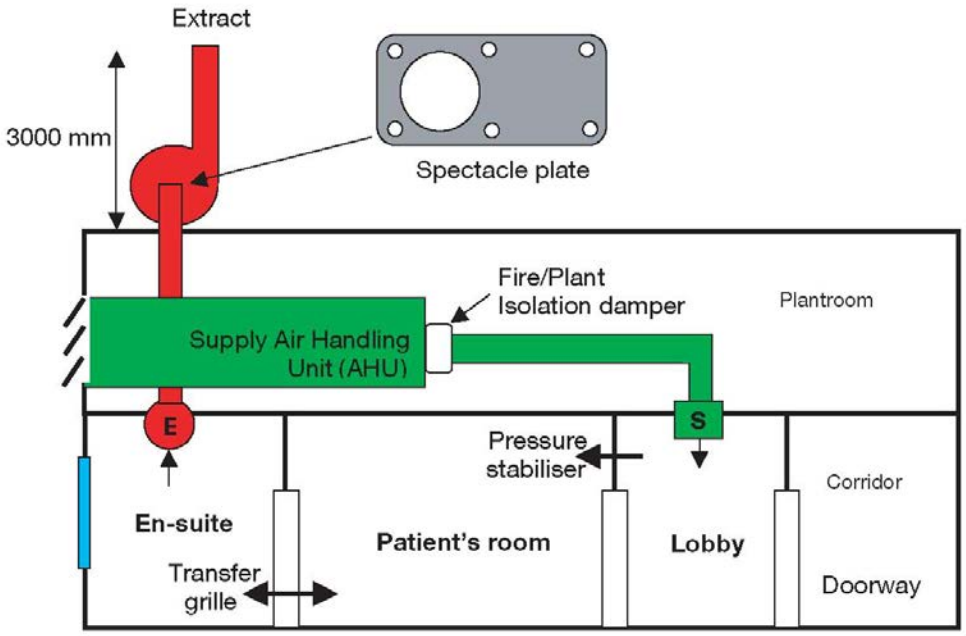
4.22 A direct reading gauge showing the pressure in the lobby with respect to the corridor should be mounted at eye level on the corridor wall adjacent to the lobby entry door. The gauge and lobby entry door must be clearly marked to identify the isolation suite to which they refer. In common systems serving more than one isolation room, automatic closing backdraught dampers will be required. Where HEPA filters are installed, these should be located so that staff can access them without recourse to entering isolation suites. Audio and visual alarms must be located at the entrance to the lobby and bedroom to warn nursing and maintenance staff of potential unsafe conditions. Continuous monitoring should be provided with remote indication at nurses stations, interlinked to the Building Management System with time delay (adjustable by Estates personnel) to take account of running-up of standby motors or damper operations or other plant items that may take time to open or close. Alarms based on sensing airflow failure should be provided rather than electrical failures. Alarm sound levels should be sufficient to attract attention without distress or annoyance and, if muted, should re-activate at 5-10 minute intervals.

Record keeping

4.23 A logbook will be required for each isolation suite. It should contain the following information:

- a schematic layout of the isolation suite and ventilation system serving it;
- information on the ventilation design parameters;
- a record of the actual ventilation performance at initial validation. (All of the tests set out in Appendix 2 ‘Acceptance testing of isolation suite’ should be carried out);
- records of the annual validations. (The parameters set out in Appendix 2 should be measured);
- records of the lobby pressure, taken by ward staff from gauges and monitoring devices provided;
- records of any routine service and maintenance activities;
- records of any repairs or modifications;
- a method statement for disinfecting the system.

Estates management should ensure that nursing staff are familiar with pressure gauges and able to record readings in the appropriate log book.



Isolation suite ventilation system – example layout

When the suite is taken out of use, the logbook should be preserved for at least five years.

Other considerations

4.24 As far as practicable, access to domestic hot and cold water services and their associated thermostatic mixing valves should be via access panels in the lobby or corridor. Every effort should be made to avoid service and maintenance staff having to enter or pass through the bedroom when carrying out routine service and maintenance tasks.

Service and maintenance

4.25 Spectacle plates or gas-tight dampers should be used to seal the system, should the suite and/or its ventilation system require disinfection. A method statement should be prepared detailing the procedure. For further guidance on disinfection refer to 'Biological agents: Managing the risks in Laboratories and healthcare premises' by the Advisory Committee on Dangerous Pathogens, available from HSE. All works of service and maintenance should be subject to a permit to work.

Appendices

Appendix 1: Example room layouts – Use of single rooms for Isolation: Key Design Principles

Appendix 2: Acceptance testing of isolation suite

Appendix 1 : Example room layouts

Use of single rooms for Isolation: Key design principles

The room layouts in this Appendix are examples and are intended as a guide. Other room configurations are possible.

Current guidance (Scottish Health Planning Note 04: In-patient accommodation: Options for choice, May 2000) recommends that *"where not in a single-bed room each bedspace should not be less than 3.0m x 2.7m".* However interim guidance, issued on the 21st February 2007 by the Scottish Executive states that having regard to ergonomic criteria, primarily the space required for patient handling and other activities which take place in the immediate vicinity of the bed it is recognised that the minimum bedspace should not be less than 3.6m x 3.7m. It also states that when planning any new in-patient accommodation or any major refurbishments of existing accommodation it is recommended that the increased bedspace is adopted.

In planning for the construction or major refurbishment of healthcare facilities it is appropriate to provide an overall single occupancy room level of between 50% and 100%.

The appropriate level within that range is a matter for each individual NHSScotland Board to consider based on the following broad criteria:

- science-based decisions relating to the clinical and nursing care of patients and overall hygiene standards;
- value-based judgements about the nature of personal services and responsiveness to the local community and generational cultures;
- operational needs, for example managing volatility in demand or changing clinical needs and priorities; and
- the need to balance these against economic considerations.

Each Board may also want to give consideration to the patient group being treated.

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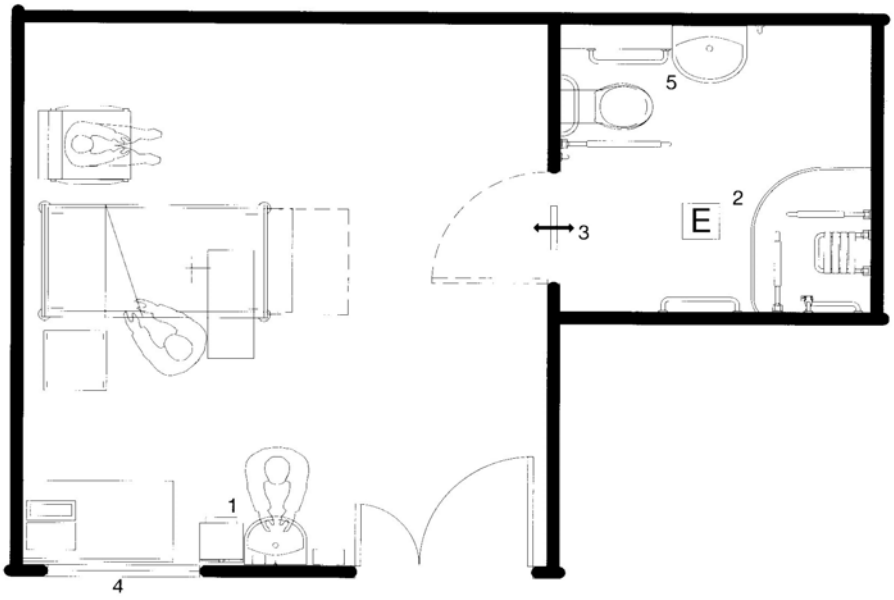
Sheet 1: New build single room with en-suite facilities.



Minimum requirements:

1. Clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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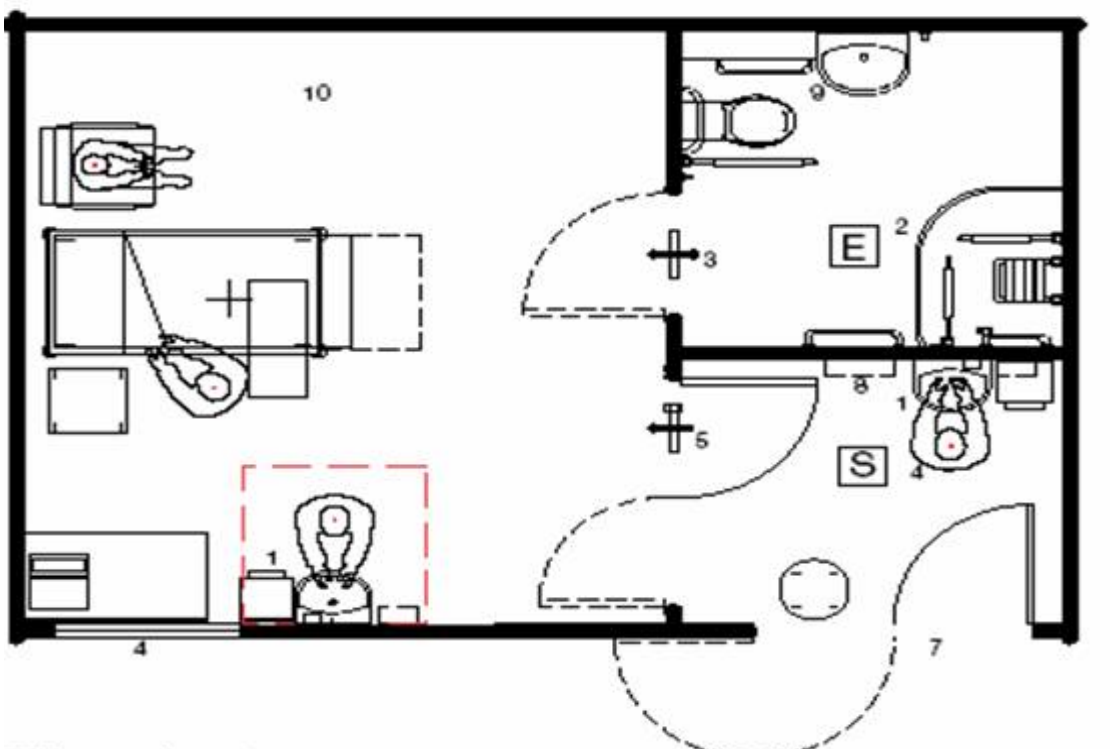
Sheet 2: New build single room with en-suite facilities and bed-access lobby (isolation suite)



Minimum requirements:

1. Clinical hand-wash-basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
7. Double door for personnel and bed access.
8 Disposable apron dispenser.
9. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.
10. Ceiling to be sealed solid construction, external window to be sealed.

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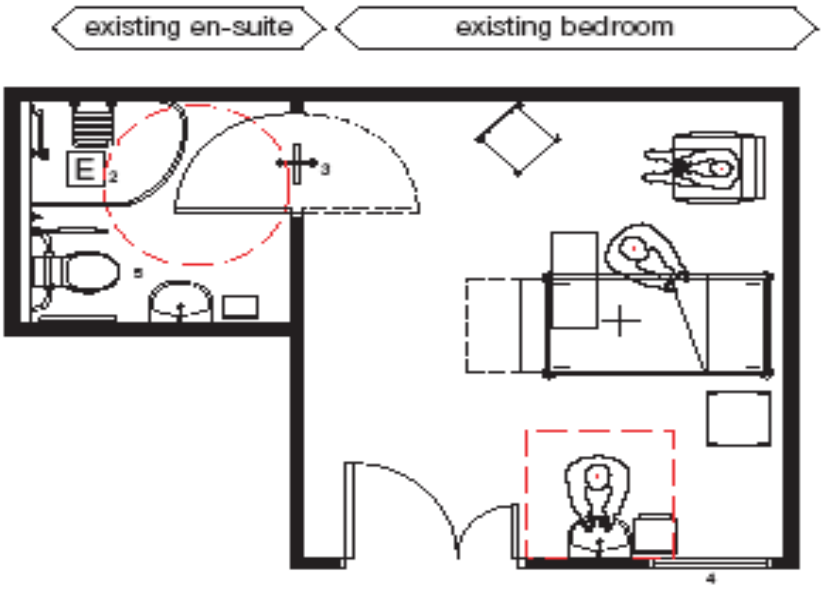
Sheet 3: Existing single room with en-suite facilities



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Upgrade existing extract fan.
3. Install transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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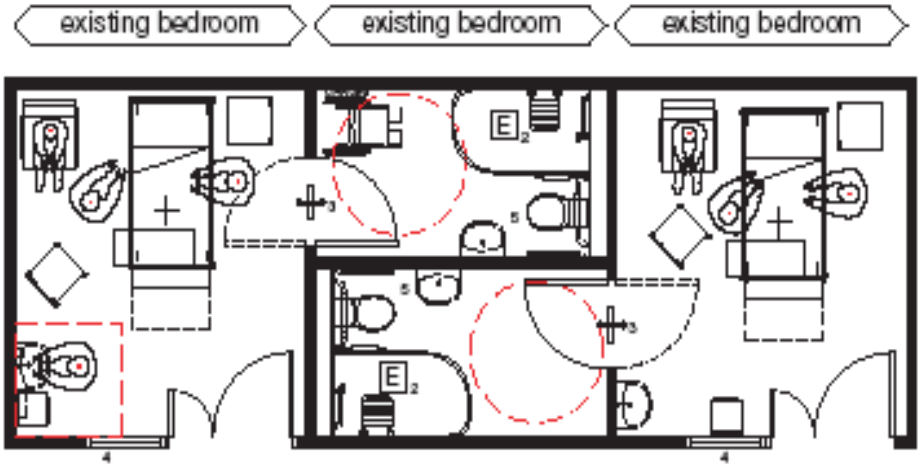
Sheet: 4 Single rooms without en-suite facility. Upgrading three existing single rooms to provide two single rooms with en-suite facilities



Minimum requirements to upgrade existing facilities:

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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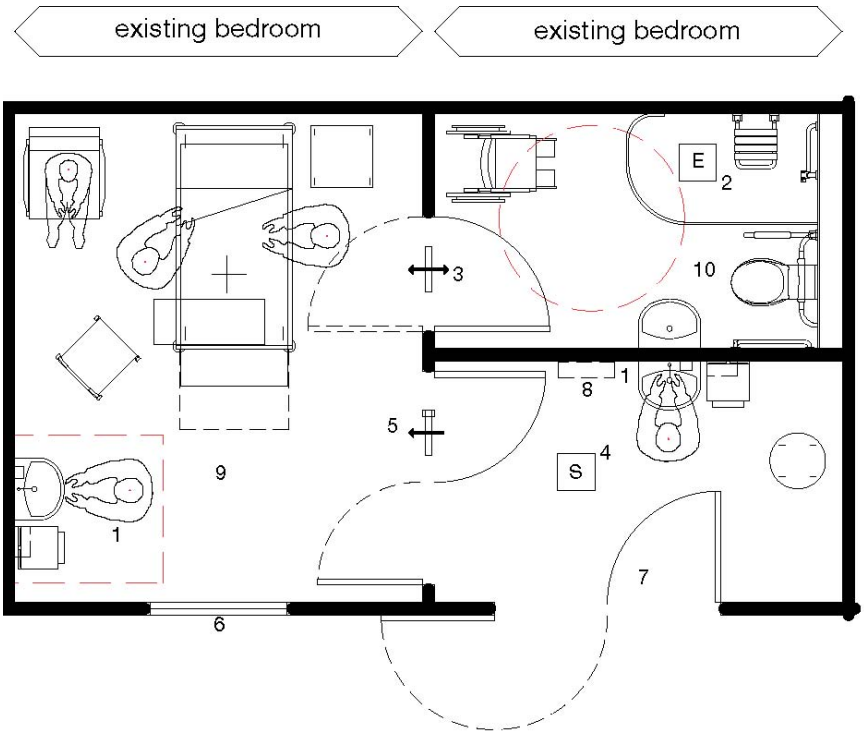
Sheet 5: Single rooms without en-suite facility. Upgrading two existing single rooms to provide one single room with en-suite facilities and bed access lobby



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow staff observation and patients views out.
7. Double door for personnel and bed access.
8. Disposable apron dispenser.
9. Upgrade ceiling to sealed solid construction, external windows to be sealed.
10. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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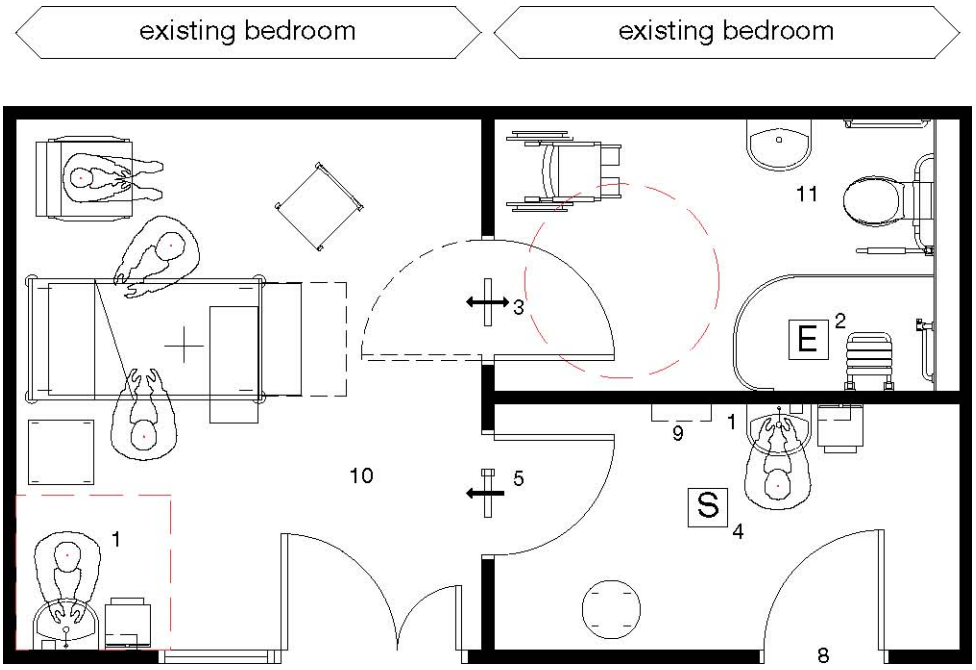
Sheet 6: Single rooms without en-suite facility. Upgrading two existing single rooms to provide one single room with en-suite facilities and personnel access lobby



Minimum requirements to upgrade existing facilities

1. Add clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
7. Existing door and a half for bed access only must be kept locked and have seals to minimise air transfer.
8. Single door access via lobby.
9. Disposable apron dispenser.
10. Upgrade ceiling to sealed solid construction, external windows to be sealed.
11. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.

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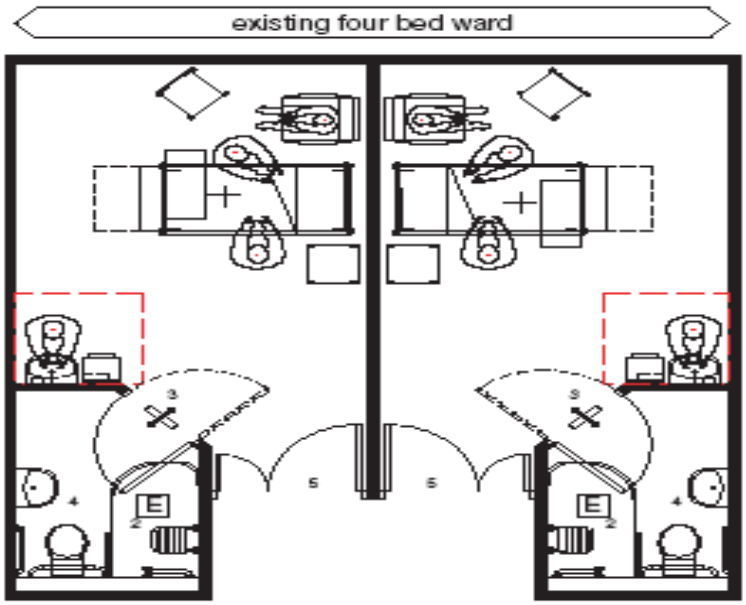
Sheet 7: Upgrading existing four bedded room to provide two single rooms with en-suite facilities.



Minimum requirements

1. Clinical hand-wash basin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Transfer grille to en-suite door.
4. En-suite WC to be non-touch flush and hand-wash basin to have single tap with flow and temperature control.
5. Doors to be fully glazed, with integral privacy blinds, to allow staff observation and patients views out.

Appendix 2: Acceptance testing of isolation suite

Definitions

Isolation suite

Includes the entry lobby, patient's room, en-suite facility and any storage or other area directly accessible from the patient's or en-suite room.

Isolation suite envelope

The isolation room suite bounded by a solid floor, solid ceiling and full-height walls that separate it from any other adjoining space or the outside.

Validation – Isolation suite air permeability (leakage rate)

The suite will be considered fit for purpose if at a test pressure of +20 and –20 Pascals it has an average leakage rate of not more than 1 l/s of air per 1m^3 of envelope volume. The method of testing is set out below.

Rationale*:* To ensure effective isolation, it is important that air leakage to or from adjacent areas is kept to a minimum. Construction gaps should be minimised and service penetrations sealed before the suite is tested. The test pressures are significantly more than would be achieved under a ventilation fault condition within the isolation suite. When in operation, the patient's room and en-suite are designed to be at a neutral or slightly negative pressure so the actual leakage between adjoining spaces should be insignificant.

Validation

Filtration test standards

General and fine filter grades to BS EN 779:2002 should be visually inspected to ensure that they are free from tears or other damage at the time of installation. They should be a good fit in their housing, with no obvious gaps that could allow air bypass.

High Efficiency Particulate Air (HEPA) filters, where fitted, should be certified by their manufacturer for conformity to BS EN 1822:2000. When installed, their performance should be checked with a particle counter using the method set out in BS EN 1822:2000 for in situ aerosol testing.

Air permeability – Tests method

1. Establish the volume of the isolation suite envelope as defined above.
2. Turn off the suite supply and extract ventilation systems and those serving adjoining spaces. (Rationale: All adjoining spaces need to be at atmospheric pressure in order to establish the true leakage rate.)
3. Seal all supply and extract terminals.
4. Wedge all internal doors open.
5. Fit a temporary board seal and test fan in the lobby to corridor doorway.
6. Run the fan to maintain a positive test pressure of 20 Pascal for at least two minutes.
7. Measure the airflow rate of the fan.
8. Reverse the fan and run it to maintain a negative test pressure of 20 Pascal for at least two minutes.
9. Measure the airflow rate of the fan.
10. Average the two airflow readings obtained.
11. Calculate the leakage rate in l/s of air per m^3 of envelope volume. If the isolation suite envelope is correctly sealed the readings should be within 5% of each other.

Further details of the test method are contained in 'Testing buildings for air leakage', CIBSE, TM23, 2000.

Close all internal doors and, using the test fan, check that the pressure stabiliser opens at 10 Pascal and that it will carry the design airflow without flutter.

These tests should be carried out at initial commissioning and as necessary thereafter following works of refurbishment or when there is any doubt as to the actual performance standard of the suite.

System operating standard

The suite will be considered fit for purpose if, with the ventilation system operating and all doors closed, the following parameters are achieved:

- a positive pressure of between 10 and 12 Pascals between the entry lobby and the corridor;
- the patient's room has an air change rate of at least 10 per hour;
- the en-suite room is at a negative pressure with respect to the patient's room;
- a failure of either the supply or extract fan will be indicated at a designated nurse station and the estates department.

The suite should be tested following initial commissioning and thereafter re-tested at least annually for conformity with this operating standard.

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References

Acts and Regulations

Control of Substances Hazardous to Health (COSHH) Regulations 2002 and subsequent amendments, SI 2002 No 2677. The Stationery Office. http://www.opsi.gov.uk/si/si2002/20022677.htm

The Building (Scotland) Regulations 2004 and Amendment Regulations 2006, 2007, SI 2000 No 2531. The Stationery Office. http://www.hmso.gov.uk/legislation/scotland/ssi2004/20040406

British Standards etc

BS 8300: 2001 Design of buildings and their approaches to meet the needs of disabled people – Code of practice. British Standards Institute, London.

BS EN 779:2002 Particulate air filters for general ventilation. Determination of the filtration performance.

BS EN 1822-4:2000 High efficiency air filters (HEPA and ULPA). Determining leakage of filter element (scan method).

BS EN 1822-5:2000 High efficiency air filters (HEPA and ULPA). Determining the efficiency of filter element.

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Scottish Health Technical Memorandum 2015: 'Bedhead Services' Health Facilities Scotland 2001.

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Health Facilities Scotland, August 2001. (new edition forthcoming 2008, 'SHTM 03')

Scottish Health Technical Memorandum 2027: 'Hot and cold water supply, storage and mains services'. Health Facilities Scotland, December 2001. (Revised version SHTM 04 in preparation for publication in 2008).

Scottish Health Technical Memorandum 2040: 'The control of legionellae in healthcare premises: a code of practice'. Health Facilities Scotland December 2001. (Revised version in preparation for publication in 2008 within SHTM 04).

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The management and control of hospital acquired infection in acute NHS Trusts in England. National Audit Office, 2000.

Biological agents: Managing the risks in Laboratories and healthcare premises. Advisory Committee on Dangerous Pathogens, The Stationary Office.

http://www.hse.gov.uk/biosafety/biologagents.pdf

Testing buildings for air leakage. CIBSE, TM23, 2000.

Useful websites

Hospital Infection Society	http://www.his.org.uk
Infection Control Nurses' Association	http://www.icna.co.uk
Health Protection Agency	http://www.hpa.org.uk
Royal College of Nursing	http://www.rcn.org.uk
Health Facilities Scotland	http://www.hfs.scot.nhs.uk
Health Protection Scotland	http://www.hps.scot.nhs.uk

From: Hanley, Dorothy
To: Sutherland, SarahJane
Subject: RE: Room Reviews RHSC/DCN
Attachments: image001.jpg

Yes please
Thanks
Dorothy

From: Sutherland, SarahJane
Sent: 25 January 2019 15:49
To: Hanley, Dorothy; Mackenzie, Janice
Cc: Guthrie, Lindsay; Collett, Emma; Cameron, Fiona; Munro, Anna; Halcrow, Fiona; Haig, Karen; Shah, Mashoodha
Subject: RE: Room Reviews RHSC/DCN

Hi Dorothy,

9.15am is great. I will meet Emma beforehand and sign in at security booth. Shall we meet in the project offices 4th Floor?

Kind regards
Sarah

From: Hanley, Dorothy
Sent: 25 January 2019 15:45
To: Sutherland, SarahJane; Mackenzie, Janice
Cc: Guthrie, Lindsay; Collett, Emma; Cameron, Fiona; Munro, Anna; Halcrow, Fiona; Haig, Karen; Shah, Mashoodha
Subject: RE: Room Reviews RHSC/DCN

9.15 would be better for me Sarah as our team meeting is at 8.30 and may not be quite finished by 9. If Emma has a security access pass that would save me having to come to the turnstile to bring you up as she can escort you . Karen or Mashoodha will confirm parking availability and let you know

Thanks
Dorothy

From: Sutherland, SarahJane
Sent: 25 January 2019 15:35
To: Mackenzie, Janice
Cc: Guthrie, Lindsay; Collett, Emma; Cameron, Fiona; Munro, Anna; Hanley, Dorothy; Halcrow, Fiona
Subject: RE: Room Reviews RHSC/DCN

Hi Janice,

Apologies for late reply I have been in meetings all afternoon. It would be helpful for my learning and the Band 6's development in relation to building works and HAI Scribe if we could come along at 9am Monday morning and have a look around some rooms if Dorothy can accommodate that.

I am bringing along IPCN Emma Collett who has a security pass so not sure if she requires to be on the visitors list. Will it be possible to park in Car park 1B again?

Kind regards
Sarah

Sarah Jane Sutherland
Lead HAI Scribe Advisor
Infection Prevention and Control Team
NHS Lothian
[redacted]

From: Mackenzie, Janice
Sent: 25 January 2019 12:04
To: Sutherland, SarahJane
Cc: Guthrie, Lindsay; Collett, Emma; Cameron, Fiona; Munro, Anna; Hanley, Dorothy; Halcrow, Fiona
Subject: RE: Room Reviews RHSC/DCN

Hi Sarah

Hopefully to reassure you Janette was fully involved in the room review process. She was provided with the timetable for our first and second round of reviews and she chose which ones she wanted to attend. To ensure a consistent approach was taken to the reviews a checklist of what to look at was developed, see attached, which was discussed with Janette. The purpose of what we have been doing over the last 4-6 weeks has been to check that previous observations made by us have been addressed and to identify any further observations that have occurred since the 2nd room reviews.

However of course happy for you to come over and look at some rooms with one of us. Handover is likely to be very soon so there is now very limited time and opportunity for this to happen. If you want to do this on Monday morning at 9am, since you said you were free, then Dorothy from our team would be happy to accompany you. If you can let me know so we can add you to the visitors list.

Kind regards
Janice

From: Sutherland, SarahJane
Sent: 25 January 2019 11:10
To: Mackenzie, Janice
Cc: Guthrie, Lindsay; Collett, Emma; Cameron, Fiona; Munro, Anna
Subject: RE: Room Reviews RHSC/DCN

Hi Janice,

Many thanks for your email.

Is there any scope to come and look over some of the rooms at any other time as I appreciate that Janette's reviews will have been a while ago, just to ensure that there are not any unidentified issues from and IPC perspective that have not been picked up prior to handover.
Kind regards
Sarah
Sarah Jane Sutherland
Lead HAI Scribe Advisor
Infection Prevention and Control Team
NHS Lothian Infection Prevention & Control Services
[redacted]
[redacted]
For more information visit the IPCT
http://intranet.lothian.scot.nhs.uk/Directory/InfectionPreventionAndControl/Pages/NHSLothianInfectionPreventionandControl.aspx

---

From: Mackenzie, Janice
Sent: 25 January 2019 09:28
To: Sutherland, SarahJane
Subject: RE: Room Reviews RHSC/DCN

Hi Sarah
Thanks for your email, appreciate you have had a busy diary. We have been very busy doing room reviews over the last couple of weeks as there is a need to get these completed before the hospital handover date which we anticipate will be soon. Therefore we only have the stair cores left to do on Monday & Tuesday and I don't think it would be good use of your time to come for that.
Kind regards
Janice

From: Sutherland, SarahJane
Sent: 24 January 2019 11:24
To: Mackenzie, Janice
Subject: Room Reviews RHSC/DCN

Hi Janice,
Apologies I have not been in touch before now, my diary has been very busy.
I will block out time on Monday 28/1/19 to come and participate in some room reviews if you could let me know if that is suitable.
I aim to bring one of the IPCNs from RIE with me if their diary allows, I will advise you in advance.
Do you know how long the room reviews will continue to run?
Kind regards
Sarah
Sarah Jane Sutherland
Lead HAI Scribe Advisor
NHS Lothian
Infection Prevention and Control Team
[redacted]
[redacted]

From: Henderson, Ronnie
To: Sutherland, SarahJane; Inverarity, Donald
Cc: Guthrie, Lindsay
Subject: RE: IPC SITE VISIT 20/03/19
Date: 27 March 2019 13:10:32
Attachments: image001.jpg

Hi Sarah,
Unfortunately I won't be at the meeting next week as on holiday.
The system has been designed to ensure the correct airflows and pressures are present at all times however this will need to be confirmed during final commissioning and validation post completion of the works we viewed and discussed last week. If required I can provide the design information that we have available.
Regards
Ronnie

Ronnie Henderson
Commissioning Manager Hard FM
RHSC & DCN - Little France
NHS Lothian
RHSC & DCN Site Office
Little France Crescent
Edinburgh
EH16 4TJ
[redacted]

From: Sutherland, SarahJane
Sent: 27 March 2019 12:09
To: Inverarity, Donald
Cc: Guthrie, Lindsay; Henderson, Ronnie
Subject: RE: IPC SITE VISIT 20/03/19
Hi Donald,
I will take this question with me and have copied in Ronnie for his information in advance.
Ronnie please see below.
Kind regards
Sarah

From: Inverarity, Donald
Sent: 27 March 2019 11:20
To: Sutherland, SarahJane
Cc: Guthrie, Lindsay
Subject: RE: IPC SITE VISIT 20/03/19
Hi Sarah,
As part of this can you ensure that for all the isolation rooms in the new buidling that we are provided with details of the air pressures in the room and anteroom or corridor and ensure that there has been some assessment of air flows and pressures in the room and anteroom, particularly when doors are open.
I had been speaking to some of the ID consultants at QEUH and the Glasgow children's hospital yesterday and they explained that all their isolation rooms were being refitted as the original design didn't seem to provide appropriate pressures and air flows when the rooms were occupied.
Thanks
Donald

From: Sutherland, SarahJane
Sent: 25 March 2019 09:23
To: Mackenzie, Janice
Cc: McMahon, Alex; GORDON, David; Currie, Brian; Guthrie, Lindsay; Cameron, Fiona; Inverarity, Donald; Henderson, Ronnie
Subject: RE: IPC SITE VISIT 20/03/19
Good Morning Janice,
I will be over at RIE next week and wondered if any of the following dates/times would be suitable for us to meet to discuss a phasing plan for the Stage 4 HAI Scribe?.
Wed 3rd April anytime 1pm onwards
Thurs 4th April anytime after RHSC/DCN Commissioning meeting
Kind regards
Sarah

Sarah Jane Sutherland
Lead HAI Scribe Advisor
Infection Prevention and Control Team
NHS Lothian Infection Prevention & Control Services
[redacted]

For more information visit the IPCT
http://intranet.lothian.scot.nhs.uk/Directory/InfectionPreventionAndControl/Pages/NHSLothianInfectionPreventionandControl.aspx

From: Henderson, Ronnie
Sent: 21 March 2019 13:30
To: Inverarity, Donald
Cc: Mackenzie, Janice; McMahon, Alex; Sutherland, SarahJane; GORDON, David; Currie, Brian
Subject: IPC SITE VISIT 20/03/19

Hi Donald,

It was good to meet yesterday and have the opportunity to reassure and clarify how the project team are addressing concerns raised by IPC. As discussed I will produce a table of water sampling test results showing positive for Legionella and/or P.Aeruginosa. I am presently reviewing the certificates on the data management system to identify the relevant ones and I will get these to you as soon as possible but no later than Monday 25th March.

I have summarised the main points of discussion and evidence seen:

1. Attendees:
   Janice McKenzie(JM), Ronnie Henderson(RH), Alex McMahon(AM), Donald Inverarity(DI), Sarah Jane Sutherland(SJS), David Gordon(DG) (Bouygues)
2. Introduction:
   - JM/RH felt that the walkround had been arranged specifically to address concerns over water safety and ventilation issues post press articles about QEUH. DI had thought that the HAI SCRIBE handover audit was to take place.
   - DI expressed concern that this HAI SCRIBE audit had not taken place before handover
   - RH/JM explained that although handover had occurred there were still significant ongoing construction works affecting areas that would automatically result in a HAI SCRIBE failure in terms of NHSL being able to occupy the affected spaces clinically.
   - Theatre validation was discussed and DI agreed to forward report from St John's for reference
   - It was agreed that SJS/RH/JM carry out the desktop elements of the HAI SCRIBE audit and discuss phasing of the site visit elements to coincide with completion of site works. SJS to send JM her availability over next 2 weeks for a planning meeting to agree how this will be done
3. Water Safety Management:
   - RH explained the sampling process and current status of results and water management
   - The group visited the location of a known outstanding P. Aeruginosa positive and the implications were discussed
   - RH agreed to forward test results showing positives for Legionella and Pseudomonas as well as subsequent clear results and the area and clinical specialty affected
   - DG explained BYES approach and the next steps after they receive a clear set of results from MPX
4. Ventilation:
   - RH explained the commissioning and validation that had taken place for both isolation rooms and theatres and that records were available on the project data storage system
   - The group visited an isolation room, the theatre suite and a ventilation plantroom where RH and DG explained the ventilation philosophy for each area
   - The group visited external areas to view pest prevention measures and active measures to prevent ingress of pigeon droppings were demonstrated
   - RH explained that both isolation and theatre validation would be re done once construction works were completed
5. Outstanding issue from previous visit:
   - The group visited room 1-L1-068 where DI had identified an openable window in an isolation room. JM explained that this had been identified previously by the room review team and as demonstrated had now been resolved. DI was satisfied that this had been addressed.

If I have incorrectly interpreted anything or have missed something relevant, please get back to me and I will amend

Regards

Ronnie

Ronnie Henderson
Commissioning Manager Hard FM
RHSC & DCN - Little France
NHS Lothian
RHSC & DCN Site Office
Little France Crescent
Edinburgh
EH16 4TJ
[redacted]

NHS National Services Scotland

SHFN 30
Part B: HAI-SCRIBE

Implementation strategy and assessment process

Health Facilities Scotland
Engineering and Environment

October 2014

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Acknowledgements

Health Facilities Scotland would like to thank the SHFN30/HAI-SCRIBE Steering Group for their efforts in producing Part B of SHFN 30: HAI-SCRIBE. Their input has been gratefully appreciated.

Thanks are also due to the Pilot Study Group for their assistance with trialling the process.

Finally, HFS would take this opportunity to express gratitude to everyone who contributed to the consultation phase of completing this document.

Preface

Collaboration among Capital Planners, Infection Prevention & Control Teams, Clinical staff, Design Teams and Estates & Facilities Teams is the key to ensuring that infection control risks are highlighted, managed and mitigated.

Scrutiny of this guidance will highlight the frequent use of the word "Partnership". Successful use of HAI-SCRIBE requires participation and cooperation particularly between Estates & Facilities staff and Infection Prevention and Control Teams.

To manage or mitigate the risks highlighted through use of HAI-SCRIBE requires knowledge from many sources. However, it is not expected that any group will possess full knowledge or experience of another's discipline. It is expected, therefore, that there will be an ongoing liaison during each stage of development where appropriate specialist knowledge from all sources of relevant expertise can be derived and incorporated into the project briefing, contract conditions, specification, and quality control of construction and maintenance.

The principal stages of development of any healthcare facility comprise:

- consideration of the proposed site and relevant implications;
- design and planning;
- construction and refurbishment;
- ongoing maintenance.

Note: The Scottish Government's 2020 Vision is that by 2020 everyone should be able to live longer healthier lives at home, or in a homely setting. It states that when hospital treatment is required, and cannot be provided in a community setting, day case treatment will be the norm.

Good infection prevention and control to reduce the spread of infection is no less important in these community-based settings so an extension of this guidance to these settings, when appropriate, would appear to be a logical progression. However, there is a perception that conditions in community-based settings could potentially be less demanding than in an acute setting. Additionally, there is an awareness of the need to project a more homely environment. Despite these views, the need to minimise the risk of cross-infection is no less important in community health settings than in the acute sector, but other factors such as creation of a homely environment will need to be taken into consideration when managing the risks associated with the prevention and control of infection.

HAI-SCRIBE: a point of reference

This document introduces the main components of HAI-SCRIBE and identifies the steps required to ensure that HAI-SCRIBE is successfully utilised and implemented and that the assessment process is carried through.

Note: This document can provide an insight to the key factors within the built environment which can impact on prevention and control of infection. It is intended as a point of reference for healthcare estates and facilities managers, designers, project managers, contractors, engineers, surveyors, health planners and Infection Prevention and Control Teams working on healthcare estate new build and refurbishment projects. It will also be useful as a guide for best practice in existing healthcare facilities.

This guidance consists of two parts:

- **SHFN 30 Part A: Manual**: This provides Built Environment Infection Prevention and Control information for Design Teams, Construction Teams, Infection Prevention and Control Teams and Estates & Facilities Teams.
- **SHFN 30 Part B: HAI-SCRIBE:** comprises the Implementation and Assessment Process which describes the process for identifying, eliminating or managing built environment infection control risks. It also describes the key personnel involved in this process together with their roles and responsibilities and the fact that collaboration among all those involved in the process is pivotal to its success.

It is envisaged that participants will use the HAI-SCRIBE document (SHFN 30 Part B) to help them identify, manage and record built environment infection control risks. The same Group will use the Manual document (SHFN 30 Part A) on sourcing information to help in the decision making process so that identified risks can either be eliminated or successfully managed.

Questionsets and Proformas

Arrangements have been made to make available on the HFS Website, separately, the portfolio of Questionsets and Pro-formas for each stage of project development suitable for photocopying and application to individual projects as appropriate.

1. Setting the scene

Healthcare Associated Infection

1.1 Healthcare Associated Infection (HAI) is the term used to describe infections that occur as a result of medical care, or treatment, in any healthcare setting. It is seen as a widespread issue and the prevention and control of these infections is a priority issue for NHSScotland.

1.2 Infection originating or spread in hospitals and other healthcare facilities is recognised as a serious and widespread problem. Although standards of hygiene in healthcare facilities and standards of personal hygiene have been identified as potential sources of infection and infection spread, it can also be said that the design, planning, construction, refurbishment and ongoing maintenance of a healthcare facility also have an important role to play in the prevention and control of infection. For example, controls can be designed-in and risks designed-out such as extending wall storage units right up to ceiling level to avoid having the potential build up of dust on high level ledges that are difficult to clean.

The Challenge

1.3 Patients using healthcare facilities are more likely to be immuno-compromised and also more likely to receive intensive medical interventions, which in turn increase their vulnerability to opportunistic infections. Every effort must be taken to acknowledge and ultimately reduce these risks. This includes risks associated with the built environment that can arise from, for example, demolition, construction and refurbishment activities.

1.4 Research and investigation have consistently confirmed that the healthcare environment can be a reservoir for organisms with the potential for infecting patients, whether internally or from external sources (via openable windows or fresh air intakes). For HAIs to be reduced, it is imperative that Infection Prevention and Control (IPC) measures are “designed-in” and IPC risks are “designed-out” at the very outset of the planning and design stages of a healthcare facility and that input continues up to, into and beyond the final building stage. Inevitably, there will be residual risks which will require identification, registering and monitoring.

1.5 To achieve this, it is necessary that designers, architects, engineers, facilities managers and planners work in collaborative partnership with IPC teams, healthcare staff and the users to deliver facilities in which IPC needs have been anticipated, planned for and met.

Note: HAI-SCRIBE is an acronym for **H**ealthcare **A**ssociated **I**nfection **S**ystem (for) **C**ontrolling **R**isk **I**n the **B**uilt **E**nvironment. The procedure has been developed as a framework for these groups to work together to identify, manage and mitigate issues in the built environment impacting on infection prevention and control risks.

Throughout this document, the term 'Project Team' is referred to. The term describes the team of NHS Staff assembled to fulfil the role of 'The Client' and to manage the delivery of the project. Through the various stages of the project it may include NHS Project Managers, Clinicians, Estates Staff and Infection Prevention and Control specialists.

This would be best achieved with the establishment of a Project Team with HAI-SCRIBE procedures as part of their responsibilities. (The note box above and Paragraphs 1.8 and 2.1 to 2.4 also refer).

1.6 HAI-SCRIBE aims to ensure that IPC measures are not only designed-in but also maintained throughout the lifetime of the healthcare facility. It also aims to highlight potential IPC risks so that these can be designed-out. This is achieved through identifying the infection control risk associated throughout each of the following stages of lifecycle of the healthcare facility.

- Development Stage 1 - consideration of the initial brief and **proposed site for development.** This coincides with Business Case Stage: 1A**;**
- Development Stage 2 - **Design and planning;**
- Development Stage 3 - **Construction and refurbishment;**
- Development Stage 4 - **Pre-handover check, ongoing maintenance and feedback.**

(Many maintenance-related projects do not necessarily go through this approval process but the need for collaboration remains undiminished).

1.7 The purpose of HAI-SCRIBE is to provide a framework around which potential risks associated with the proposed site development, design and planning, construction/refurbishment and ongoing maintenance of Healthcare Facilities can be identified assessed and subsequently managed or mitigated.

1.8 To facilitate this and for ease of use the Implementation Strategy document is divided into three key parts which describe the activities associated with its use, namely;

Part A Assembling the Project Team with HAI-SCRIBE forming part of its responsibilities.

Part B Assessing the risk via use of Questionsets (1) – (4).

Part C Gathering the information to inform dialogue. NB: This is set out in the planning and design manual (SHFN 30, Part A) which accompanies this document.

Getting Started - preparation

1.9 It is important that the following procedures are followed:

- always consult the Estates & Facilities Management and Infection Prevention and Control Team at an early stage:
  - whenever refurbishment is planned;
  - whenever major capital bids are planned;
- do not wait until patients are ready to move in;
- do not wait until fixtures, fittings and furnishings have been purchased;
- do not let immediate cost or space consideration override reason or functional requirements;
- long-term value for money/risk reduction considerations should prevail.

Note: The best products or designs may be more expensive initially but in the long term they will probably realise cost benefits as they may prevent outbreaks. They may last longer, require less maintenance and be more durable.

Who should implement HAI-SCRIBE?

1.10 Successful use of HAI-SCRIBE is dependent on meaningful and ongoing dialogue and exchanges of information generated from representatives from Infection Prevention and Control and Estates & Facilities Managers, Project Managers and construction professionals who can contribute individual and relevant expertise in their own disciplines. Their active partnership and participation is essential. Similar dialogue is necessary when these parties are not involved, such as routine or periodic maintenance activities.

Note: NHS Boards' internal governance should identify who is responsible for implementing or taking ownership of HAI-SCRIBE procedures. These procedures may vary among NHS Boards. Typical NHS Board organisational structure is provided in Appendix 9.

1.11 It is recognised that the risks identified from the design process will be competing against other risks identified via other risk management processes. Consideration and prioritisation of all risks identified will have to take place.

1.12 Implementation of HAI-SCRIBE should be the responsibility of a specialist multi-disciplinary professional team who possess the necessary skills in relation to the healthcare facility being planned, designed, constructed, refurbished or maintained. The multi-factorial nature of projects and activities dictate the need for a multi-disciplinary team and include an array of both healthcare professionals and contractor personnel where appropriate to take ownership of relevant documents and risk assessments throughout each stage. It is essential, however, that all members of the assembled Team have a

background understanding of the principles of prevention and control of infection in the built healthcare environment for the specific project.

1.13 There are instances where the need to implement HAI-SCRIBE assessments will not be obvious (e.g. external works, offices, laboratories). Any decision to do so should be based on the impact any works would have on accommodation in the nearby area used for patient care.

1.14 The services of a member of administration staff will be helpful in providing administration support to members of the Project Team throughout the project.

1.15 Project Teams should not succumb to unacceptable pressures of time and financial expenditure that would compromise decision-taking and clinical outcomes. It is essential that proposals should be signed-off by the Project Team before any start on site.

1.16 It is essential that members of the Project Team including the Project Manager should be aware that externally funded projects have the potential to proceed without prior knowledge of Infection Prevention and Control specialists or representatives of Estates and Facilities department and Project Managers. This must not be allowed to happen.

Refurbishment issues

1.17 Implementation of HAI-SCRIBE is aimed at all personnel who may be involved in providing not only new build, but also refurbished or extended healthcare establishments.

Note: For the avoidance of any doubt, there is a clear demarcation between “redecoration” or “refreshing of accommodation” and “refurbishment”. The need for input from Infection Prevention and Control specialists should be verified when upgrading of facilities is limited to cosmetic attention as even in these circumstances attendant activities could generate risks from dust generation or disruption to air or water systems or switchgear.

1.18 Any of the following “refurbishment” activities would have the potential to generate dust. This is not an exhaustive list:

- removal of lay-in or screwed-in ceiling tiles from a suspended ceiling grid;
- unscrewing of service ducts access panels;
- unscrewing of panels forming part of integrated plumbing systems and general services concealment;
- removal of protective covers from radiators;
- lifting and replacement or repair of floor coverings;
- drilling masonry or plasterboard walls;
- replacement of door-sets;
- drilling through plasterboard partitions;

- replacement of sanitary fittings;
- removing or patching thermal insulation on pipes and ducts;
- raggling of plastered walls;
- general hammering;
- sanding and planing of surfaces;
- plasterwork, (new work, patching and repair);
- removal of redundant electrical socket outlets;
- dismantling luminaires;
- dismantling grilles and diffusers;
- inadequate sealing of ductwork serving adjacent areas during modifications;
- bagging and disposal of debris.

Note: Any premises constructed pre-2000 have the potential to contain asbestos as part of the fabric (e.g. thermal insulation, suspended ceiling tiles, thermo-plastic floor tiles, etc.) This would be confirmed in the NHS Board's Asbestos Management Plan where presence and condition of asbestos containing materials (ACMs) should be recorded.

1.19 Events such as the generation of dust or disruption to a facility's air or water system have the potential to spread micro-organisms. These could disperse, if not checked, into adjacent areas where patients may continue to be treated. It can be seen that advice from and liaison with Infection Prevention and Control specialists is essential under these circumstances whereas this would be less likely when work is restricted to redecoration. As individual circumstances could vary from site to site, all such work in or adjacent to patient treatment accommodation should be risk assessed and appropriate precautions implemented.

Note: Appendices 6 and 7 show in flow chart form, the procedures to be followed where demolition work or removal of fixed structures is involved where moderate or high levels of dust can be expected. Appendices 4 and 5 show the procedures for activities where little or no dust is generated.

1.20 Given that NHS procurement can be by Framework, Non-Profit Distribution (NPD) or HUB essentially to achieve a transfer of risk from public to private sector, it should be noted that its application to existing premises subject to refurbishment or alteration will entail risks that cannot be predicted with certainty. Therefore cost effectiveness will be difficult to predict.

1.21 Advances in technical and therapeutic methodologies are among the range of factors which present further challenges in relation to control of infection. Organisms with antimicrobial resistance have become a major public health threat, making infection occurring within healthcare premises increasingly difficult to treat. Infection originating in hospitals and other healthcare facilities

is now recognised as a serious and widespread problem. The physical environment has to assist, not hinder, good practice.

1.22 Routine maintenance should follow the NHS Board's Standard Operating Procedures (SOPs) for the various applications and departments. SOPs should in themselves be subject to risk assessments which may be iterative reflecting changes in parameters. NHS Boards have developed HAI-SCRIBE method statements for common, repetitive, activities which allow common tasks to be risk assessed and generic control measures put in place. Communication between Infection Prevention & Control and Estates staff when this process was being carried out is still necessary.

The neighbourhood environment

1.23 Neighbourhoods change whereby new or extended industries and commercial operations could have been developed since initial assessment of the site. The Capital Planning managers of the healthcare facility need to be alert to this as it may present a new HAI risk.

Record keeping

1.24 A detailed record of the initial application of HAI-SCRIBE and all subsequent applications and reviews must be kept in legible writing and be available for reference, retained in a central register and an audit trail maintained highlighting good and bad practice. The records of the applications of HAI-SCRIBE and the regular reviews of the system should be available for the appropriate management group of the healthcare facility. This may be the NHS Board's risk management steering group headed by the Chief Executive Officer which addresses risk management. However, this arrangement may vary from Board to Board. There should also be checks to ensure that control measures are being adhered to; these should also be recorded.

1.25 Internal governance should ensure that records are kept of out-of-hours working and any contractors involved. This should also identify who oversees the HAI-SCRIBE processes.

Works involving low risk

1.26 In attempting to differentiate between minor and major works in the context of applying the correct level of HAI-SCRIBE procedures, this will come down to the project's complexity or impact of activities, rather than size or extent. It is not always appropriate to follow the entire HAI-SCRIBE processes when dealing with small scale and minor works projects, Figure 1 on the following page comprises a decision-making tool for evaluating the extent of proposed activities and their impact. It might be helpful to maintain an ongoing log of activities. A typical exemplar for minor works is shown in Appendix 8.

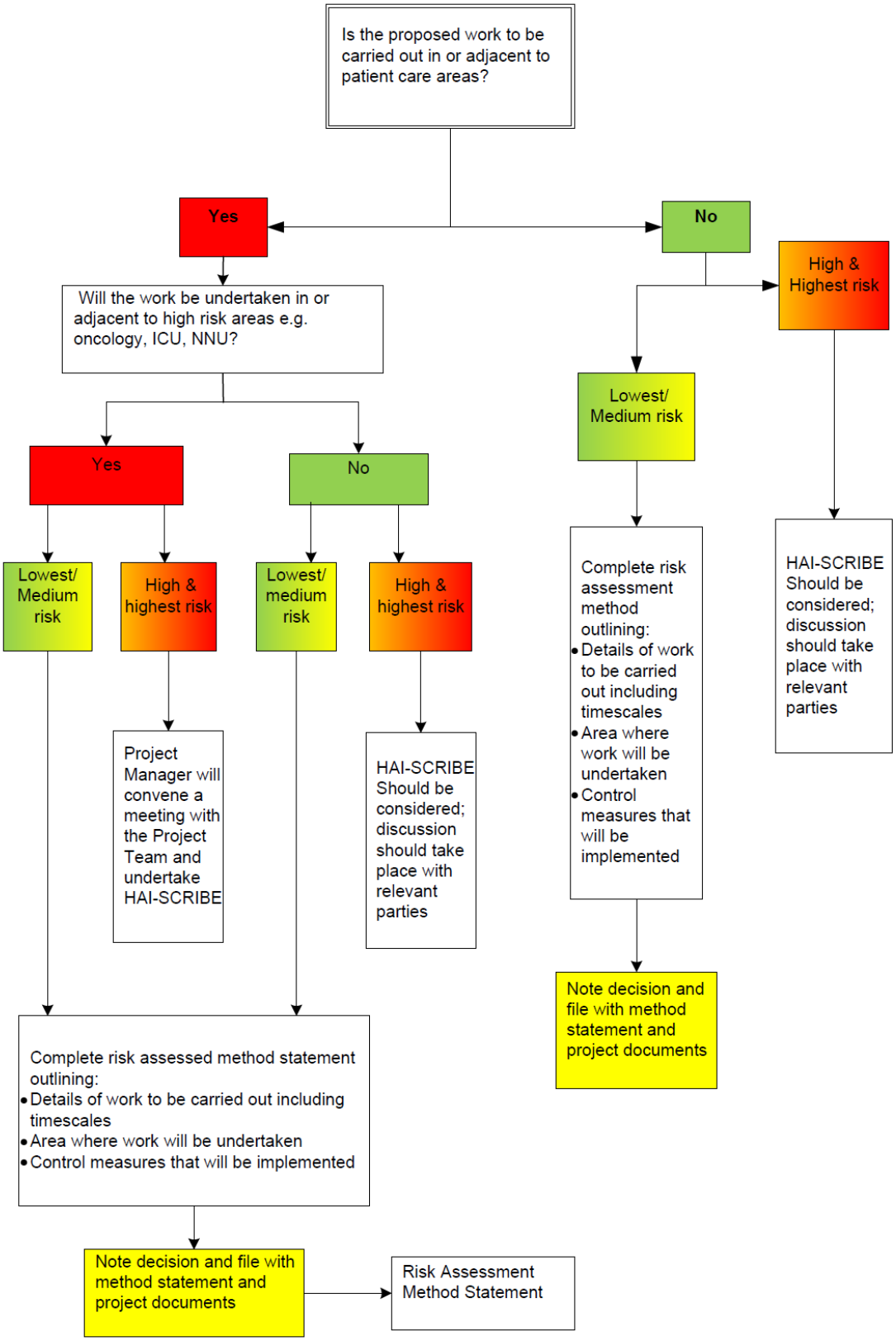


Figure 1: Decision-making tool for evaluating need for Minor Works and Small Repairs

Note: Consideration could be given to employing proformas such as contained in the following Appendices:

Appendix 1: Pre-start and construction proforma for particulars of project comprising a routine reporting procedure for submission to the Project Team before and during works setting out performance checks and assessment of hazards.

Appendix 2: Commissioning stage proforma comprising contract particulars setting out requirements prior to commissioning activities.

Appendix 3: Permit-to-work form comprising particulars, processes and criteria relative to the issue of Permits-to-Work, where required.

Appendix 4: Flow chart for work stages and procedures associated with minor works and small repairs in areas categorised as High, Medium and Low Risk.

Appendix 5: Ditto for small scale works.

Appendix 6: Ditto for works involving removal of fixed structures or where moderate to high levels of dust are generated.

Appendix 7: Ditto for major demolition and construction.

Appendix 8: Overview exemplar comprising typical monitoring spreadsheet for minor works.

Appendix 9: Gives an example of a Typical NHS Board organisational structure.

Appendix 10: Overview exemplar of a completed questionset.

1.27 Whatever risk designation is agreed, there will be a need for the NHS Board to re-visit the project prior to handover to verify that the brief has been completely fulfilled.

Note: Common maintenance tasks should be assessed and method statements produced setting out how to manage risks. There should be no need to reassess every time the same task is repeated unless parameters change such as working in a low risk patient group risk area and then in a high patient group risk area.

2. Part A

Assembling the Project Team

2.1 This part of the documentation sets out the responsibilities of all those involved in implementing HAI-SCRIBE and the processes to be employed in doing so.

Responsibilities in relation to HAI-SCRIBE

2.2 The successful implementation of HAI-SCRIBE requires input from a wide range of professionals including Managers, Facilities Staff, Planners, Infection Prevention and Control Staff and Clinical Staff. Overall responsibility for ensuring the implementation of HAI-SCRIBE is determined by the Development Stage as indicated in the following text. Some NHS Boards may wish to give responsibility to another project team member. In such instances it is important that the responsible person for each stage is named.

Development stage

- Stage 1: “Initial brief and Proposed site for development” - the responsible officer is the Project Owner/Sponsor;
- Stage 2: “Design and planning stage” - the responsible officer is the Project Manager;
- Stage 3: “Construction and refurbishment” - the responsible officer is the Project Manager;
- Stage 4: “Pre-handover check (carried out by the Project Team) and ongoing maintenance” (carried out by the Estates team).

2.3 For Capital Project and Refurbishment schemes, the Project Team will have been assembled already. HAI-SCRIBE implementation will be one of their responsibilities as part of ensuring that an accurate design brief is developed. Regular meetings and communication with stakeholders in the Team to discuss design, tendering, build and commissioning will ensure the facility is functionally suitable and fit for purpose. This will ensure that due attention is paid to prevention and control of infection risks for subsequent elimination or mitigation.

Who should lead?

2.4 The allocation of the lead role will be a function of the type, size and complexity of the project, its adjacency to sources of contamination (known or suspected), its proximity to other operational departments and the type of patients being treated. Priorities will vary depending on these issues. The principal role of the designated leader of the Project Team is to ensure that the most appropriate representation is achieved with specialist knowledge provided when it is required.

2.5 The following suggested activities and allocation of responsibilities are offered for guidance.

Project Owner/Sponsor

2.6 In ensuring that HAI-SCRIBE is completed for all major Development Stage 1 Projects, the Project Owner/Sponsor shall:

- identify an appropriate individual to lead the HAI-SCRIBE process;
- ensure that a formal risk assessment is undertaken by a designated clinical member of the Project Team in relation to the risk to patients for all construction activity. This is in addition to the HAI-SCRIBE Risk Assessment and should be recorded with an entry made in the risk register;
- ensure that the risk assessment includes the identification of "particularly at risk" patients and that designated clinical members of the Project Team will generate options for care. The rationale for deciding upon a course of action should be recorded and reviewed on a regular basis throughout the contract period;
- ensure that key personnel are involved in undertaking HAI-SCRIBE i.e. Infection Prevention and Control, Health & Safety and other specialist advisors as necessary. As a minimum at Stage 1, representatives from the Project Manager, Infection Prevention and Control, Health & Safety, Estates, Clinical Environment, Domestic Services and Fire Safety should be in attendance;
- ensure that HAI-SCRIBE documentation has been signed-off by key representatives involved in the process;
- ensure that the requirements identified by HAI-SCRIBE are incorporated into the contract documentation including a requirement that the contractor signs a specific statement relating to the implementation of HAI-SCRIBE and that it is adhered to during the project.

HAI-SCRIBE Project Manager

2.7 The main responsibilities of the Project Manager are:

- taking ownership of and leading the HAI-SCRIBE process;
- ensuring that HAI-SCRIBE is completed for all **Development Stage 2, 3 and 4** projects;
- identifying appropriate individuals to undertake the HAI-SCRIBE process;
- ensuring that a formal risk assessment is undertaken by a designated clinical member of the Project Team in relation to the risk to patients for all construction activity. This is in addition to the HAI-SCRIBE Risk Assessment and should be recorded with an entry made in the risk register;
- ensuring that value for money in capital and life cycle costs are taken into account;

- ensuring that the risk assessment includes identification of "particularly at risk" patients and that designated clinical members of the Project Team will generate options for care. The rationale for deciding upon a course of action should be recorded and reviewed on a regular basis throughout the contract period;
- ensuring that key personnel are involved in undertaking HAI-SCRIBE i.e. Infection Prevention and Control, Health & Safety and other specialist advisors as necessary. As a minimum at Stage 2 and 3, representatives from the Project Manager, Infection Prevention and Control, Health & Safety, Estates, Clinical, Environment, Domestic Services and Fire Safety should be in attendance. This applies to major projects;
- ensuring HAI-SCRIBE documentation has been signed-off by all key representatives involved in the process;
- ensuring that the requirements identified by HAI-SCRIBE are incorporated into the contract documentation, including a requirement that the contractor signs a specific statement relating to the implementation of HAI-SCRIBE and that it is adhered to during the project;
- ensuring that systems are in place to monitor contractors' compliance throughout the duration of the project, including documented evidence of compliance with agreed monitoring arrangements;
- exercising authority to stop work if there is a breach of any infection control preventive measures during construction or refurbishment;
- reporting any issues on the risk management system (e.g. Datix) from ongoing activity that may affect HAI-SCRIBE and require re-assessment. Datix investigation must clearly identify causes and assurance that these will then be managed accordingly;
- ensuring that the HAI-SCRIBE assessment is reviewed should there be any significant changes to the management of the project;
- keeping a record of the initial application of HAI-SCRIBE and all subsequent applications and reviews for reference in a central register.

Estates/Facilities Manager/Maintenance (Soft FM and Hard FM)

2.8 The above responsibilities undertaken by the Project Manager include involvement of the Project Team in the HAI-SCRIBE process. This will include full briefing of the Estates Manager. Where no Project Manager is appointed the person authorising the work will assume the main responsibilities.

The Estates/Facilities Manager must also keep the Project Team up-to-date on new projects where the project work itself potentially increases the risk of HAI as determined by the Infection Prevention and Control Risk Assessment for the Project as specified in HAI-SCRIBE.

- Other responsibilities of the Estates/Facilities Manager:
  - **Partnership Working** with the Infection Prevention and Control specialists and other members of the Project Team and designers;

- **Communication** with the Infection Prevention and Control specialists to keep everyone up to date on all new projects where the work potentially increases the risk of HAI;
- **Safe methods of working** - ensuring that all visiting contractors work safely in the existing healthcare environment.

Note: 'Turnkey' procurement arrangements occur where the supplier carries out everything for the project and enables the user to "turn the key". This kind of arrangement would apply for, say, a supplier of an X-ray machine who would be handed a 'stripped-out space' in which they would fit out an X-ray room with power, lighting and other services from identified interface points on the services installations, provide and install floor coverings, wall panels and ceilings, connect up and commission the room, the machine and all the supply systems before handover to the user with manuals etc. Typical applications would comprise MRI installations, CT Scanners, Linear Accelerators and other large pieces of specialist equipment such as Sterilisers, etc.

Infection Prevention and Control

2.9 The main responsibilities of Infection Prevention and Control specialists are:

- advising the Project Team on the principles of infection prevention and control of infection as applied to the built environment;
- contributing to risk assessment and providing advice on infection risk to susceptible patients;
- contributing to advice and guidance on control measures to be implemented;
- advising Project Manager/Estates Manager as to the need to stop work where infection prevention and control measures have not been adequately implemented or have failed;
- providing education on infection prevention and control measures to relevant staff involved in the project where required;
- determining with the Project Team and Health & Safety representatives a suitable and sufficient dust monitoring methodology for each project;
- assisting in the review of all HAI-SCRIBE assessments within agreed timescale.

Health and Safety

2.10 The main responsibilities of Health & Safety representatives are:

- advising the Project Team on the principles of risk assessment as applied to the built environment;
- contributing to the risk assessment process and providing advice and guidance on control measures to be implemented;

- inspecting the construction site in order to evaluate on-site health and safety competence of contractors employed where the risk has been determined as significant;
- advising the Project Manager/Estates Manager of the need to stop work where health and safety measures have not been adequately implemented or have failed;
- providing education on health and safety risk management and control measures to relevant staff involved in the project where required;
- contributing to and understanding the roles of the various members of the Project Team;
- assisting in the review of all HAI-SCRIBE assessments within agreed timescales.

Note: To ensure compliance with HAI-SCRIBE procedures during the construction/refurbishment phase it is recommended that a Supervising Officer is designated by the NHS Board with the remit of recording deviations, liaising with Infection Prevention and Control Specialists and given delegated authority immediately to stop work or advise the Project Manager of the need to do so until remediation has been satisfactorily completed, this may be the Project Supervisor.

Lead Consultant/Architect (if appointed)

(NB: Parts of these responsibilities can be undertaken by the Project Manager)

2.11 The main responsibilities of the Lead Consultant/Architect/Design Team are:

- facilitating partnership working with the Infection Prevention and Control specialists, Estates and Facilities Managers and other members of the Project Team;
- ensuring outcomes of HAI-SCRIBE are incorporated into the design of the building;
- ensuring design enhances the prevention and control of infection;
- ensuring that materials utilised are suitable and enhance the prevention and control of infection;
- ensuring compliance with professional standards, NHS guidance and statutory regulations in development and design;
- maintaining up to date knowledge and understanding of infection prevention and control principles.

Note: The Lead Consultant and Design Team should consider the views of all relevant healthcare personnel into the final design of the new healthcare facility. In addition, the timescale involved to plan a new healthcare build or refurbish an existing establishment can vary from a short period of a few months in the case of a small refurbishment to as long as three or four years for a major capital project.

It is important that Infection Prevention and Control teams are notified of potential projects or contracts awarded, at the earliest possible opportunity. This applies irrespective of the form of contract adopted or whether in-house facilities or consultant or contractor design teams are employed.

Every consideration should be given to the quality of composition of the Design Team. Selection of Design Teams entirely, or primarily, on cost is contrary to public sector procurement requirements which demand a best-value approach. Architects and Designers for healthcare projects must be suitably experienced in terms of their knowledge and understanding of prevention and control of infection**.** Deficiencies in knowledge of or experience with HAI-SCRIBE will be informed by interview and should be determined during the pre-qualification stages *prior to appointment*. In Non Profit Distribution (NPD), HUB and Framework Projects the appointment of designers is through the Contractor team. It is therefore essential that those responsible for appointments are acquainted as to these issues and that the NHS Board takes account of the Contractor's selected designers and their relationship with and attitude towards them.

Lead Contractor/Contractors

2.12 The main responsibilities of the Contractor, under this guidance, are:

- coordinating and advising the Infection Prevention & Control Team to assist in identifying potential risks and control measures prior to and during construction;
- incorporating and coordinating above in pre-construction H&S Plan and construction method statements to enable safe working during works;
- regular monitoring of risks, control measures and documentation; updating as project develops to ensure continuous safe working during and after works.

The above may also include post-completion works, e.g. snagging and latent defects.

Note: The Lead Contractor is the representative of the team responsible for delivering the works. In most cases this is also the 'Principal Contractor' as defined in the Construction (Design and Management) Regulations 2007. This requires a Principal Contractor and a CDM Co-ordinator to be appointed if a project is notifiable. Construction is notifiable if it lasts more than 30 working days or involves more than 500 person-days (for example 50 people working over ten days). In smaller projects, this may be the site manager of the firm contracted to deliver the works. The works may include construction, demolition, repairs and /or maintenance.

NB**:** The role of CDM Co-ordinator is currently under review by the Health & Safety Executive.

Domestic Services Manager/Soft Facilities Manager

2.13 The main responsibilities of the Domestic Manager are:

- ensuring that staff are monitoring dust levels and advising when increases in dust levels occur;
- advising on any additional cleaning requirements required, either within the area in which the work is being undertaken or adjacent areas;
- advising on cleaning required from contractors on completion of work and prior to hand over;
- advising on and ensuring that cleaning required from domestic services is undertaken after handover and before the area is put into use.

Departmental Representatives

2.14 Key healthcare staff, currently working in relevant wards and/or departments, should be involved in the project from the earliest opportunity to ensure that the needs of patients and staff are taken into consideration when planning the new or refurbished facility.

- Main responsibilities of the Ward/Departmental representatives:
  - **Partnership Working** with the Infection Prevention and Control specialists and other members of the Project Team;
  - **Patient safety** - awareness of the patient population and the potential health risks that may occur during a project;
  - **Special precautions** - require to be identified to mitigate risks for specific patient groups e.g. patients who are immuno-compromised or who have underlying medical conditions;
  - **Fit for Purpose** - advice on the new facility being functionally suitable for healthcare delivery and patient use.

Note: The required input from the various representatives will be at varying levels dependent on the type of accommodation being provided and during various stages of design development and construction.

Minimising infection risks

2.15 A variety of measures will contribute to the prevention and control of infection. However, despite every best effort, not all infections are preventable. Resources must be directed towards minimising the risk where infection can be prevented and facility design plays an important role in achieving this. HAI-SCRIBE can be applied to other operational areas of NHSScotland.

2.16 There are three key steps involved in HAI-SCRIBE:

- identifying the hazard;
- assessing the risk from the identified hazard;
- managing the risk to eliminate or minimise its impact.

2.17 The application of these three key steps of HAI-SCRIBE is aided by a range of questions set out in Section 3 which are appropriate for particular development stages of the healthcare facility.

Note: Care needs to be taken to ensure that the System does not solely become a mechanical 'box-ticking' exercise, but rather a rigorous questioning and auditing of proposals and of operating facilities.

2.18 In assessing the risk from the identified hazards, and in determining how to manage the risk to eliminate or minimise its impact, the nature of exposed population is a critical consideration.

2.19 In most cases there will be no option but to manage the risk to eliminate or minimise its impact. Health economics will inevitably be applied by the management of the healthcare facility in circumstances where there are several competing bids for resources and where those with an infection risk have a number of options suggested for the management of the risk. In such cases, the assessment of risk and the measures necessary to manage the risk must be evaluated carefully as part of the health economics decision-making.

2.20 This dedicated Project Team should be representative of the appropriate specialists but small enough in number to ensure effective decision-making.

2.21 Implementation of HAI-SCRIBE requires an accurate record of the process of hazard assessment and risk management which is essential 'due diligence' information.

2.22 Records of the applications of HAI-SCRIBE and the regular reviews of the System should be reported to the Project Manager of ongoing work.

2.23 In circumstances where HAI-SCRIBE is being applied to the site for a proposed development, design and planning, or the construction of a new- build

healthcare facility, the Project Board needs to be advised of the outcome. In cases where it is being applied to the refurbishment or operational management of an existing healthcare facility, the organisation's risk management steering group should be advised of the outcome of the HAI-SCRIBE applications on an annual basis.

Summarising

2.24 The following questions should be answered:

- have all members of the multi-disciplinary Project Team been identified?
- has it been confirmed that all members of the Project Team have background knowledge and access to specialist knowledge in infection prevention and control?
- has a person been identified who will lead on HAI-SCRIBE assessments?
- have full telephone and e-mail contact details been obtained to confirm full commitment and availability to participate in the project?

Note: Do not proceed to the questionsets within the next Step until you can answer "**Yes**" to the above questions.

3. Part B

Assessing the risk via use of Questionsets

3.1 The assessment process has been developed into a series of questionsets for each of the four stages of development. It will be noted that, although the framework and process for each stage is broadly similar, the construction and refurbishment stage poses particular problems arising from dust and other pollutants which could potentially impact on nearby facilities for ongoing patient care. Much of the content of the questionsets for the post-construction stage will refer to decisions already taken but should be revisited to allow responses to verify that they were correctly implemented and maintained in optimum condition.

3.2 The various questionsets forming part of the assessment process are set out for self-assessment. All questions in each of the Development Stages of HAI-SCRIBE should be answered.

Note: It is expected that many of the questions will have a 'Yes' response but the process should not be regarded as a 'box ticking' exercise.

3.3 Each "Yes" or "No" answer should be backed up with additional written information relevant to the particular question, as some questions may require further consideration. Such information will be useful for reference at different stages of a new build project. (A worked example of a Development Stage 1 Questionset is contained in Appendix 10).

3.4 For example, if answering 'Yes' to the following question at Development Stage 1:

"Are there industries or other sources in the neighbourhood which may present a risk of noise, other pollution or infection e.g. animal by-products processing plant?"

It is necessary to describe fully what these 'industries' or 'other sources' are.

Similarly, if answering 'Yes' to:

"Will lack of space limit the proposed development and future expansion of the facility?"

It is necessary to describe fully what the "limitations" are and what actions need to be taken to eliminate or minimise the risk they pose together with who is responsible for ensuring that the actions are carried out.

Situations can arise when a decision related to managing risk cannot be taken in a satisfactory or compliant manner. When this happens the issue should be recorded and escalated to a higher authority.

Detailed assessments

Note: The following section comprises the questionsets that should be scored for each of first two Stages of development of projects from inception to ongoing use. They follow basically the same format except that the Questionset covering construction and refurbishment involving dust and pollutants arising from construction and refurbishment activities sets out additional risks to be assessed and managed. The Questionset for ongoing use etc. covers similar ground to Questionset applicable at the design and planning stage in that the latter reflects decisions taken in the former and should be seen as a checklist.

Questionset for Initial brief and proposed site for development

3.5 The initial application of HAI-SCRIBE examines the intended brief and site for the new build healthcare facility.

3.6 If any actual or potential hazards are identified during this initial stage, it is important that a full risk assessment is carried out to identify the nature of the risk. If risks are highlighted, remedial measures need to be identified in order that systems and processes can be designed into the project plans so that the impact of the risk can either be eliminated or its impact reduced.

3.7 The risks and the remedial actions should be clearly documented.

Constraints of developing on a pre-determined brief or site

3.8 In some cases the brief is driven by outside factors or there is no choice in the use of a particular site and steps must be taken to minimise any inherent adverse issues encountered. These would include a lack of space limiting the proposed development and any future expansion or reconfiguration of the facility (e.g. to increase single room provision). This might potentially create or increase the risk of infection.

(Further information is set out in greater detail in the Manual (SHFN 30 Part A) of this document).

3.9 The questionsets do not necessarily comprise an exhaustive list of points that need to be considered.

3.10 Where a potential hazard is identified a careful assessment of that hazard must be undertaken. Some hazards may present a risk of pollution rather than direct infection but the consequences for the healthcare facility may be to keep windows and ventilation intakes closed and this, in turn, may increase the risk of HAI in the healthcare facility. Solving one problem can lead to another and clinical outcomes should themselves be risk assessed. It may be necessary, therefore, to seek further information as part of the assessment of the hazard and this may include questions about:

- the extent of the dust, noise, smell and other pollution;
- the hours of operation;

- the volume of traffic;
- the kind of materials being handled and processed;
- the volumes of materials being handled and processed;
- the time/frequency of deliveries and traffic movement volume;
- the deliveries being in closed or open containers;
- the transfer arrangements from delivery vehicles to storage/processing facilities;
- the exhaust flues from the processing plant;
- the prevailing wind direction;
- the areas of the healthcare development most likely to be affected;
- the measures which could be designed into the proposed healthcare development to eliminate or minimise the impact of the pollution and if these measures might increase the risk of HAI.

3.11 Other existing industries in the area of the proposed healthcare facility development may present a more obvious and direct risk of bacterial or fungal infection e.g. any cooling towers posing a potential *Legionella* risk, and/or any demolition or construction work posing a fungal infection risk. The assessment must take account of the source of the potential risk, its relationship to the healthcare facility and particular areas of the healthcare facility, the exposed population, and the measures which are available to the healthcare facility to reduce the impact of the infection risk. Consideration should also be given to infection risks at outpatient departments within the healthcare facility and access to the facility and outpatient departments.

In considering whether a site presents a potential HAI hazard, the following questions should be examined. In signing-off or initialling resolution of issues, it is necessary also to print the name of the individual completing the responses.

Note: Records of cooling towers in the vicinity of the NHS premises will be held by the Local Authority if not the NHS Board's own public health department with whom consultation should take place in assessing the locality.

Risk assessments require to be kept up to date and amended as and when new circumstances/issues come to light both in surrounding premises and on site.

Initial brief and proposed site for development HAI – SCRIBE Sign off		
HAI-SCRIBE Name of Project		
Name of Establishment		National allocated number
HAI-SCRIBE Review Team		
Completed By (Print Name)		Date
Signature(s)		Date
Stage 1:		
Additional Notes:		

Note: Advice may be required from specialists on issues such land engineering, etc.

Development stage 1: Initial brief and proposed site for development

Some Hazards in the surrounding areas may present a risk of pollution rather than direct infection with the control measures for the healthcare facility to keep windows and ventilation intakes closed however. However, this may increase the risk of HAI in the healthcare facility. It may be necessary to seek further information as part of the assessment of the hazard. Potential hazards from adjacent sites may include:

- the extent of the dust, noise, smell and other pollution;
- the risk of bacterial or fungal infection from existing industries in the area which may be present e.g. cooling towers and/or demolition or construction works;
- the hours of operation;
- the volume of traffic;
- the kind of materials being handled and processed;
- the volumes of materials being handled and processed;
- the time/frequency of deliveries and site traffic movement volume;
- the deliveries being in closed or open containers;
- the transfer arrangements from delivery vehicles to storage/processing facilities;
- the exhaust flues from the processing plant;
- the prevailing wind direction;
- the areas of the healthcare development most likely to be affected;
- the measures which could be designed into the proposed healthcare development to eliminate or minimise the impact of the pollution and if these measures might increase the risk of HAI;
- risk of flooding;
- asbestos in any existing buildings;
- proximity of rivers or streams;
- previous use of site, greenfield/brownfield site;
- land contamination;
- potentially polluting activities during periods of high rainfall.

Initial Brief and proposed Site for development identification of hazards, associated risks and control measures		
1.a	Brief description of the proposed development project and the planned development site.	
1.b	Identify any potential hazards associated with the design and/or proposed site.	
1.c	Identify any risk associated with the hazards above.	
1.d	Outline the control measures that require to be implemented to eliminate or mitigate the identified risks. Ensure these are entered on the project risk register.	
	Control Measures.	
1.e	It has been recognised that control measures identified to address the project risk may have unintended consequences e.g. closure of windows can lead to increased temperatures in some areas. Such issues should be considered at this point, they should be noted and action to address these taken.	
	Potential Problems.	
	Control Measures.	
1.f	Actions to be addressed.	
By		Deadline

Initial Brief and proposed site for development, development stage 1: checklist to ensure all aspects have been addressed		
1.1	Is contaminated land an issue? e.g. asbestos, oils and heavy metals. (Refer to the Contaminated Land Register) Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.2	Is there a locally recognised increased risk of contamination or infection e.g. cryptosporidium? If yes give details. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.3	Are there industries or other sources in the neighbourhood which may present a risk of infection or pollution e.g. animal by-products processing plant? If yes give details. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.4	If there are any industries or other sources identified in question 1.3 above, will they affect the designed operation of the healthcare system? Consider the planned function of the design as well as issues such as: Ventilation Opening of doors and windows Water systems etc. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		

Initial Brief and proposed site for development, development stage 1: checklist to ensure all aspects have been addressed continued		
1.5	Are there construction/demolition works programmed in the neighbourhood which may present a risk of pollution or infection (including fungal infection)? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.6	Are there cooling towers in the neighbourhood which may present a risk of *Legionella* infection? Consider also air handling units, water pipes etc. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.7	Does the topography of the site in relation to the surrounding area and the prevailing wind direction present any HAI risk e.g. from entrainment of plumes containing *Legionella*? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.9	Will the proposed development impact on the surrounding area in any way which may present potential for infection risk? Consider possible restrictions being applied to the operation of the proposed facility e.g. Facilities Management routes. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		

Initial Brief and proposed site for development, development stage 1: checklist to ensure all aspects have been addressed continued		
1.10	Will lack of space limit the proposed development and any future expansion or change of use of the facility? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.11	Has a demolition/refurbishment asbestos survey been carried out? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
1.12	Has consideration been given to the projected lifespan of the facility and its impact on planning and development?	Yes ☐ No ☐ N/A ☐
Comments		
Additional notes - Stage 1		

Development Stage 1: HAI-SCRIBE applied to the initial brief and proposed site for development			
Certification that the following documents have been accessed and the contents discussed and addressed at the Infection Control and Patient Protection Meeting held on.			
Venue		Date	
'Healthcare Associated Infection System for Controlling Risk in the Built Environment' *'HAI-SCRIBE' Implementation Strategy: Scottish Health Facilities Note (SHFN) 30: Part B*			
Declaration: We hereby certify that we have co-operated in the application of and where applicable to the aforesaid documentation.			
Present			
Print name	Signature	Company	Telephone Numbers	Email address

Questionset for design and planning stage

Note: The application of HAI-SCRIBE is essential in the detailed planning and design of a new healthcare facility or a major redevelopment, refurbishment or extension of an existing healthcare facility. It is at the planning and design stage that hazards associated with potential HAI risk should be identified and assessed and measures taken to manage the risks. It is sensible to 'design-in' at this stage, measures which will eliminate or minimise the impact of identified hazards and effectively manage the HAI risk. It is also essential to ensure that the appropriate guidance as applicable in Scotland is being followed.

3.12 HAI-SCRIBE, as applied to healthcare facility plans and designs, will involve a systematic and thorough review of the plans with a view to identifying and assessing potential hazards and managing the risks by eliminating or minimising their impact. This may well involve amendments to plans, bearing in mind that it is likely to be more cost effective to achieve the management of HAI risk at the planning stage rather than after physical completion.

3.13 Issues to be considered include the following:

- while the introduction of people to a healthcare facility immediately introduces challenges in terms of managing infection risk, the design and layout of the healthcare facility should discourage the spread of infection;
- the design and layout of the healthcare facility should take account of the proposed healthcare procedures and services and the appropriate management of risk required for the range of population groups.

3.14 Issues to be considered at the design and planning stage of the development will include:

- an overall assessment of infection and infection spread risk from the design and layout of the healthcare facility;
- an assessment of infection risk from detailed engineering and building features. Further issues to be considered at this stage might include those set out below.

Logistics

3.15 The design of the healthcare facility must realistically consider the logistics of a functioning facility. It is essential that systems are in place which will reduce the risk of spread of infection and resources and personnel are managed so they do not contribute to the risk of infection.

3.16 Examples of logistical issues to consider include:

- the delivery and distribution of materials and people via connecting corridors and lifts;
- the collection, transportation and storage pending removal or management of waste materials;

- clinical workflows.

3.17 These issues require careful planning and design which recognise the potential for infection spread through the mismanagement of such issues.

3.18 Initial planning and design in new builds need to consider:

- numbers of beds;
- provision of single bed rooms (paragraphs 4.14 and 4.15 in SHFN 30 Part A (Manual)) refer;
- appropriate space required between beds;
- design, accessibility and space in patient areas;
- access to equipment around the bed;
- access for staff to hand hygiene facilities;
- sufficient space for equipment (e.g. hoists);
- sanitary facilities and showers/bathrooms for easy access, convenience and independence where possible;
- sufficient space for activities to take place and to avoid transmission of organisms either by air or by contact with blood, body fluid or equipment.

3.19 Particular aspects for consideration include:

- patient groups;
- transmission of micro-organisms:
  - avoiding cross-infection;
  - the environment and its role in cross infection;
  - shared equipment;
  - movement of patients.
- management of patients:
  - clinical pressures;
  - best use of single rooms;
  - avoiding unnecessary movement of patients between areas.
- implications of choosing natural ventilation;
- optional forms of heat emitters;
- provision and pattern of sanitary fitting and types of taps;
- concealment of pipes and ducts;
- importance of maintenance;
- access for maintenance.

3.20 HAI-SCRIBE, as applied to healthcare facility plans and designs, will involve a systematic and thorough review of the plans with a view to identifying and assessing potential hazards and managing the risks by eliminating or minimising their impact. This may well involve amendments to plans, bearing in mind that it is likely to be more cost effective to achieve the management of HAI risk at the planning stage rather than after physical completion.

3.21 The design and layout of the facility should take account of the proposed healthcare procedures and services and the appropriate management of risk required for the range of population groups.

3.22 Reference should also be made to the Questionset applied to the built healthcare facility in operation for more detail of the issues to be addressed in relation to:

- finishes and floors, walls, ceilings, ceiling voids, doors, windows, fixtures and fittings;
- space around beds;
- isolation rooms;
- provision of hand-wash basins, liquid soap dispensers, paper towels and alcohol-based hand rub dispensers;
- provision of sinks for decontamination purposes;
- engineering services;
- storage;
- laundry and linen services;
- spaces for large pieces of equipment;
- disposal of healthcare and food waste.

Development stage 2: Design and planning		
HAI-SCRIBE Name of Project		
Name of Establishment		National allocated number
HAI-SCRIBE Review Team		
HAI – SCRIBE **Sign Off**		
Completed by (Print name)		Date
Signature(s)		Date
Stage 2		
Additional notes		

Development Stage 2: HAI-SCRIBE applied to the design and planning stage of the development

Issues to be considered at the design and planning stage of the development will include an overall assessment of the project and any infection spread risk from the design and layout of the facility. An assessment of infection risk from detailed engineering and building features should also be undertaken.

Issues to be considered include (but are not limited to) the following:

- the design and layout of the healthcare facility should inhibit the spread of infection;
- the design and layout of the healthcare facility should take account of the healthcare procedures and services to be provided and the appropriate management of risk required for the range of population groups (refer to Table 2) verification of work carried out);
- finishes and floors, walls, ceilings, doors, windows, fixtures and fittings;
- space around beds;
- isolation rooms;
- provision of hand-wash basins, liquid soap dispensers, paper towel and alcohol hand rub dispensers;
- provision of sinks for decontamination purposes;
- engineering services;
- storage facilities;
- laundry and linen services.

Note: It should be noted that this document can be used for clinical and non clinical areas and some of the questions in the checklist may not apply e.g. building external plant rooms, car parking facilities. In these cases other issues may require to be addressed and the project team should consider these. All additional information should be added to the appropriate section of this document.

Design and Planning: checklist to ensure all aspects have been addressed		
2.a	Brief description of the work being undertaken.	
2.b	Identify any potential hazards associated with this work.	
2.c	Identify any risk associated with the hazards identified above.	
2.d	Outline the control measures that require to be implemented to eliminate or mitigate the identified risks. Ensure these are entered on the project risk register.	
	Control Measures.	
2.e	It has been recognised that control measures identified to address the project risk may have unintended consequences e.g. closure of windows can lead to increased temperatures in some areas. Such issues should be considered at this point, they should be noted and action to address these taken.	
	Potential Problems.	
	Control Measures.	
2.f	Actions to be addressed.	
By		Deadline

General overview		
2.1	In order to minimise the risk of HAI contamination is there separation of dirty areas from clean areas? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
2.2	Are the food preparation areas (including ward kitchens) and distribution systems fit for purpose and complying with current food safety and hygiene standards? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
2.3	Are waste management facilities and systems robust and fit for purpose and in compliance with the Waste (Scotland) Regulations? Consider: Local and central storage Systems for handling and compaction of waste Systems for segregation and security of waste (especially waste generated from healthcare requiring specialist treatment/disposal) to avoid mixing with other waste and recyclates. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		

General overview continued		
2.4	Are there satisfactory arrangements for effective management of laundry facilities? Consider: Local and central storage Systems for movement of laundry to central storage Systems for handling laundry Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
2.5	Are there sufficient facilities and space for the cleaning and storage of equipment used by hotel services staff? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
2.6	Are staff changing and showering facilities suitably sited and readily accessible for use, particularly in the event of contamination incidents? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
2.7	Is the space around beds for inpatients, day case and recovery spaces in accordance with current relevant NHSScotland guidance?	Yes ☐ No ☐ N/A ☐
Comments		

General overview continued		
2.8	Are there sufficient single rooms to accommodate patients known to be an infection or potential infection risk?	Yes ☐ No ☐ N/A ☐
Comments		
2.9	Are all surfaces, fittings, fixtures and furnishings designed for easy cleaning?	Yes ☐ No ☐ N/A ☐
Comments		
2.10	Are soft furnishings covered in an impervious material in all clinical and associated areas, and are curtains able to withstand washing at disinfection temperatures?	Yes ☐ No ☐ N/A ☐
Comments		
2.11 P	Is the bathroom/shower/toilet accommodation sufficient and conveniently accessible, with toilet facilities no more than 12m from the bed area?	Yes ☐ No ☐ N/A ☐
Comments		
2.12 D	Are the bathroom/shower/toilet facilities easy to clean?	Yes ☐ No ☐ N/A ☐
Comments		
2.13	Where required are there sufficient en-suite single rooms with negative/positive pressure ventilation to minimise risk of infection spread from patients who are a known or potential infection risk?	Yes ☐ No ☐ N/A ☐
Comments		

NB: In the above and following Table “D” refers to “Design” and “P” refers to “Planning”.

Provision of hand-wash basins, liquid soap dispensers, paper towels and alcohol rub dispensers		
2.14	Does each single room have clinical hand-wash basin, liquid soap dispenser, paper towels, and alcohol rub dispenser in addition to the hand-wash basin in the en-suite facility?	Yes ☐ No ☐ N/A ☐
Comments		
2.15	Do intensive care and high dependency units have sufficient clinical hand-wash basins, liquid soap dispensers, paper towels, and alcohol rub dispensers conveniently accessible to ensure the practice of good hand hygiene? An assessment should be made, however, to ensure that there is not an over-provision of hand-wash basins resulting in under-use.	Yes ☐ No ☐ N/A ☐
Comments		
2.16	Is there provision of clinical l hand-wash basins, liquid soap dispensers, paper towels, and alcohol rub dispensers in lower dependency settings like mental health units, acute, elderly and long term care settings appropriate to the situation with a ratio of 1 basin/dispenser to 4–6 beds?	Yes ☐ No ☐ N/A ☐
Comments		
2.17	Do out-patient areas and primary care settings have a clinical hand-wash basin close to where clinical procedures are carried out?	Yes ☐ No ☐ N/A ☐
Comments		
2.18	Do all toilets have a hand-wash basin, liquid soap dispenser and paper towels?	Yes ☐ No ☐ N/A ☐
Comments		
2.19	Are all clinical hand-wash basins exclusively for hand hygiene purposes?	Yes ☐ No ☐ N/A ☐
Comments		

Provision of hand-wash basins, liquid soap dispensers, paper towels and alcohol rub dispensers continued		
2.20	Does each clinical hand-wash basin have wall mounted liquid soap dispenser, paper towel dispenser?	Yes ☐ No ☐ N/A ☐
Comments		
2.21 D	Does each clinical hand-wash basin satisfy the requirement not to be fitted with a plug?	Yes ☐ No ☐ N/A ☐
Comments		
2.22 D	Are elbow-operated or other non-touch mixer taps provided in clinical areas?	Yes ☐ No ☐ N/A ☐
Comments		
2.23 D	Does each hand-wash basin have a waterproof splash back surface?	Yes ☐ No ☐ N/A ☐
Comments		
2.24 D	Is each hand-wash basin provided with an appropriate waste bin for used hand towels?	Yes ☐ No ☐ N/A ☐
Comments		

Provision of facilities for Decontamination LDU		
2.25 D	Are separate, appropriately sized sinks provided locally, where required, for decontamination? (The sinks should be large enough to immerse the largest piece of equipment and there should be twin sinks, one for washing and one for rinsing. A clinical hand-wash basin should be provided close to the twin sinks).	Yes ☐ No ☐ N/A ☐
Comments		
2.26 P	Are appropriate decontamination facilities provided centrally for sterilisation of specialist equipment?	Yes ☐ No ☐ N/A ☐
Comments		
2.27 P	Is there adequate provision in terms of transport, storage, etc. to ensure separation of clean and used equipment and to prevent any risk of contamination of cleaned equipment?	Yes ☐ No ☐ N/A ☐
Comments		
2.28 P	Does the system in operation comply with the current guidance on decontamination facilities and procedures?	Yes ☐ No ☐ N/A ☐
Comments		

Storage		
2.29 P	Is there suitable and sufficient storage provided in each area of the healthcare facility for the following if required patients' clothes and possessions, domestic cleaning equipment and laundry, large pieces of equipment e.g. beds, mattresses, hoists, wheelchairs, trolleys, and other equipment including medical devices, wound care, and intravenous infusion equipment, consumables etc?	Yes ☐ No ☐ N/A ☐
Comments		
2.30 P	Is there separate, suitable storage for contaminated material and clean material to prevent risk of contamination?	Yes ☐ No ☐ N/A ☐
Comments		
Engineering services (Ventilation)		
2.31 P	Are heat emitters, including low surface temperature radiators, designed, installed and maintained in a manner that prevents build up of dust and contaminants and are they easy to clean?	Yes ☐ No ☐ N/A ☐
Comments		
2.32 D	Is the ventilation system designed in accordance with the requirements of SHTM 03-01 'Ventilation in Healthcare Premises'?	Yes ☐ No ☐ N/A ☐
Comments		
2.33 D	Is the ventilation system designed so that it does not contribute to the spread of infection within the healthcare facility? *(Ventilation should dilute airborne contamination by removing contaminated air from the room or immediate patient vicinity and replacing it with clean air from the outside or from low-risk areas within the healthcare facility.)*	Yes ☐ No ☐ N/A ☐
Comments		

Engineering services (Ventilation) continued		
2.34 D	Are the ventilation system components e.g. air handling, ventilation ductwork, grilles and diffusers designed to allow them to be easily cleaned?	Yes ☐ No ☐ N/A ☐
Comments		
2.35 P & D	Are ventilation discharges located a suitable distance from intakes to prevent risk of contamination?	Yes ☐ No ☐ N/A ☐
Comments		
2.36 P	Does the design and operation of re-circulation of air systems take account of dilution of contaminates and the space to be served? *(NB: Recirculation would only arise in UCV theatres)*	Yes ☐ No ☐ N/A ☐
Comments		
2.37	Is the ventilation of theatres and isolation rooms in accordance with current guidance?	Yes ☐ No ☐ N/A ☐
Comments		
2.38	Do means of control of pathogens consider whether dilution or entrainment is the more appropriate for particular situations?	Yes ☐ No ☐ N/A ☐
Comments		
2.39	Where ventilation systems are used for removal of pathogens, does their design and operation take account of infection risk associated with maintenance of the system?	Yes ☐ No ☐ N/A ☐
Comments		
2.40	Are specialised ventilation systems such as fume cupboards installed and maintained in accordance with manufacturers' instructions?	Yes ☐ No ☐ N/A ☐
Comments		

Engineering services (Lighting)		
2.41 D	Is the lighting designed so that lamps can be easily cleaned with minimal opportunity for dust to collect?	Yes ☐ No ☐ N/A ☐
Comments		
Engineering services (Water services)		
2.42 D	Are water systems designed, installed and maintained in accordance with current guidance?	Yes ☐ No ☐ N/A ☐
Comments		
2.43	Are facilities available to enable special interventions for *Legionella*?	Yes ☐ No ☐ N/A ☐
Comments		
2.44	Is the drainage system design, especially within the healthcare facility building, fit for purpose with access points for maintenance carefully sited to minimise HAI risk?	Yes ☐ No ☐ N/A ☐
Comments		
2.45	Are surface mounted services avoided and services concealed with sufficient access points appropriately sited to ease maintenance and cleaning? (These services would include water, drainage, heating, medical gas, wiring, alarm system, telecoms, equipment such as light fittings, bedhead services, heat emitters.)	Yes ☐ No ☐ N/A ☐
Comments		

Estates services (Pest control)		
2.46	Is the concealed service ducting designed, installed and maintained to minimise risk of pest infestation?	Yes ☐ No ☐ N/A ☐
Comments		
Estates services (Maintenance access)		
2.47	Does the design and build of the facility allow programmed maintenance of the fabric to ensure the integrity of the structure and particularly the prevention of water ingress and leaks and prevention of pigeon and other bird access?	Yes ☐ No ☐ N/A ☐
Comments		
Additional notes - Stage 2		

Development stage 2: HAI-SCRIBE applied to the planning and design stage of the development.			
Certification that the following documents have been accessed and the contents discussed and addressed at the Infection Control and Patient Protection Meeting held on.			
Venue		Date	
'Healthcare Associated Infection System for Controlling Risk in the Built Environment' *('HAI-SCRIBE) Implementation Strategy Scottish Health Facilities Note (SHFN) 30: Part B).*			
Declaration: We hereby certify that we have co-operated in the application of and where applicable to the aforesaid documentation.			
Present			
Print name	Signature	Company	Telephone Numbers	Email address

Questionset for construction and refurbishment

Refurbishment of existing healthcare facilities

3.23 HAI-SCRIBE would be appropriate in redevelopment and refurbishment situations where the business of the healthcare facility continues concurrently with construction work on site. There are obligations on the contractors to undertake their construction operations in such a way that health and safety and other issues are adequately addressed.

3.24 Redevelopment and refurbishment of healthcare facilities in Scotland are common and the kind of work involved is varied.

3.25 In assessing the hazards of the above construction activities and the management of the potential risks, account has to be taken of the exposed population (in this case the patients), staff and visitors likely to be affected.

3.26 A range of precautions is needed to eliminate or manage the risk of infection.

- In order to ensure the risk of infection is minimised during construction works consideration must be given to:
  - the type of construction/refurbishment work being carried out (Table 1);
  - the population group being treated (Table 2);
  - the risk associated with these two factors (Table 3).

Table 1 highlights different types of construction/refurbishment activities likely to take place in the healthcare facility.

Table 2 highlights the different population groups within the healthcare facility and the risk associated with each group.

Table 3 estimates the overall risk of infection arising and indicates the level of precaution that should be implemented.

Note: Appendices 4-8 show a proposed process chart for each type of activity.

Type	Construction/Refurbishment Activity
Type 1	**Inspection and non-invasive activities.** Includes, but is not limited to, removal of ceiling tiles or access hatches for visual inspection, painting which does not include sanding, wall covering, electrical trim work, minor plumbing and activities which do not generate dust or require cutting of walls or access to ceilings other than for visual inspection.
Type 2	**Small scale, short duration activities which create minimal dust.** Includes, but is not limited to, installation of telephone and computer cabling, access to chase spaces, cutting of walls or ceiling where dust migration can be controlled.
Type 3	**Any work which generates a moderate to high level of dust, aerosols and other contaminants or requires demolition or removal of any fixed building components or assemblies.** Includes, but is not limited to, sanding of walls for painting or wall covering, removal of floor coverings, ceiling tiles and casework, new wall construction, minor duct work or electrical work above ceilings, major cabling activities, and any activity which cannot be completed within a single work shift.
Type 4	**Major demolition and construction projects.** Includes, but it not limited to, activities which require consecutive work shifts, requires heavy demolition or removal of a complete cabling system, and new construction.

Table 1: Redevelopment and refurbishment construction activity.

Risk to patients of infection from construction work in healthcare premises, by clinical areas	
Risk rating	**Area**
Group 1 Lowest risk	1. Office areas; 2. Unoccupied wards; 3. Public areas/Reception; 4. Custodial facilities; 5. Mental Health facilities.
Group 2 Medium risk	1. All other patient care areas (unless included in Group 3 or Group 4); 2. Outpatient clinics (unless in Group 3 or Group 4); 3. Admission or discharge units; 4. Community/GP facilities; 5. Social Care or Elderly facilities.
Group 3 High risk	1. A & E (Accident and Emergency); 2. Medical wards; 3. Surgical wards (including Day Surgery) and Surgical outpatients; 4. Obstetric wards and neonatal nurseries; 5. Paediatrics; 6. Acute and long-stay care of the elderly; 7. Patient investigation areas, including; • Cardiac catheterisation; • Invasive radiology; • Nuclear medicine; • Endoscopy. Also (indirect risk) 8. Pharmacy preparation areas; 9. Ultra clean room standard laboratories (risk of pseudo-outbreaks and unnecessary treatment); 10. Pharmacy Aseptic suites.
Group 4 Highest Risk	1. Any area caring for immuno-compromised patients*, including: • Transplant units and outpatient clinics for patients who have received bone marrow or solid organ transplants; • Oncology Units and outpatient clinics for patients with cancer; • Haematology units • Burns Units. 2. All Intensive Care Units; 3. All operating theatres; Also (indirect risk) 4. CSSUs (Central Sterile Supply Units).

Table 2: The different areas within the healthcare facility and the risk associated with each area.

Immuno-compromised patients are:

- those patients whose immune mechanisms are deficient because of immunologic disorders (e.g. human immunodeficiency virus [HIV] infection or congenital immune deficiency syndrome);
- patients with chronic diseases (e.g. diabetes, cancer, emphysema, or cardiac failure);
- patients undergoing immuno-suppressive therapy (e.g. radiation, cytoxic chemotherapy, anti-rejection medication, or steroids. (CCDR 2001).

Immuno-compromised patients who are identified as high-risk patients have the greatest risk of infection caused by airborne or waterborne micro-organisms. Patients in this subset include:

- persons who are severely neutropenic for prolonged periods of time (ie an absolute neutrophil count [ANC] of ≤ 500 cells/mL);
- allogeneic Haemopoietic Stem Cell Transplantation patients;
- renal dialysis patients;
- those who have received the most intensive chemotherapy (e.g. childhood acute myelogneous leukaemia patients). (CDC 2003).

Immuno-suppresive conditions identified as risk factors for construction-related nosocomial fungal infections include:

- graft-versus-host disease requiring treatment;
- prolonged neutropenia or granulocytopenia because of cytoxic chemotherapy;
- prolonged use of antibiotics; and steroid therapy. (CCDR 2001).

Other risk factors for the development of *aspergillosis* include dialysis and mechanical ventilation, smoking and patient age, the very young and very old being at greater risk.

	Construction Project Type			
Patient Risk Group	**TYPE 1**	**TYPE 2**	**TYPE 3**	**TYPE 4**
Lowest Risk	Class I	Class II	Class II	Class III/IV
Medium Risk	Class I	Class II	Class III	Class IV
High Risk	Class I	Class II	Class III/IV	Class IV
Highest Risk	Class II	Class III/IV	Class III/IV	Class IV

Table 3: Estimates the overall risk of infection arising and will indicate the class of precaution that should be implemented.

3.27 Having highlighted the overall degree of infection risk, appropriate infection prevention and control measures can be implemented to manage or eliminate the risk of transmission. Table 4 highlights the appropriate prevention and

control of infection precautions. Appendices 4-8 give an indication of how this can be processed.

3.28 Consideration should be given to the likelihood of patient movement outwith their speciality care area and the need for appropriate measures to control infection risk.

Surveillance and monitoring during renovation or construction work

3.29 There have been several documented outbreaks due to construction work however routine bacteriological sampling of floors, walls, surfaces and air is rarely indicated.

Note: The need for additional surveillance and environmental monitoring may be identified by the Project Team through risk assessment.

3.30 In 1995 there was widespread contamination of potable water with *Legionella pneumophila* during a period of major construction resulting in two fatal cases of healthcare associated *Legionellosis*. Multiple outbreaks of healthcare associated A*spergillosis* have also been described, including one specifically attributed to hospital renovation. It has been suggested that heightened surveillance and preventive measures may be warranted during periods of excavation on hospital grounds or when potable water supplies are otherwise shut down and later depressurised.

3.31 Since the airborne spores of *Aspergillus* spp. can travel significant distances, this will apply generally to all works in the immediate vicinity or within the boundary of the healthcare site.

Some further points for consideration

3.32 It is necessary to ensure that robust documentary evidence can be provided when considering the above issues. This will ensure that facts and data are available for reference at future stages of the project.

3.33 Barriers with signage will require to be positioned to make staff, patients and visitors aware of works.

3.34 There are key issues to be considered in assessing the hazard with a view to managing the risk. Therefore, in each situation where there is to be construction and refurbishment or repair work, the multi-disciplinary team of specialists referred to in Section 2 entitled “Assembling the Project Team” should be involved and the following questions need to be addressed.

Certain situations will require the use of barrier structures to contain contamination whilst others will require different measures eg a change of process. Therefore the following questions need to be addressed for each of these situations:

	Control measures		
	During Construction Work	**After Construction Work**	**By**
Class I	• Execute work by methods to minimise raising dust from construction operations;. • Immediately replace any ceiling tiles displaced during inspection.	• Clean areas by damp dusting with neutral detergent in warm water;. • Vacuum floor and damp mop.	Request via domestic supervisor. Request via domestic supervisor.
Class II	• Provide active means to prevent airborne dust from dispersing into atmosphere; • Water mist work surfaces to control dust while cutting; • Seal unused doors with duct tape; • Block off and seal air vents; • Place dust mat at entrance and exit of work area; • Remove or isolate HVAC system in areas where work is being performed.	• Dampwork surfaces and ledges with neutral detergent solution; • Contain construction waste before transport in tightly covered containers; • Damp mop and/or vacuum with HEPA filtered vacuum before leaving work area; • Remove isolation of HVAC system in areas where work is being performed.	Request via domestic supervisor. Estates staff. Request via domestic supervisor. Estates staff.
Class III	• Remove or Isolate HVAC system in area where work is being done to prevent contamination of duct system; • Complete all critical barriers eg plasterboard, plywood, plastic, to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins; • Maintain negative air pressure within work site utilizing HEPA equipped air filtration units; • Contain construction waste before transport in tightly covered containers; • Cover transport receptacles or carts. Tape covering unless solid lid.	• Do not remove barriers from work area until completed project is inspected by the Board's Health & Safety representative and Infection Control Department and thoroughly cleaned by the Board's domestic services staff;. • Remove barrier materials carefully to minimise spreading of dirt and debris associated with construction; • Vacuum work area with HEPA filtered vacuums; • Damp mop area with neutral detergent and warm water; • Remove isolation of HVAC system in areas where work is being performed.	Request by Estates Dept. Contractor/Estates Staff. Request via domestic supervisor. Request via domestic supervisor. Contractor/Estates Staff.

Table 4: Describes the required Infection Control Precautions depending on class of risk

	During Construction Work	After Construction Work	By
Class IV	• Isolate HVAC system in area where work is being done to prevent contamination of duct system; • Complete all critical barriers eg plasterboard, plywood, plastic to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins; • Maintain negative air pressure within work site utilizing HEPA equipped air filtration units; • Seal holes, pipes, conduits, and punctures appropriately; • Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave the work site; • All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area; • Do not remove barriers from work area until completed project is inspected.	• Remove barrier material carefully to minimise spreading of dirt and debris associated with construction; • Contain construction waste before transport in tightly covered containers;. • Cover transport receptacles or carts. Tape covering unless solid lid; • Vacuum work area with HEPA filtered vacuums; • Damp dust area with neutral detergent and warm water; • Scrub floor area with neutral detergent in warm water; • Remove isolation of HVAC system in areas where work is being performed.	Contractor. Contractor. Contractor. Request via domestic supervisor. Request via domestic supervisor. Contractor/Estates Staff.

Table 4 continued: Describes the required Infection Control Precautions depending on class of risk

Note: Temporary critical barrier partitions should be inspected and their condition monitored and signed off on a daily basis to assess any damage, gaps, etc. Polythene sheeting and tape would only be suitable in small areas for limited periods.

Development stage 3: Construction and refurbishment work			
HAI-SCRIBE Name of Project			
Name of Establishment			
National allocated number			
HAI-SCRIBE Review Team			
HAI-SCRIBE Sign Off			
Completed By (Project Manager) (Print Name)			Date
Signature			Date
Stage 3			
Additional Notes			

Immuno-compromised patients who are identified as high-risk patients have the greatest risk of infection caused by airborne or waterborne micro-organisms. Patients in this subset include persons who are severely neutropenic for prolonged periods of time (ie an absolute neutrophil count [ANC] of ≤ 500 cells/mL), allogeneic HSCT patients, and those who have received the most intensive chemotherapy (e.g. childhood acute myelogneous leukaemia patients). (**CDC 2003**)

Immuno-suppresive conditions identified as risk factors for construction-related nosocomial fungal infections include graft-versus-host disease requiring treatment; prolonged neutropenia or granulocytopenia because of cytoxic chemotherapy; prolonged use of antibiotics; and steroid therapy. Other risk factors for the development of aspergillosis include dialysis and mechanical ventilation, smoking and patient age, the very young and very old being at greater risk Grauhan and colleagues reported that the risk of a fungal infection increases in patients who exhibit three or more risk factors ($p<0.001$). **CCDR (2001)**

Development stage 3: HAI-SCRIBE applied to the proposed site for development Prior to the commencement of work		
3.1.1	Brief description of the work being carried out.	
3.1.2	Using the matrix above establish the type and extent of construction and refurbishment /repair work, patients at risk and level of control measures.	
Type of work.		
Patient risk group.		
Risk class.		
3.1.3	Identify any potential hazards associated with this work.	
3.1.4	Identify any risk associated with the hazards identified above.	
3.1.5	Outline the control measures that require to be implemented to eliminate or mitigate the identified risks. Ensure these are entered on the project risk register.	
Control measures		
3.1.6	It has been recognised that control measures identified to address the project risk may have unintended consequences e.g. closure of windows can lead to increased temperatures in some areas. Such issues should be considered at this point, they should be noted and action to address these taken.	
Potential problems		
Control measures		
3.1.7	Actions to be addressed	
By		Deadline

In terms of infection risk have the following been addressed		
3.2.1	The population groups most susceptible to infection. Items to be considered: Adjacent rooms, wards and departments Relocation of susceptible patients Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
3.2.2	The hours of operation of the construction work and the impact of this on the clinical area. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
3.2.3	Separation of construction and healthcare activities including delivery and supply routes, removal of waste and patient transfers. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
3.2.4	The construction of temporary barriers and/or sealing of doors and windows to minimise contamination of the environment by dust and potentially infectious particles created during the construction works. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		

In terms of infection risk have the following been addressed continued		
3.2.5	Airflow patterns including:	
	Internal and external ventilation systems	Yes ☐ No ☐ N/A ☐
	Exhaust ventilation	Yes ☐ No ☐ N/A ☐
	Sealing of doors and windows	Yes ☐ No ☐ N/A ☐
	Oxygen and Suction points	Yes ☐ No ☐ N/A ☐
	Air handlers, coils, fans and grilles	Yes ☐ No ☐ N/A ☐
	Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐
Comments		
3.2.6	Work with sinks or plumbing which could give rise to aerosol water droplets in high risk areas.	Yes ☐ No ☐ N/A ☐
	Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐
Comments		
3.2.7	Impact on stock storage areas including:	
	Sterile and non-sterile items	Yes ☐ No ☐ N/A ☐
	Patient care equipment	Yes ☐ No ☐ N/A ☐
	Medications	Yes ☐ No ☐ N/A ☐
	Medical records and documentation	Yes ☐ No ☐ N/A ☐
	Linen and waste facilities including sharps	Yes ☐ No ☐ N/A ☐
	Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐
Comments		

During the construction phase have the following been addressed?		
3.3.1	Where external work is being carried out: Prevention of insect and rodent entry and prevention of weather/water entry to internal areas during the construction phase. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
3.3.2	Cleaning of site and adjacent areas both during the construction phase and prior to handover. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
3.3.3	Enforcement of control and reporting system to ensure compliance with above issues. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐
Comments		
Additional notes - Stage 3		

Development stage 3: HAI-SCRIBE applied to the construction/redevelopment phase				
Certification that the following documents have been accessed and the contents discussed and addressed at the Infection Control and Patient Protection Meeting held on				
Venue		Date		
'Healthcare Associated Infection System for Controlling Risk in the Built Environment' *('HAI-SCRIBE) Implementation Strategy Scottish Health Facilities Note (SHFN) 30: Part B).*				
Declaration: We hereby certify that we have co-operated in the application of and where applicable to the aforesaid documentation.				
Present				
Print name	Signature	Company	Telephone Numbers	Email address

Contractor Endorsement Certificate

(I) Statement of Intent:

Healthcare Associated Infection (HAI) is a complex issue involving the many different elements of patient care and provision. Due to its multi-factorial nature, there is a need to develop a holistic approach to minimising the risk of infection in the built environment.

NHS National Services Scotland Health Facilities Scotland (NSS HFS), in conjunction with other organisations, has endeavoured comprehensively to tackle this situation through the creation of documents such as the 'Healthcare Associated Infection System for Controlling Risk of Infection In the Built Environment': (HAI-SCRIBE) comprising 'Scottish Health Facilities Note (SHFN) 30: Parts A & B.

Non-application of these documents is extremely detrimental in preventing the spread of infection and to the healthcare sector in general. In certifying this endorsement you verify that you will endeavour to do all within your power to aid in this process and reduce the risk of infection within the built environment.

(II) Certification of the following documents;

'Healthcare Associated Infection System for Controlling Risk In the Built Environment' (HAI-SCRIBE) comprising 'Scottish Health Facilities Note (SHFN) 30': Parts A & B.

(III) Declaration:

We hereby certify that we agree to co-operate in the application of, on whole or where applicable to the aforementioned documentation and any amendment /revision forthwith enclosed or existing at the time of this declaration.

Name (please print) _____

Signed _____

Designation _____

Company Name_____

Witnessed by (please print)_____

Signed _____

Designation _____

Company Name _____

Questionset for pre-handover check - Ongoing use of HAI-SCRIBE in an existing healthcare facility

3.35 Once a Project (new build or refurbishment) is ready for operation, This Questionset would be used as an assessment that the outcomes from the earlier Questionsets have been successfully fulfilled. The Questionset relevant to this stage should be seen as a final, pre-handover checklist that everything briefed has been provided.

Design in use

3.36 Within the built healthcare facility it is important to ensure there will be an ongoing application of HAI-SCRIBE. This is a verification process of particular importance not only where there are subsequent alterations to the building, but also to arrangements within the building, and to procedures and practices. The three key stages involved in HAI-SCRIBE have a continuous application:

- identifying the hazard;
- assessing the risk from the identified hazard;
- managing the risk to eliminate or minimise impact.

Physical monitoring

3.37 Physical monitoring of the healthcare environment includes temperature, humidity, air change rates, leak rates, direction of air and water flow, particle counts and filter efficiency.

3.38 Testing methods can help ensure that environmental conditions in the healthcare facility are such that they do not contribute to the spread of infection.

3.39 Stagnant air, possibly through poor ventilation, can contribute to fungal contamination whilst excessive air turbulence can increase airborne particulate levels and contribute to the dispersal of micro-organisms.

3.40 Visual inspection must be part of physical monitoring to ensure for instance that filters are fitted correctly, that surfaces are smooth, impermeable, free of cracks and joins, and without the accumulation of dust which may harbour fungi and bacteria.

Microbial monitoring

3.41 In terms of quality assurance, microbial monitoring may be required on the advice of the Project Team. Microbial sampling of the air, water and surfaces of the healthcare facility has an important role to play in helping combat the spread of infection within the built healthcare environment.

3.42 NHS Boards should have a formal protocol for infection prevention and control monitoring of the built healthcare environment with regard to the prevention and control of infection. When sampling of the area is carried out, the laboratory should have appropriate accreditation for carrying out the sampling. Some

sampling may have to be performed in response to an investigation of an outbreak of infection. Results obtained should be interpreted using scientifically established baseline values for comparison e.g. Health and Safety Executive guidelines. On completion of analysis, actions to be implemented should be based on the results obtained.

3.43 It may be necessary for an NHS Board to seek specialist advice on microbial monitoring protocols to allow the Project Team to take responsibility. Areas where the built environment is suspected of contributing to the spread of infection or where construction or refurbishment work is proposed should be referred to the Infection Prevention and Control Team for consideration of monitoring and advice as appropriate.

Feedback

3.44 The Scottish Capital Investment Manual states that feedback is a mandatory requirement as part of Post Project Evaluation to ensure lessons are learned and disseminated for future projects.

HAI-SCRIBE auditing of accommodation *in use* should also make use of the following questionsets:

Development stage 4: Review of completed project	
HAI-SCRIBE Name of project	
Name of Establishment	National allocated number
HAI-SCRIBE Review Team	
HAI-SCRIBE **Sign Off**	
Completed by (Print name)	Date
Signature(s)	Date
Stage 4	
Additional notes	

General overview		
4.1	Is the space around beds in accordance with current NHSScotland guidance?	Yes ☐ No ☐ N/A ☐
4.2	Are there sufficient single rooms to accommodate patients known to be an infection of potential infection risk?	Yes ☐ No ☐ N/A ☐
4.3	Are all surfaces, fittings, fixtures and furnishings designed for easy cleaning?	Yes ☐ No ☐ N/A ☐
4. 4	Are soft furnishings covered in an impervious material in all clinical and associated areas, and are curtains able to withstand washing at disinfection temperatures?	Yes ☐ No ☐ N/A ☐
4. 5	Is the bathroom/shower/toilet accommodation sufficient and conveniently accessible, with toilet facilities no more than 12m from the bed area?	Yes ☐ No ☐ N/A ☐
4.6	Are the bathroom/shower/toilet facilities easy to clean?	Yes ☐ No ☐ N/A ☐
4.7	Where required are there sufficient en-suite single rooms with negative/positive pressure ventilation to minimise risk of infection spread from patients who are a known or potential infection risk?	Yes ☐ No ☐ N/A ☐
Provision of hand-wash basins, liquid soap dispensers, paper towels and alcohol rub dispensers		
4.8	Does each single room have a clinical hand-wash basin, liquid soap dispenser, paper towels, and alcohol rub dispenser over and above the hand-wash basin in the en-suite facility?	Yes ☐ No ☐ N/A ☐
4.9	Do intensive care and high dependency units have sufficient clinical hand wash basins, liquid soap dispensers, paper towels, and alcohol rub dispensers conveniently accessible to ensure the practice of good hand hygiene? An assessment should be made, however, to ensure that there is not an over-provision of hand-wash basins resulting in under-use.	Yes ☐ No ☐ N/A ☐
4.10	Is there provision of clinical hand-wash basins, liquid soap dispensers, paper towels, and alcohol rub dispensers in lower dependency settings like mental health units, acute, elderly and long term care settings appropriate to the situation with a ratio of 1 basin/dispenser to 4–6 beds?	Yes ☐ No ☐ N/A ☐
4.11	Do out-patient areas and primary care settings have a clinical hand-wash basin close to where clinical procedures are carried out?	Yes ☐ No ☐ N/A ☐
4.12	Do all toilets have a hand-wash basin, liquid soap dispenser and paper towels?	Yes ☐ No ☐ N/A ☐
4.13	Are all clinical hand-wash basins exclusively for hand hygiene purposes?	Yes ☐ No ☐ N/A ☐
4.14	Does each clinical hand-wash basin have wall mounted liquid soap dispenser, paper towel dispenser?	Yes ☐ No ☐ N/A ☐

Provision of hand-wash basins, liquid soap dispensers, paper towels and alcohol rub dispensers continued		
4.15	Does each clinical hand-wash basin satisfy the requirement not to be fitted with a plug?	Yes ☐ No ☐ N/A ☐
4.16	Are elbow-operated or other non-touch mixer taps provided in clinical areas?	Yes ☐ No ☐ N/A ☐
4.17	Does each hand-wash basin have a waterproof splash back surface?	Yes ☐ No ☐ N/A ☐
4.18	Is each hand-wash basin provided with an appropriate waste bin for used hand towels?	Yes ☐ No ☐ N/A ☐
Provision of facilities for Decontamination		
4.19	Are separate, appropriately sized sinks provided locally, where required, for decontamination? *(The sinks should be large enough to immerse the largest piece of equipment and there should be twin sinks, one for washing and one for rinsing. A clinical hand-wash basin should be provided close to the twin sinks).*	Yes ☐ No ☐ N/A ☐
4.20	Are appropriate decontamination facilities provided centrally for sterilisation of specialist equipment?	Yes ☐ No ☐ N/A ☐
4.21	Is there adequate provision in terms of transport, storage, etc. to ensure separation of clean and used equipment and to prevent any risk of contamination of cleaned equipment?	Yes ☐ No ☐ N/A ☐
4.22	Does the system in operation comply with the current guidance on decontamination facilities and procedures?	Yes ☐ No ☐ N/A ☐
Storage		
4.23	Is there suitable and sufficient storage provided in each area of the healthcare facility for the following if required patients' clothes and possessions, domestic cleaning equipment and laundry, large pieces of equipment e.g. beds, mattresses, hoists, wheelchairs, trolleys, and other equipment including medical devices, wound care, and intravenous infusion equipment, consumables etc?	Yes ☐ No ☐ N/A ☐
4.24	Is there separate, suitable storage for contaminated material and clean material to prevent risk of contamination?	Yes ☐ No ☐ N/A ☐

Engineering services (Ventilation)		
4.25	Are heat emitters, including low surface temperature radiators, designed, installed and maintained in a manner that prevents build up of dust and contaminants and are they easy to clean?	Yes ☐ No ☐ N/A ☐
4.26	Is the ventilation system designed in accordance with the requirements of SHTM 03-01 'Ventilation in Healthcare Premises'?	Yes ☐ No ☐ N/A ☐
4.27	Is the ventilation system designed so that it does not contribute to the spread of infection within the healthcare facility? *(Ventilation should dilute airborne contamination by removing contaminated air from the room or immediate patient vicinity and replacing it with clean air from the outside or from low-risk areas within the healthcare facility.)*	Yes ☐ No ☐ N/A ☐
4.28	Are the ventilation system components e.g. air handling, ventilation ductwork, grilles and diffusers designed to allow them to be easily cleaned?	Yes ☐ No ☐ N/A ☐
4.29	Are ventilation discharges located a suitable distance from intakes to prevent risk of contamination?	Yes ☐ No ☐ N/A ☐
4.30	Does the design and operation of re-circulation of air systems take account of dilution of contaminates and the space to be served? *(NB: Recirculation would only arise in UCV theatres)*	Yes ☐ No ☐ N/A ☐
4.31	Is the ventilation of theatres and isolation rooms in accordance with current guidance SHTM 03-01, SHPN 04-01 Supplement 1 and the Scottish Hospital Infection Manual)?	Yes ☐ No ☐ N/A ☐
4.32	Do means of control of pathogens consider whether dilution or entrainment is the more appropriate for particular situations?	Yes ☐ No ☐ N/A ☐
4.33	Where ventilation systems are used for removal of pathogens, does their design and operation take account of infection risk associated with maintenance of the system?	Yes ☐ No ☐ N/A ☐
4.34	Are specialised ventilation systems such as fume cupboards installed and maintained in accordance with manufacturers' instructions?	Yes ☐ No ☐ N/A ☐
Engineering services (Lighting)		
4.35	Is the lighting designed so that lamps can be easily cleaned with minimal opportunity for dust to collect?	Yes ☐ No ☐ N/A ☐
Engineering services (Vacuum Units)		
4.36	Are vacuum-controlled units with overflow protection devices for mechanical suction used to avoid contaminating the system with aspirated body fluid?	Yes ☐ No ☐ N/A ☐

Engineering services (Water services)		
4.37	Are water systems designed, installed and maintained in accordance with current guidance? (SHTM 04-01 series – Water safety)	Yes ☐ No ☐ N/A ☐
4.38	Are facilities available to enable special interventions for *Legionella* such as chlorination/chlorine dioxide, copper/silver ionisation treatment of water?	Yes ☐ No ☐ N/A ☐
4.39	Is the drainage system design, especially within the healthcare facility building, fit for purpose with access points for maintenance carefully sited to minimise HAI risk?	Yes ☐ No ☐ N/A ☐
4.40	Are surface mounted services avoided and services concealed with sufficient access points appropriately sited to ease maintenance and cleaning? (These services would include water, drainage, heating, medical gas, wiring, alarm system, telecoms, equipment such as light fittings, bedhead services, heat emitters.)	Yes ☐ No ☐ N/A ☐
Estates services (Pest control)		
4.41	Is the concealed service ducting designed, installed and maintained to minimise risk of pest infestation?	Yes ☐ No ☐ N/A ☐
Estates services (Maintenance access)		
4.42	Does the design and build of the facility allow programmed maintenance of the fabric to ensure the integrity of the structure and particularly the prevention of water ingress and leaks and prevention of pigeon and other bird access?	Yes ☐ No ☐ N/A ☐
Additional notes – Stage 4		

Development stage 4: HAI-SCRIBE Review of completed project	
4.43	Brief description of the work carried that was carried out.
4.44	Identify any issues associated with this work.
4.45	Identify any risk associated with the issues identified above.
4.46	Outline the measures that required to be implemented to eliminate or mitigate the identified issues. Ensure these are entered on the project risk register.

Appendix 1

Construction and Refurbishment Stage – Minor Works

Work in progress

Form to be submitted to the Project Team before work commences, with minimum monthly updates for the duration of complex/long-term projects.

Name of person completing: _____

Date: _____

Project *(brief Summary including site, specialty)*				
New build	Yes	☐	No	☐
Redesign	Yes	☐	No	☐
Near patient activity likely	Yes	☐	No	☐
Date of initial meeting	_____			
Work expected to commence	_____			
Work due for completion	_____			

Responsible Officers

Department	Name	Designation
Estates & Property		
Infection prevention & Control		
Domestic Services		
Health & Safety		
Procurement		
Clinical representative		

While work is being carried out and particularly where there are building activities in or near patients' areas there should be regular, recorded visits and inspections to the site by appropriate members of the group.

Issues to be considered for Construction and Refurbishment Stage

This is not exhaustive and, depending on the specialty and facility; there may be further issues which require consideration.

Onsite contractors aware of safety measures	Yes	☐	No	☐
Limited spread of dust	Yes	☐	No	☐
Additional cleaning ongoing	Yes	☐	No	☐
Water/ventilation to surrounding areas isolated	Yes	☐	No	☐
Staff in surrounding areas satisfied with precautions	Yes	☐	No	☐

The answers to the questions above should be "yes". Where a potential hazard is identified a careful assessment of that hazard must be undertaken.

Additional Issues/Potential Hazards
Discussion
Outcome

Appendix 2

Commissioning Stage

To be with Project Team before expected completion date.

Name: _____ Date: _____

Project *(brief Summary including site, specialty)*				
New build	Yes	☐	No	☐
Redesign	Yes	☐	No	☐
Near patient activity likely	Yes	☐	No	☐
Date of initial meeting _____				
Work commenced _____				
Work completed _____				

Responsible Officers

Department	Name	Designation
Estates & Property		
Infection Prevention & Control		
Domestic Services		
Health & Safety		
Microbiology		

Issues to be considered for Commissioning Stage

This is not exhaustive and, depending on the specialty and facility, there may be further issues which require consideration.

Approved plans followed	Yes	☐	No	☐
Infection Prevention & Control measures adhered to	Yes	☐	No	☐

The answers to the questions above should be "yes". Where a potential hazard is identified a careful assessment of that hazard must be undertaken.

Additional Issues/Potential Hazards
Discussion
Outcome

What commissioning checks are required for this project?

Settle plates	Yes	☐	No	☐
Air sampling	Yes	☐	No	☐
On site inspection	Yes	☐	No	☐

Appendix 3

Permission to Work (if necessary)

Description of work to be completed:

Specific area e.g. room number within ward area.

Risk assessment completed Yes ☐ No ☐

Signature _____ Date _____

Risks identified

Comments/Actions taken

Date work planned _____

Estimated completion _____

Nurse in charge Signature _____Date _____

Acceptance of work

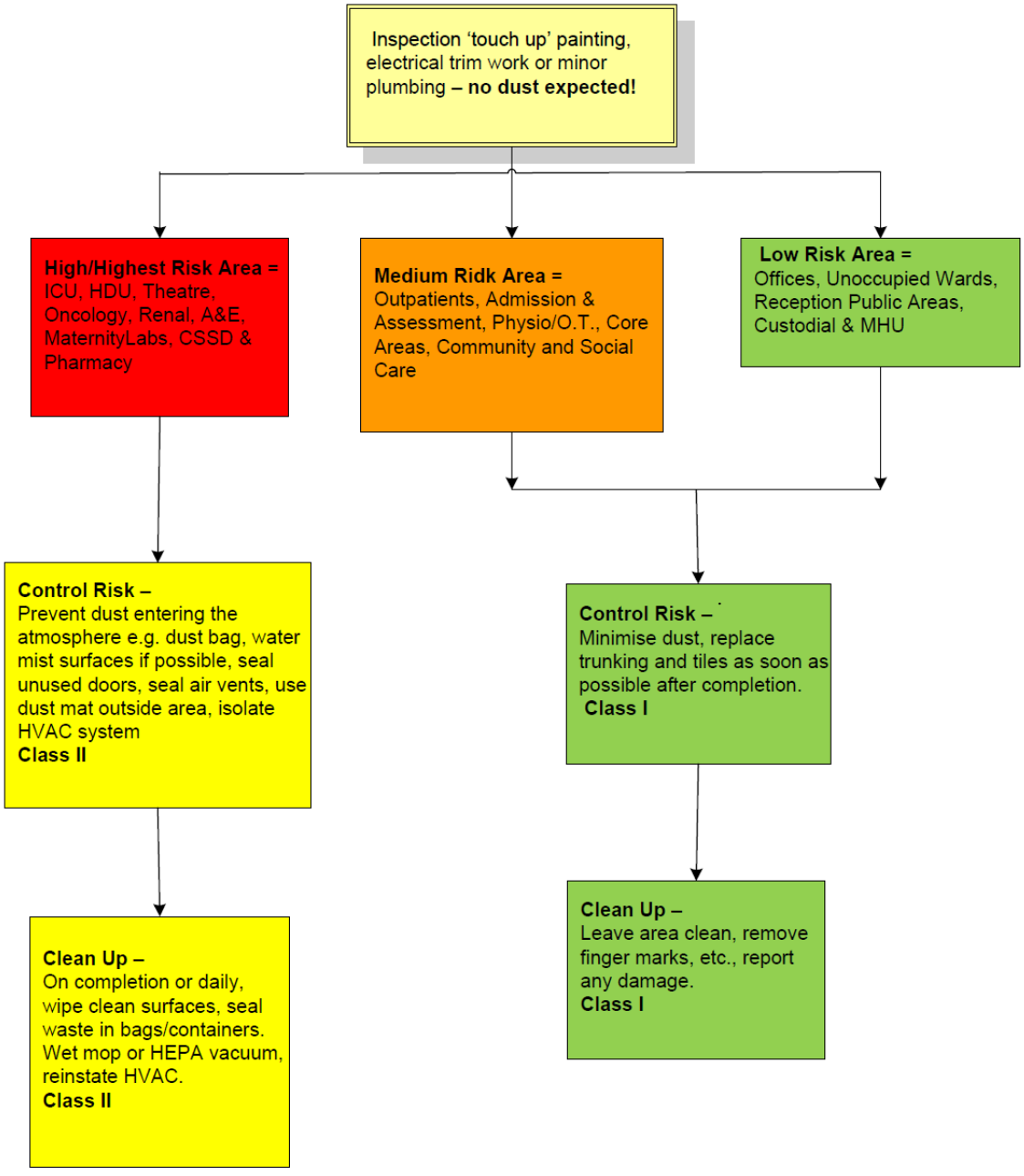
Sister/Charge Nurse acceptance of work on completion _____

Estates Officer Signature _____

Comments:

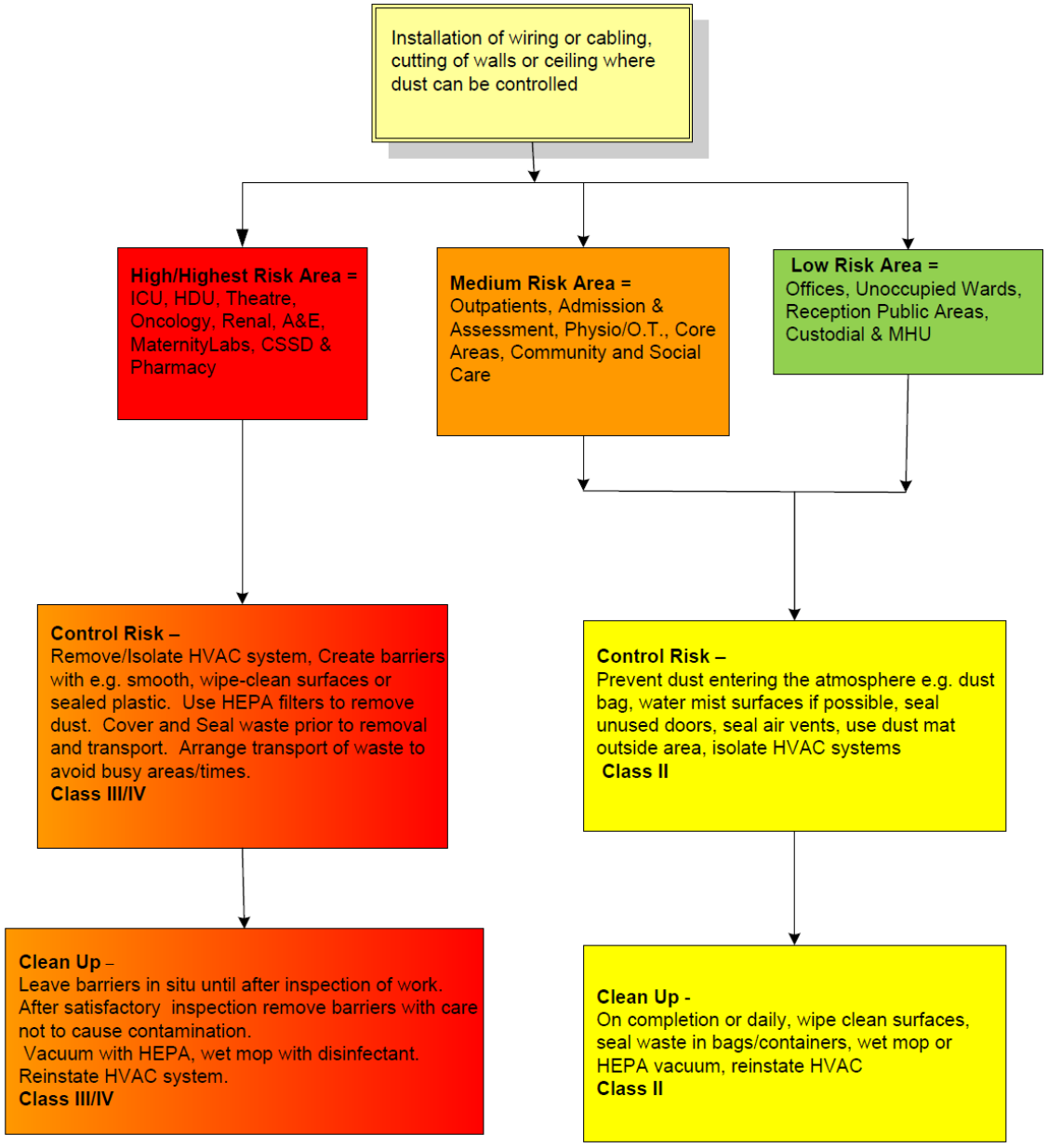
Appendix 4

Minor Works and Small Repairs



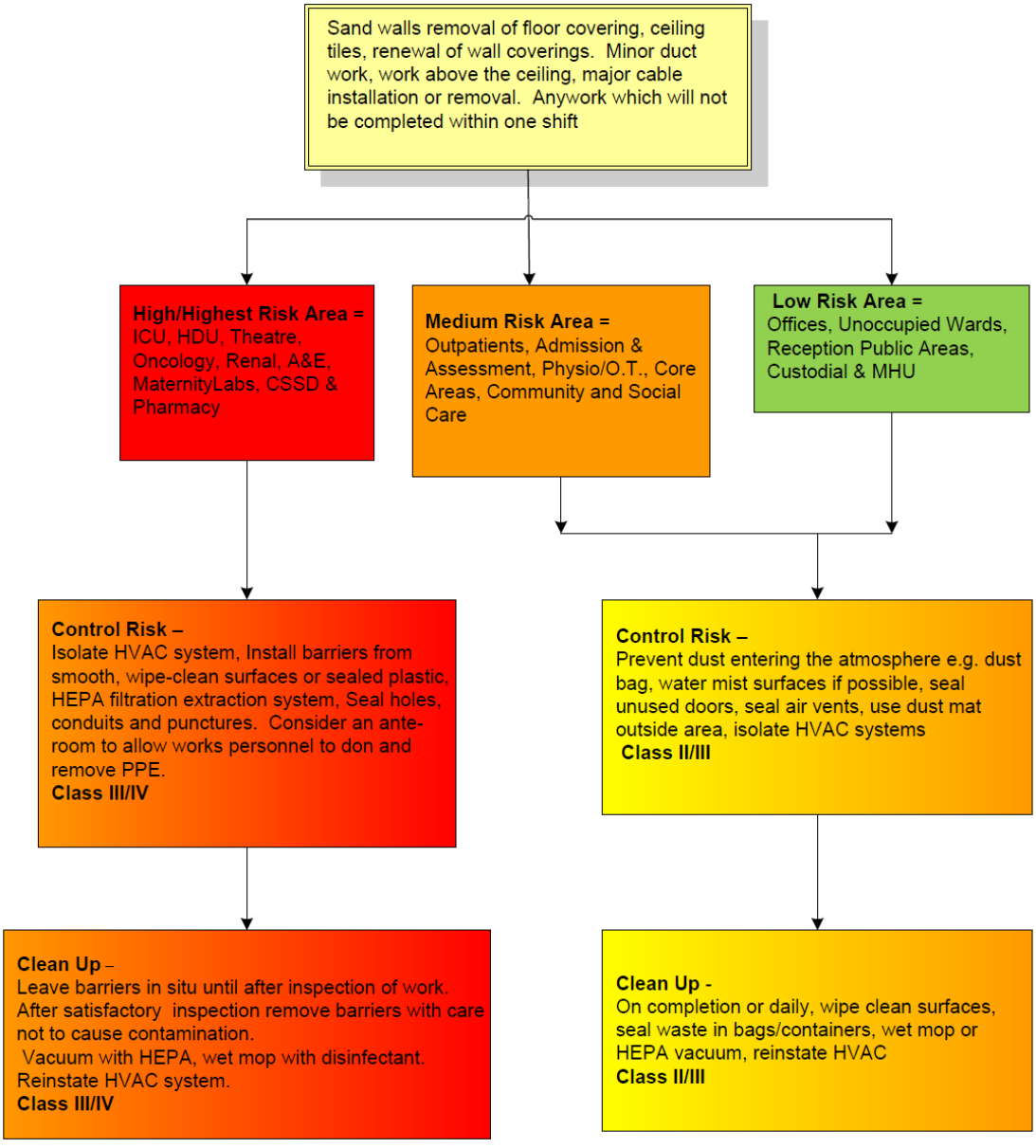
Appendix 5

Small Scale Work



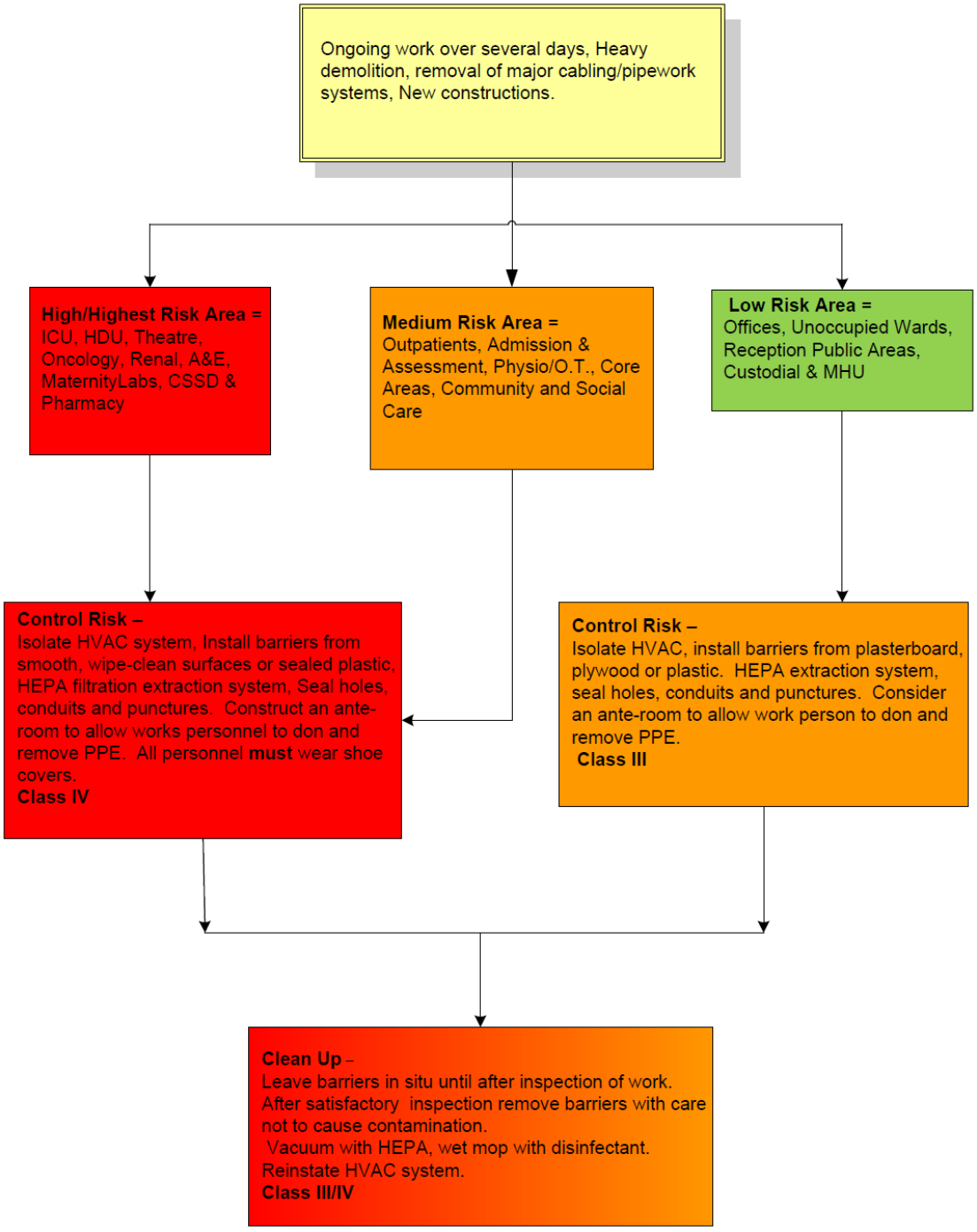
Appendix 6

Demolition work or removal of fixed structures or work where moderate-high level dust expected



Appendix 7

Major demolition work and construction



Appendix 8

A typical exemplar is set out below comprising an overview of various ongoing HAI-SCRIBE activities for minor works.
The entries are fictitious.

HAI-SCRIBE Reg No.	Date of issue by	Site location	Project details	Stage	Risk level	Date Assess review (optional)	Date Assess complete	Date Project started	Date Project finished	Comments
W/1	11-8-12 IGS	West ward block, Level 3	Painting bedrooms	Stage 3	Low	N/A	N/A	01/10/2012	30/10/2012	Access problems
L/6	20-8-12 BB	Lab Block	Replacing defective pipework at risers	Stage 3	Low	N/A	N/A	03/09/2012	05/10/2012	No issues
W/12	02/09/2012 WD	East ward block isolation rooms	HEPA filter replacement	Stage 3	Low/Medium	05/09/2012	Cancelled			Bedroom occupied
D/23	06/10/2012 FF	Dining Room entrance	Replacement floor covering	Stage 3	Low/Medium		31/10/2012	15/11/2012	Delayed	Asbestos found

Appendix 9

The following sets out typical NHS Board organisation showing the inter-relationship between the Board's internal organisation and external resources, when employed. This should be read in conjunction with Section 2.

NHS Board internal organisation

- **NHS Board** - should monitor cost and progress of all capital investment projects at regular meetings. If problems are identified, it needs to be satisfied that appropriate steps are being taken to resolve them;
- **Chief Executive Officer** (CEO) – accountable to the NHS Board and perhaps the only person with total responsibility for project and any other related activities. The CEO takes responsibility for management of all major capital schemes at all stages of the process from inception to post project evaluation;
- **Project Board** - comprising senior staff within the NHS Board who are responsible for the project and whose activities will be affected by the project, such as staff from clinical areas including infection prevention and control specialists and Estates & Facilities managers;
- **Project Director** - responsible for overall project management also managing the NHS Board's interest in the Project. Other responsibilities include evaluating competence of and appointing Consultants and Contractors who will undertake design and construction activity and acting as point of contract in dealings with Contractors;
- **Estates Adviser** - experienced in procuring construction, design and operation of healthcare facilities;
- **User Panel** - representatives of each of the relevant service departments, in each case authorised to define their department's needs and to review and agree how those needs are to be met.

NHS Board External resources:

- **Project Manager** – NHS Boards do not necessarily have capacity in-house to develop and manage all aspects of the project, therefore it is often necessary to appoint external Consultants. The Project Manager's role is to provide a single point of responsibility for the project brief and design. A list of responsibilities is set out in paragraph 2.7.
- **External Consultants** – this includes CDM Coordinator, Medical Planners, Designers and Contractor. They are managed by the Project Manager, appointed by the Project Director. However, their responsibility will be to, and their contracts with, the NHS Board.

Appendix 10

Exemplar questionset

Initial Brief and proposed Site for development identification of hazards, associated risks and control measures		
1.a	Brief description of the proposed development project and the planned development site	New build two-storey development at Lochee Hospital comprising treatment wards and clinics for haematology patients.
1.b	Identify any potential hazards associated with the design and/or proposed site.	Adjacent brewery has cooling towers on site.
1.c	Identify any risk associated with the hazards above	There is the potential for air with water-borne bacteria to be drawn into the new accommodation.
1.d	Outline the control measures that require to be implemented to eliminate or mitigate the identified risks. Ensure these are entered on the project risk register.	Windows may require to be non openable and mechanical ventilation relied upon. Air intakes will have to be located on the lee side of the building.
Control Measures		
1.e	It has been recognised that control measures identified to address the project risk may have unintended consequences e.g. closure of windows can lead to increased temperatures in some areas. Such issues should be considered at this point, they should be noted and action to address these taken	
	Potential Problems Patient and staff discomfort and fatigue due to potential overheating during hot weather if building is sealed.	
	Control Measures Mechanical ventilation will be required	
1.f	Actions to be addressed • Check out climate profile to determine extent of summer temperatures in excess of internal design temperatures. • Make initial assessment of extent of sources of internal heat gains. • Determine need for mechanical cooling of incoming ventilation supply air using rule of thumb method. • Check affordability.	
By Gordon Strachan		Deadline 31st March 2015

Initial Brief and proposed site for development, development stage 1: checklist to ensure all aspects have been addressed						
1.1	Is contaminated land an issue? e.g. asbestos, oils and heavy metals. (Refer to the Contaminated Land Register) Have these issues and actions to be taken been noted in actions to be addressed section?	Yes		No	x	N/A
		Yes		No		N/A	x
Comments Contaminated Land Register and geotechnical surveys confirmed that historical use of site was non-industrial						
1.2	Is there a locally recognised increased risk of contamination or infection e.g. *cryptosporidium*? If yes give details. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes		No	x	N/A
		Yes		No		N/A	x
Comments No record has been traced. (see comments re 1.1)						
1.3	Are there industries or other sources in the neighbourhood which may present a risk of infection or pollution e.g. animal by-products processing plant? If yes give details Have these issues and actions to be taken been noted in actions to be addressed section?	Yes	x	No		N/A
		Yes	x	No		N/A
Comments Adjacent brewery produces smells and vapour-laden discharges from plant and cooling towers. This confirms need for sealed windows, mechanical ventilation and (potentially) cooling. Charcoal filters may be required to mitigate ingress of odours.						
1.4	If there are any industries or other sources identified in question 1.3 above, will they affect the designed operation of the healthcare system? Consider the planned function of the design as well as issues such as: Ventilation Opening of doors and windows Water systems etc. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes	x	No		N/A
		Yes	x	No		N/A
Comments As per section 1.3. The water system is unaffected.						

Initial Brief and proposed site for development, development stage 1 – checklist to ensure all aspects have been addressed continued		
1.5	Are there construction/demolition works programmed in the neighbourhood which may present a risk of pollution or infection (including fungal infection)? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☐ No ☒ N/A ☐ Yes ☐ No ☐ N/A ☒
Comments No issues arising		
1.6	Are there cooling towers in the neighbourhood which may present a risk of *Legionella* infection? Consider also air handling units, water pipes etc. Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☒ No ☐ N/A ☐ Yes ☒ No ☐ N/A ☐
Comments See under 1.3		
1.7	Does the topography of the site in relation to the surrounding area and the prevailing wind direction present any HAI risk e.g. from entrainment of plumes containing *Legionella*? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☒ No ☐ N/A ☐ Yes ☒ No ☐ N/A ☐
Comments		
1.9	Will the proposed development impact on the surrounding area in any way which may present potential for infection risk? Consider possible restrictions being applied to the operation of the proposed facility e.g. Facilities Management routes Have these issues and actions to be taken been noted in actions to be addressed section?	Yes ☒ No ☐ N/A ☐ Yes ☐ No ☒ N/A ☐
Comments Previous 'issues to be addressed' related to the new build. For surrounding accommodation, consideration will have to be given to the need for temporary closure of windows, impact on internal environmental conditions, suppression of dust from excavations, plant noise, creation of segregated routes for waste removal.		

Initial Brief and proposed site for development, development stage 1 – checklist to ensure all aspects have been addressed continued		
1.10	Will lack of space limit the proposed development and any future expansion or change of use of the facility? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes [x] No [ ] N/A [ ] Yes [x] No [ ] N/A [ ]
Comments It cannot be ruled out that restricted space may inhibit future development or impact on the current project but this cannot be determined until the extent and type of project is known.		
1.11	Has a demolition/refurbishment asbestos survey been carried out? Have these issues and actions to be taken been noted in actions to be addressed section?	Yes [x] No [ ] N/A [ ] Yes [x] No [ ] N/A [ ]
Comments Question 1.1 also refers. No demolition is necessary as part of this new-build project. The hospital asbestos register is held in the estates office and confirms that no asbestos is present in the vicinity of the proposed site.		
1.12	Has consideration been given to the projected lifespan of the facility and its impact on planning and development?	Yes [ ] No [ ] N/A [ ]
Comments		

Additional notes - Stage 1

This project would not normally incorporate mechanical ventilation/cooling within a sealed building. It is necessary to verify that the cost allowance will accommodate this abnormal provision to avoid the need for unwanted compromises later in order to reduce costs.

Restricted site space will not necessarily impact on the current development but may have an impact in future on both the current Project and surrounding areas.

Development Stage 1: HAI-SCRIBE applied to the initial brief and proposed site for development			
Certification that the following documents have been accessed and the contents discussed and addressed at the Infection Control and Patient Protection Meeting held in			
Venue	Seminar Room 2, Lochee Hospital	Date	15th July 2014
'Healthcare Associated Infection System for Controlling Risk in the Built Environment' *(HAI-SCRIBE), comprising 'Scottish Health Facilities Note (SHFN) 30: Parts A & B..*			
Declaration: We hereby certify that we have co-operated in the application of and where applicable to the aforesaid documentation.			
Present			

Print name	Signature	Company	Telephone Numbers	Email address

References

CCDR (2001), **Construction-related Nosocomial Infections in Patients in Health Care Facilities Decreasing the Risk of Aspergillus, Legionella and Other Infections**, Division of Nosocomial and Occupational Infections, Bureau of Infectious Diseases, Centre for Infectious Disease Prevention and Control, Population and Public Health Branch, Health Canada, Ottawa, Ontario, Canada K1A 0L2

CDC (2003), **Guideline for Environmental Infection Control in Health-Care Facilities, 2003 Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)**, Hospital Infection Control Practices Advisory Committee.

NHS National Services Scotland

Scottish Health Facilities Note 30: Version 3

Infection control in the built environment: Design and planning

Health Facilities Scotland

A47168969

NHS National Services Scotland

Scottish Health Facilities Note 30

Version 3

Infection Control in the Built Environment: Design and Planning

Health Facilities Scotland

June 2007

A47168969

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1. Scope

1.1 This document is a revision of Scottish Health Facilities Note 30 (SHFN 30): 'Infection Control in the built environment: design and planning' which was published in 2002. The need for a revised document has become increasingly apparent in light of the determined focus being applied to reducing Healthcare Associated Infections (HAIs). This focus has highlighted the need for initial, rigorous examination of proposals for new build healthcare facilities, extensions to healthcare facilities, and refurbishment of healthcare facilities in relation to prevention and control of infection. Having highlighted the need for a rigorous examination of proposals in relation to new healthcare facilities, good practice also requires an ongoing audit of existing healthcare facilities.

1.2 SHFN 30 is intended to guide and stimulate thinking on the planning and execution of new construction and refurbishment works in all types of healthcare facilities.

1.3 The document is aimed at all those involved in the provision of new or refurbished facilities and aims to ensure that prevention and control of infection issues are identified, analysed and planned for at the earliest stage of a project.

1.4 Project team members and contributors from various disciplines will take different points from the document and it is the ensuing debate and analysis which will improve the quality of the delivered facility.

1.5 SHFN 30 should also be seen as a reference guide, for use in conjunction with the HAI System for the Control of Risk of Infection in the Built Environment (HAI-SCRIBE), which is concurrently being developed for use within NHSScotland. HAI-SCRIBE aims to reduce infection hazards through the development of a prevention and control of infection questionnaire using a number of scenarios within the built healthcare environment.

These scenarios are:

- the proposed site for development of a healthcare facility;
- the design and planning stage of the proposed healthcare facility;
- the construction and refurbishment stage of the healthcare facility;
- the ongoing maintenance of the healthcare facility.

1.6 Although HAI-SCRIBE is intended mainly for new build and refurbishment of healthcare facilities, the question set relating to ongoing maintenance should also be applied to all existing healthcare facilities. Continual maintenance of existing healthcare buildings is important in ensuring that there is no deterioration of existing healthcare facilities. The built environment includes existing buildings used for healthcare purposes and new build projects, and the intention is to apply HAI-SCRIBE from design and planning through to occupation and operation of the facility.

2. Introduction

2.1 In recent years there has been an increase in concern about the risks to health from receiving treatment and care in healthcare facilities. The Report of a Joint Scottish Executive Health Department and NHSScotland Working Group (Carey Group 2001) states that studies have found:

- an estimated 9% of hospital patients acquire an infection during their stay;
- risks are not only present in hospitals but also in primary healthcare and social care settings;
- there is a risk of vCJD, the human form of BSE, being spread from person to person by surgical instruments.

Furthermore, a report by Walker (2001) estimates that the total cost to Scotland of HAI is approximately £186 million per annum.

2.2 Advances in technical and therapeutic methodologies are among the range of factors which present further challenges in relation to control of infection. Organisms with antimicrobial resistance have become a major public health threat, making infection occurring within healthcare premises increasingly difficult to treat. Infection originating in hospitals and other healthcare facilities is now recognised as a serious and widespread problem. Although standards of hygiene in healthcare facilities and standards of personal hygiene have been identified as likely sources of infection and infection spread, it can also be said that the design, planning, construction, refurbishment and ongoing maintenance of the healthcare facility also have an important role to play in the control of infection. The physical environment has to assist, not hinder, good practice.

Origins

2.3 Healthcare Associated Infection (HAI) is a priority issue for NHSScotland. A major programme of work to improve the prevention and control of HAI across NHSScotland was laid out in the Ministerial HAI Action Plan, HDL(2002)82. Under the Chairmanship of the Chief Medical Officer (CMO), the HAI Task Force is now carrying out the programme of work highlighted by the Action Plan. Part of the HAI Task Force 3-year programme of work involves producing guidance on updating the physical environment for older buildings and reviewing the current guidance relating to prevention and control of infection in the built environment; the HAI Task Force Groups 6 & 8 have been charged with undertaking this work. These groups have been combined and are led by Health Facilities Scotland.

Background

2.4 Healthcare Associated Infection (HAI) can be described as infection that is acquired during a visit or is related to a stay in a healthcare facility. In recent years there has been an increase in concern surrounding the risks to health from receiving treatment and care in healthcare facilities. Incidences of HAI are

now recognised as a serious and widespread problem, although the true extent of healthcare associated infection is difficult to quantify.

2.5 As part of the national HAI strategy, an HAI prevalence survey will be undertaken to provide data on the overall burden and costs of HAI to Scotland. This survey is being progressed by the HAI Task Force, through Health Protection Scotland (HPS). The Pilot Survey started in May 2005.

2.6 HAI is significant medically because of the associated mortality and morbidity. This is highlighted by the fact that approximately 1 in 10 patients acquire an infection as a result of receiving treatment and care in healthcare facilities (Plowman et al, 1999). It is also important economically, with one estimate suggesting that the annual cost to NHSScotland due to HAI may be as high as £186 million with the loss of 380,000 bed days (Walker, 2001). Furthermore, research findings show that at least 20% of HAIs are preventable (Harbarth, 2003). Control of HAI is therefore a major concern, and the high incidence of HAI is seen as evidence of poor quality of healthcare delivery, which leads inevitably to avoidable costs (WHO, 2002). It has been estimated that the compensation cost from clinical negligence resulting in HAI is £4 million per annum and non-conformance with recommendations and guidelines of all kinds accounts for 32% of United Kingdom NHS compensation costs (Wanless, 2001).

2.7 The Report of a Joint Scottish Executive Health Department and NHSScotland Working Group in April 2002 states that HAI can affect patients, staff and others in all healthcare settings, not just in hospitals. Potential consequences to health as a result of HAI may be wide ranging including hospital admission, prolonged stay, absence from work, increased costs to the NHS, the individual and/or families, and emotional distress to the latter.

2.8 The most common types of HAIs are urinary tract infection, surgical site infection, and lower respiratory tract infections such as pneumonia, which account for an estimated 92% of all HAIs. Figure 1 adapted from Ayliffe (1992) shows the routes of transmission for Healthcare Associated Infections.

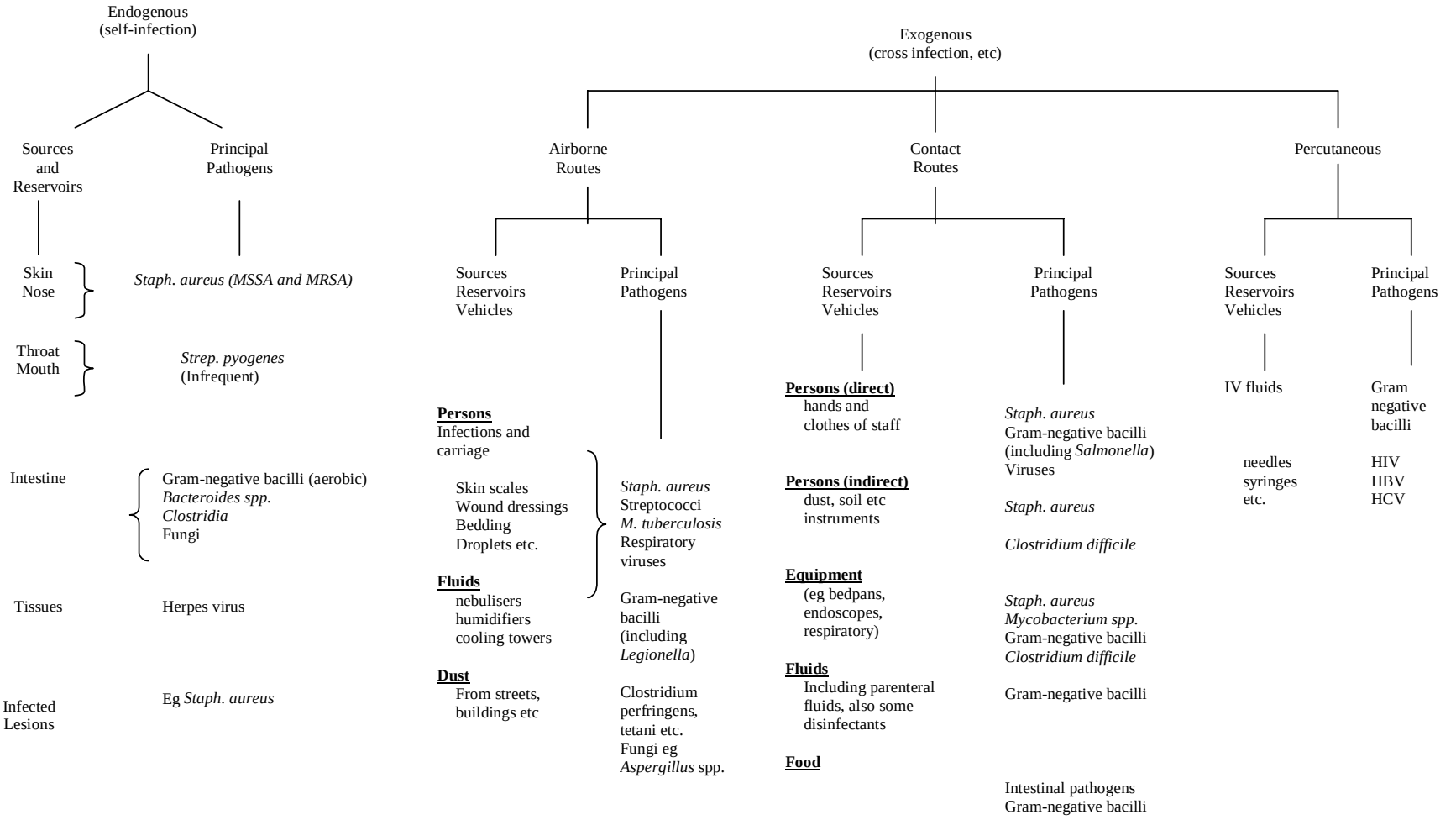

Figure 1: Roots of transmission adapted from Ayliffe (1992)

Purpose of this document

2.9 This guidance document should not be seen as being an infection control manual or a comprehensive guide to the principles underpinning the global issues surrounding prevention and control of infection. It should be seen as guidance which highlights the prevention and control of infection issues associated with site development, design and planning, construction and refurbishment and on-going maintenance of the healthcare facility.

2.10 The document's principal aim is to provide information on the prevention and control of infection, and on the prevention of cross-infection and cross contamination in healthcare facilities, to those responsible for the planning, design and maintenance of such facilities. It is imperative that those involved in these processes have a sound knowledge of prevention and control of infection in the built environment. This document can provide an insight to the key factors within the built environment which can impact on the control of infection. However, further knowledge may be gained by training in HAI which is available from a variety of sources from basic induction training to specialist post graduate level courses such as 'Controlling the risk from Healthcare Associated Infection in healthcare environments' module which is provided by Glasgow Caledonian University as part of the MSc Healthcare Property and Facilities Management. It is therefore intended as a first point of reference on prevention and control of infection for healthcare estates and facilities managers, architects, builders, engineers, surveyors, health planners and Infection Control Teams working on healthcare estate new build and refurbishment projects. It will also be useful as a guide for best practice in existing healthcare facilities.

2.11 Throughout the various sections of the document there are a number of key themes which are repeated. These are:

- Project Team;
- Importance of education;
- Risk management;
- Legislative issues.

2.12 These themes are discussed in Sections 3-6 of this document, in order to give an indication of why they are important in relation to the prevention and control of infection within the built healthcare environment.

2.13 Sections 7-13 refer to the processes involved in the development and maintenance of the healthcare facility. These sections highlight how the key issues fit into the processes involved in the development and maintenance of the healthcare facility.

The built environment and quality of care

2.14 HAI is a complex issue involving the whole patient journey and the many different elements of treatment and care provision, however, it is clear that the built environment plays a key role in the prevention and control of HAI.

2.15 Developing solutions to this serious problem requires a clear understanding of how the commissioning, planning, design, procurement, construction and operation and maintenance of healthcare properties can contribute to the prevention and control of HAI. The absence of a holistic approach to the management of these stages of development and maintenance of healthcare facilities may compromise prevention and control of infection. Although there is a need to improve the evidence base in some areas, much of the knowledge surrounding the control of HAI has been published in standards, journals and guidelines. Much of the solution to the existing HAI problem lies in the effective dissemination and implementation of existing knowledge to all involved, in a logical, accessible form.

3. The Project Team

3.1 Healthcare Associated Infection (HAI) is a complex issue involving the many different elements of patient care and provision. Due to its multi-factorial nature there is a need to develop a holistic approach to combating the spread of infection within the built environment. To achieve this, knowledge from a wide variety of sources is needed including Infection Control Specialists, Architects, Facilities Managers and Engineers.

3.2 A comprehensive approach to planning needs to include consultation with, and participation of, appropriate specialists from its inception through to post-project evaluation.

Management of the Project

3.3 The Scottish Executive Health Department's, Scottish Capital Investment Manual (SCIM) sets out the organisational structure of the Project within NHSScotland, a summary of which can be described as follows:

NHS Board internal organisation

i. **NHS Board** - monitor cost and progress of all capital investment projects at regular meetings. If problems are identified, it needs to be satisfied that appropriate steps are being taken;

ii. **Chief Executive Officer** – accountable to NHS Board. May be only person with total responsibility for project and any other related activities. Responsible for management of all major capital schemes at all stages of the process from inception to post project evaluation;

iii. **Project Board** - comprising senior staff within the NHS Board who have an interest in the project and whose activities will be affected by the project, e.g. staff from clinical areas such as infection control;

iv. **Project Director** - responsible for overall project management. Managing the NHS Boards interest in the Project. Evaluating competence of and appointing Consultants and Contractors who will undertake design and construction activity and act as point of contract in dealings with Contractors;

v. **Professional Adviser** - experienced in construction and design, especially of healthcare facilities;

vi. **User Panel** - representatives of each of the relevant service departments, in each case authorised to define their department's needs and to review and agree how those needs are to be met.

External resources:

i. **Project Manager** – NHS Boards rarely have capacity in-house to develop and manage all aspects of the project, therefore it is usually necessary to appoint external Advisors and Consultants. The Project Manager's role is to provide a single point of responsibility for the project brief and design. They also oversee the day to day progress of the project;

ii. **Other Consultants** – this includes Design Consultants, M & E Engineers and Architects. They are managed by the Project Manager, appointed by the Project Director. However, their responsibility will be to, and their contracts with, the NHS Board.

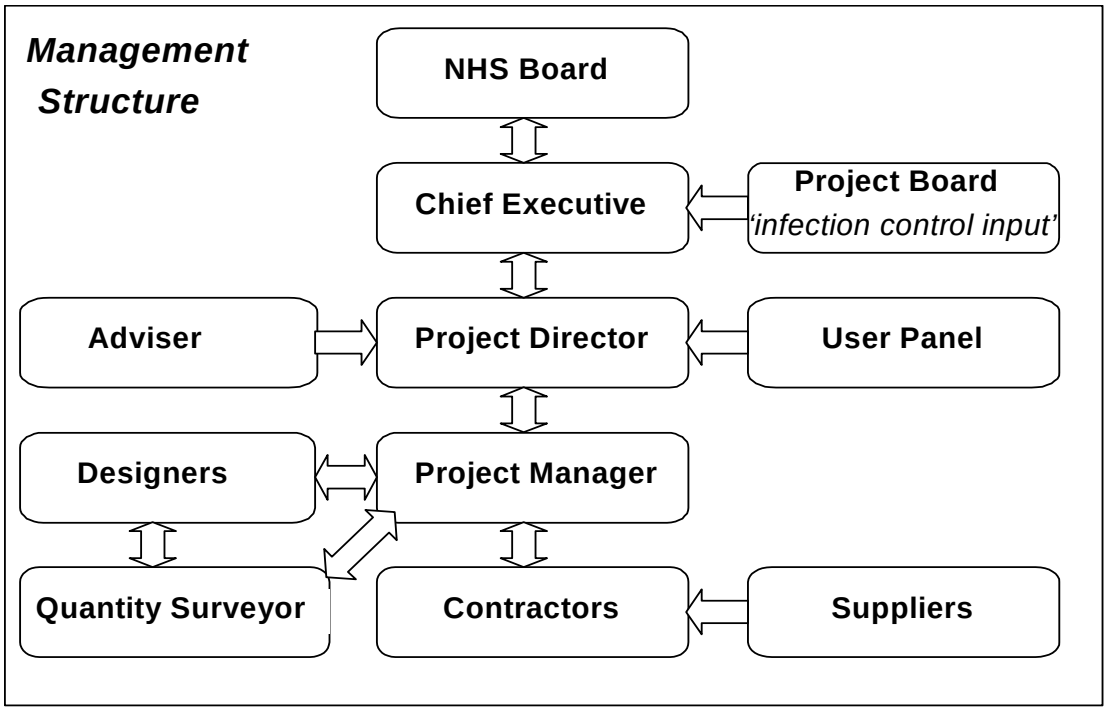

Table 1: Highlighting the management structure of the key players involved in the development of the healthcare facility

Importance of experience and understanding of prevention and control of infection in the Project Team

3.4 Due to its multi-factorial nature, knowledge and understanding of HAI is not only necessary for Infection Control Specialists. There is a necessity for all staff involved in the procurement, design, construction and maintenance of the healthcare facility to be appropriately educated in prevention and control of infection. Training on prevention and control of infection of these groups is available from a variety of sources ranging from basic induction training (NHS Education for Scotland's Mandatory HAI Induction Training Framework and NHS Education for Scotland's Cleanliness Champions Programme), to more specialist training at Post-Graduate level.

3.5 Prevention and control of Healthcare Associated Infection is significantly increasing in profile within NHSScotland. The Ministerial Action Plan

'Preventing infections acquired while receiving healthcare' HDL(2002)82 sets out an Action Plan which is being undertaken by the HAI Task Force. Within the Action Plan there is reference to the promotion of good prevention and control of infection practice in wards, clinical settings and support services, emphasising that the work environment should be conducive to good prevention and control of infection practice and that environment and equipment standards must be maintained.

3.6 There are a variety of measures which contribute to the prevention of infection. However, despite every best effort, not all infections are preventable. Resources must be directed towards minimising the risk where infection can be prevented and facility design plays an important role in achieving this.

Importance of Infection Control input

3.7 Any project to build or refurbish healthcare facilities requires the involvement of a multi-disciplinary team from planning to completion and must include input from Infection Control Specialists throughout the project. The importance of a clean, safe environment should not be under-estimated, as it will help ensure that:

- health and safety needs in terms of limiting the risk of infection of the occupants, healthcare workers and building contractors, are met during the project;
- the building design features will minimise the risk of transmission of infection;
- important design issues are considered at the project planning stage to avoid costly modification at a later stage.

3.8 Infection Control staff provide expertise and advice on the prevention and control of infection and as such play a pivotal role in ensuring other members of the Project Team are appropriately informed of any prevention and control of infection issues which may arise when:

- an initial site is being considered for development;
- the healthcare facility is being designed;
- the healthcare facility is being constructed or undergoing refurbishment;
- the healthcare facility is operational.

Examples of issues to be considered by the Project Team

3.9 Any disturbance of the environment caused by maintenance, demolition, construction and renovation presents a risk of infection to the occupants including:

- exposure to airborne micro-organisms such as *Aspergillus* spp;
- water entry and absorption into building materials leading to increased microbial contamination;

- access for insect pests and vermin;
- increased traffic through the facility;
- dust and debris in patient care areas and local/central decontamination units.

3.10 It is important to consider certain issues before construction work commences including:

- the type and extent of construction or renovation work;
- the likelihood of contamination to adjacent patient care areas;
- the impact on traffic for supplies e.g. sterile stock storage and delivery;
- the air flow and pressure differentials in the area (differentials may be varied by external wind strength and direction);
- the susceptibility of the occupants to infection e.g. through respiratory problems, immuno-compromised or intensive care patients;
- requirements for extra cleaning facilities.

3.11 Suitable efficient barriers may be required for dust control where work is to be carried out near patient areas. Examples of work include:

- demolition of walls, plaster and ceilings;
- removal of flooring, carpets, windows and doors;
- routine maintenance activities;
- any work with water which may aerosolise water droplets in high risk areas;
- exposure of ceiling voids;
- repairing water damage.

3.12 Transmission of micro-organisms with potential to cause infection requires three main elements:

- a susceptible host;
- reservoir of an infectious agent;
- an environment which allows the infection agent to colonise and possibly cause an infection in the susceptible host.

3.13 The risk of infection increases when micro-organisms exist in sufficient numbers in the environment and have the means of transmission to a susceptible host.

3.14 Implementation of effective prevention and control of infection measures reduce the risk of transmission by promoting an environment where risk of interaction between organism and susceptible host is minimised and this can be achieved by:

- proper design and maintenance of ventilation systems;

- designs which minimise accumulation of liquids in the airstream;
- designs which facilitate cleaning and good housekeeping;
- provision, where appropriate, of negative pressure ventilation;
- provision of adequate hand-hygiene facilities;
- provision, where appropriate, of adequate decontamination facilities.

3.15 Standard precautions should be adopted at all times in the healthcare setting but on occasion, additional transmission based precautions such as isolation are required to protect other patients, particularly those who are susceptible, staff and visitors. In any care setting, provision for the following in building design will assist in reducing the risk of infection:

- easy access to hand-hygiene facilities;
- suitable ventilation;
- adequate space for storage and ease of movement for patients and staff;
- surfaces, furnishing and fittings which will minimise dust accumulation;
- surfaces, furnishing and fittings which can withstand recommended decontamination processes and which are cleanable;
- secure and prompt waste and laundry disposal.

Selection of multi-disciplinary team of specialists

3.16 There are a variety of contract agreements with regards to the Project Team involved in the development of the healthcare facility. Each facility should apply the type which is most suitable to them. Ideally, the Project Team will include specialists such as those described in paragraph 3.22. Project Team members should have the appropriate authority to make and action decisions with regard to infection prevention and control.

Assembling the Project Team

3.17 The Project Team should be assembled as soon as possible to ensure that an accurate design brief is developed. Regular meetings with stakeholders referred to in paragraph 3.22 to discuss design, tendering, build and commissioning will ensure the facility is functionally suitable and fit for purpose. Regular communication during the construction and commissioning stages should also ensure that prevention and control of infection risks are highlighted and subsequently eliminated or mitigated.

Selection of consultants

3.18 The main source of guidance for procurement of healthcare facilities in Scotland is PROCODE, produced by Health Facilities Scotland. PROCODE gives guidance on the selection of consultants and is designed to compliment the Scottish Capital Investment Manual (SCIM).

3.19 Every consideration should be given to the quality of composition of the Design Team, including client representatives. Selection of Design Teams entirely, or primarily, on cost is contrary to public sector procurement requirements which demand a best value approach. The quality of the Design Team, including knowledge and understanding of healthcare associated infection, should be a key criteria in the selection of the Design Team. The design brief and/or output specification are critical in achieving a high quality environment.

Roles and responsibilities

3.20 Communication between all parties is paramount in order to ensure that prevention and control of infection risks are highlighted and then either eliminated or managed. The quality of the healthcare facility design and the subsequent tendering and construction phase will be enhanced if all potential risks and interactions with other services are fully examined and discussed as early in the process as practicable. This can be achieved if there is frequent communication and continuous co-operation between the Design Team and the successful Contractor during each stage of the healthcare facility development. Such participation can ensure that prevention and control of infection issues can be controlled promptly and effectively.

3.21 Demonstration of the decision making process e.g. minutes or project evaluation and records of significant decisions should be kept.

Representatives on Project Team

3.22 To ensure all infection issues are highlighted, input is needed from a wide variety of sources. The following list highlights some of the groups which need to be represented; each member of the Project Team must be competent in their designated area.

a) **Project Director**

Responsible for creation and management of the Project Team for delivery of a system which minimises infection in both the construction of operation of the facility.

b) **Client/Department representative**

To represent ward, department or work area. Required to represent end users to ensure the facility will be functionally suitable and fit for purpose.

c) **Infection Control Specialists - representatives from the Infection Control Team**

To ensure prevention and control of infection issues are considered at the planning stage, particularly where work may impact on existing services during the construction phase. Incorporate best practice into the final design and to review post occupancy.

Infection Control may also advise on cleaning and decontamination regimes to be operated post occupancy and to give input in areas such as storage space requirements or clean/dirty workflows.

d) **Design Team (to include Architects, Services Consultants, Planning Supervisor and Clerks of Works)**

To seek the advice of all the relevant professionals and incorporate their views into the final design of the healthcare facility. The Planning Supervisor, in accordance with the Construction, Design and Management Regulations (CDM), has the responsibility to review the Contractor's proposed project programme and advise the Client whether the works can commence. Throughout the project, the Contractor should provide method statements for discussion with the Planning Supervisor and Design Team before any significant elements of work are undertaken, records of which must be kept.

e) **Facilities services**

Depending on the management arrangements, the following functions may need to be represented. This list is not exhaustive and other groups should be consulted as needed.

i. Infection Control Manager;
ii. Domestic;
iii. Waste;
iv. Estates;
v. Catering;
vi. Portering;
vii. Security;
viii. Fire;
ix. Procurement;
x. Sterile services;
xi. Linen and laundry services

Information from these can be used to inform the Design Team and to amend existing schedules before and during the construction phase.

f) **Contractor**

To work with the Design Team to provide a manageable programme of works, ensuring that views of stakeholders and risks identified by the various stakeholders are effectively managed. This is subject to review by the Planning Supervisor (see paragraph 3.22 d) above – Design Team).

4. Importance of education

4.1 Due to HAIs multi-factorial nature, education is not only necessary for Infection Control Specialists. There is a necessity that staff involved in the procurement, design, construction and maintenance of the healthcare facility should be appropriately educated in prevention and control of infection and should be able to demonstrate their knowledge and understanding of the area.

4.2 The nature of the issue means that both the clinical and non-clinical environment are affected. An environment which is designed to be fit for purpose, which limits the risk of infection spread by incorporating facilities, design features and fabrics that facilitates the promotion of standard precautions e.g. hand-hygiene, cleaning, disinfection, decontamination, patient isolation/segregation and waste disposal facilities is therefore essential.

4.3 Training on prevention and control of infection for these groups of staff is available from a variety of sources, and ranges from basic mandatory induction training to more specialist training at Post-Graduate level. An HAI module aimed specifically at these groups of staff has been incorporated into Glasgow Caledonian University's MSc Healthcare Property and Facilities Management. The module is also available outwith the MSc as a continuing professional development course.

4.4 One of the key priorities outlined in the Ministerial Action Plan 'Preventing infections acquired while receiving healthcare' HDL(2002)82, was the introduction of mandatory induction training on HAI for healthcare workers. Based on the principle that the greater number of healthcare workers with direct or indirect patient contact who have an understanding of the Standard Infection Control Precautions, the greater the chance of promoting high personal standards and behaviours, and reducing the prevalence of HAI within NHSScotland.

4.5 NHS Education for Scotland (NES) has developed a multidisciplinary prevention and control of infection educational programme entitled 'The Cleanliness Champion'. The programme is designed for staff with direct patient contact, and introduces the concept of standard precautions being applied at all levels of care to protect patients and staff from infection risk. Further information on training on HAI can be found at www.nes-hai.info/.

5. Risk management

5.1 Risk management involves three stages:

1. Identifying risk.
2. Assessing risk.
3. Managing the identified risk by elimination or by using controls to reduce the severity of risk.

Identifying risk

5.2 The time taken to plan or refurbish a healthcare facility can vary from a relatively short period in the case of urgent renovation, to as long as three or four years for a major capital build project. It is therefore important that Infection Control Teams are notified of capital bids or contracts given to Architects at the earliest opportunity. The Infection Control Team need to be involved in the first planning meetings. Most meetings thereafter will require some input from them.

5.3 To avoid mistakes and pitfalls the Project Team must consider issues including:

- How will the product, equipment, room or clinic be used?
- What possible solutions are available?
- What are the budgetary limitations?
- Which prevention and control of infection principles or external regulations apply?
- What does the evidence suggest in relation to the specific context?
- What are the laws governing the project?
- What are the standards and guidelines from architectural and engineering bodies, government departments and accrediting agencies?
- Which product or design best balances the infection control requirements with employee and patient safety and satisfaction, and cost constraints? (Carter and Barr, 1997.)

Common pitfalls

5.4 Common pitfalls arise from a number of pressures, for example, the pressure to choose the cheapest products or design. As many authors have argued, the best products or designs may be more expensive initially but in the long term they will probably realise cost benefits as they may prevent outbreaks, or they may last longer and require less maintenance and be more durable.

Common errors

5.5 Common errors in design and construction (adapted from Carter and Barr, 1997) due to inept or non-existent risk management include:

- air intakes placed too close to exhausts or other mistakes in the placement of air intakes;
- incorrect air turnover and airflow patterns;
- air-handling systems which function only during the week or on particular days of the week;
- ventilation systems which are not fully commissioned;
- negative air-pressure rooms being omitted from large, new inpatient buildings;
- carpet placed where vinyl should be used;
- aerators on taps (also avoid swan-neck outlets where possible);
- sinks located in inaccessible places;
- patient rooms or treatment rooms which do not have sinks in which healthcare workers and visitors can wash their hands;
- doors too narrow to allow beds and equipment to be moved in and out of rooms;
- inadequate space to allow safe use of medical devices and equipment.

5.6 Carter and Barr reported these errors they had encountered during construction projects in their practice of prevention and control of infection. They recommended that Infection Control personnel inspect the construction site frequently to make sure the workers are following the correct guidance.

Assessing risk

5.7 Outbreaks of infection have been related to the design, plan, layout, function and/or finish of the built environment (Cotterill et al, 1996; Kumari et al, 1998). Thus, risk assessment is a fundamental imperative in the planning and design stages of a healthcare facility, yet it is often overlooked or compromised throughout the lifecycle of the project. Disseminating good specialist knowledge and involving Infection Control Teams throughout all phases of construction and renovation projects will reduce risks. Failure to properly assess prevention and control of infection risk can lead to expensive redesign later and expose the patient and healthcare worker to prevention and control of infection hazards.

Managing the risk

5.8 Part of the Infection Control Team's role is to help non-clinical professionals to understand the main principles of how infection is spread in the context of the built environment.

5.9 When evaluating the spread of infection and its control, three aspects should be considered:

- source;
- mode of transmission; and
- susceptible recipient.

These principles should be applied to all stages of the development of the healthcare facility.

Source

5.10 Building professionals must be convinced about the risks associated with construction projects, and that the environment can be a reservoir for potentially infectious agents. The source is the person, animal, object or substance from which an infectious agent is transmitted to a host. The immediate healthcare environment can be a potential reservoir of micro-organisms and source of infection or contamination, therefore, Designers and Planners need to consider eliminating potential sources of infection by practising good design, for example:

- storage facilities;
- choice of materials, avoiding unnecessary surfaces that may become reservoirs for infectious agents;
- ensuring materials and surfaces can be cleaned and maintained.

5.11 It has been reported (Rampling et al, 2001) that antibiotic-resistant bacteria, such as meticillin-resistant *Staphylococcus aureus* (MRSA), may survive and persist in the environment leading to recurrent outbreaks.

5.12 Attention to prevention of airborne infection by the use of ventilation in specialised areas and correct engineering and mechanical services contribute greatly to reducing potential reservoirs of infection in the built environment.

5.13 Elimination of other environmental sources of infection, for example pests, litter, insects, birds, small mammals and waste, should be considered at the outset of a project and reviewed throughout. Common pests include rats, mice, ants, cockroaches, pigeons and flies. All carry micro-organisms on their bodies and in their droppings. Healthcare facility hygiene is dependent on controlling pests.

Mode of transmission

5.14 A basic understanding of modes of transmission of infection assists in promoting joint responsibility for prevention and control of infection. Micro-organisms can be transmitted in three main ways:

- **direct** transmission involving direct transfer of micro-organisms to the skin or mucous membranes by direct contact;

- **indirect** transmission involving an intermediate stage between the source of infection and the individual, for example infected food, water or vector-borne transmission by insects;
- **airborne** transmission involving inhalation of aerosols containing micro-organisms, for example legionnaires disease or tuberculosis.

5.15 Environmental dispersal of micro-organisms during construction, resulting in HAIs, should also be emphasised to non-clinical members of the Project Teams.

5.16 There is a need to assess the infection risks during construction and how construction activity itself may be a mechanism for dissemination of infection; for example, environmental airborne contaminants and infectious agents are closely related to water and moist conditions which feature prominently in construction activity.

Susceptible recipient

5.17 Preventing transmission of infectious agents to vulnerable patient populations, healthcare workers and visitors is an important component of prevention and control of infection programmes.

5.18 Outbreaks of infection, affecting immuno-compromised patients, have been reported, and construction professionals need to understand the concept of the at-risk patient. Some groups of patients are especially susceptible to certain infectious agents to which they may be exposed in the healthcare construction environment.

Conclusion

5.19 The integration of prevention and control of infection risk management and construction is in its infancy. It represents a significant change in the management of healthcare facilities design and planning which will take time to develop to a level at which the greatest benefits can be achieved. Just as important then is the need to carry out research in the area of risk management, prevention and control of infection and the built environment to produce sound irrefutable evidence on which to base further risk management strategies.

Important

- always consult the Infection Control Team at an early stage:
  - whenever refitting or refurbishment is planned;
  - whenever major capital bids are planned;
- do not wait until patients are ready to move in;
- do not wait until fixtures, fittings and furnishings have been purchased;
- do not let cost or space consideration override reason;
- most advice will be commonsense but not always popular financially.

6. Legislative issues

Health and safety

6.1 Due to the complexity of the process of developing a new healthcare facility, there is a great scope for errors and omissions which can affect the delivered facility in terms of its ability to contribute to, or at least limit the spread of infection.

6.2 HAI is a health and safety issue and the actions or omissions of those involved in the provision or operation of the facility could become evidence in any legal action stemming from an infection. For this reason it is essential that, as with other considerations of professional competence, all those involved in the commissioning, procurement, design and planning and construction refurbishment or ongoing maintenance are able to demonstrate that appropriate expertise was in place and advice sought.

6.3 A number of pieces of legislation put the primary responsibility for the safety of the facility, including HAI, on the employer, usually the NHS Board. In construction procurement the 'employer' sets the resource, assesses the competence of the Design Team and evaluates the output. This means the employer should lead on setting the quality culture that will deliver a safe environment.

Health and Safety legislation and prevention and control of infection

6.4 It is important to remember that many of the recommendations in this guidance, while evidence based, may also be required by Health and Safety law in respect of controlling the risk of infection to staff and patients. This needs to be taken into account during the process of planning, designing and maintaining healthcare premises, as this will clearly influence the final outcome. The following outlines some of the key features of relevant legislation which impinge on the control of infection. Other relevant legislation may also be applicable.

Health and Safety at Work etc Act 1974

6.5 The duties of employers under the Health and Safety at Work etc Act 1974, including protecting the health, safety and welfare of employees, extends to patients and others who may be affected by any work – this includes control of infection measures.

The Provision and Use of Work Equipment Regulations (PUWER) 1998

6.6 Anyone involved in the supply of equipment, plant or machinery for use at work has to make sure that, as far as is reasonably practicable, it is safe and does not cause any risk to health when used at work.

For example:

- equipment should be made of materials that can easily be cleaned and which do not support microbial growth;
- plant or equipment which needs regular cleaning should be easy to access and easy to dismantle.

The Construction (Design and Management) Regulations 1994 (CDM) (as amended 2000)

6.7 These Regulations require that health and safety is taken into account and managed throughout all stages of a project, from conception, design and planning through to site work and subsequent maintenance and repair of the structure. These Regulations apply to most common building, civil engineering and engineering construction work (including demolition, dismantling and refurbishment).

6.8 The NHS Board has Client responsibilities under these Regulations; it has to pass relevant reasonably available information about health and safety matters which relate to the project to those who are responsible for planning the project.

6.9 The CDM Regulations state that Planning Supervisors have responsibility to review the Contractor's proposed project programme and advise the Client whether the works can commence.

The CDM Regulations also state that Designers should:

- ensure that when they design for construction they assess the foreseeable health and safety risks during construction as well as the eventual maintenance and cleaning of the facility in the balance with other design considerations such as aesthetics and cost. This can be achieved by applying the normal hierarchy of risk control;
- identify all the hazards inherent in carrying out the construction work and, where possible, alter the design to avoid them. If the hazards cannot be removed by changing the design, then the risks will need to be controlled and the designer should provide information about the remaining risks.

The Control of Substances Hazardous to Health (COSHH) Regulations 1999

6.10 COSHH provides a framework for controlling the risks from most hazardous substances, including biological agents, which can contribute to the risk of infection.

6.11 COSHH requires that employers assess the risk from all infectious agents to both their employees and others who may be affected by their work, for example patients. The assessment needs to be suitable and sufficient and must cover the steps that need to be taken to meet the requirements of the rest of the Regulations. This means that the assessment should also review the use of control strategies, the maintenance and use of control measures such as air

handling systems and air filtration, health surveillance requirements and, perhaps most importantly, information, instruction and training for employees.

6.13 There are a number of general measures in COSHH relating to the control of exposure to biological agents which must be applied in the light of the results of the assessment. Other procedural/management control measures must also be applied if employers are to fully meet their duties under COSHH including:

- keeping as low as practicable the number of employees exposed or likely to be exposed to biological agents;
- designing work processes and engineering control measures so as to prevent or minimise the release of biological agents into the place of work;
- displaying a biohazard sign and other relevant warning signs;
- drawing up plans to deal with accidents involving biological agents;
- specifying appropriate decontamination and disinfection procedures;
- instituting means for the safe collection, storage and disposal of contaminated waste, including the use of secure and identifiable containers, after suitable treatment where appropriate;
- making arrangements for the safe handling and transport of biological agents, or materials that may contain such agents, within the workplace;
- specifying procedures for taking, handling and processing samples that may contain biological agents;
- providing collective protection measures and, where exposure cannot be adequately controlled by other means, individual protection measures including, in particular, the supply of appropriate protective clothing or other special clothing;
- where appropriate, making available effective vaccines for those employees who are not already immune to the biological agent to which they are exposed or liable to be exposed;
- instituting hygiene measures compatible with the aim of preventing or reducing the accidental transfer or release of a biological agent from the workplace including in particular, the provision of appropriate and adequate washing and toilet facilities and the prohibition of eating, drinking, smoking and application of cosmetics in working areas where there is a risk of contamination by biological agents.

6.14 'Appropriate' in relation to clothing and hygiene measures means appropriate for the risks involved and the conditions at the workplace where exposure to the risk may occur.

7. Procurement and construction process

Overview

7.1 The procurement and construction of a healthcare facility is a highly complicated process and requires input from a wide variety of sources. During the procurement and construction process, reference should be made to existing guidance relating to the procurement and construction of healthcare facilities such as that contained in the Scottish Executive Health Department's Scottish Capital Investment Manual (SCIM).

7.2 Infection Control Specialist input is essential in relation to procurement at the design and planning stage of a project. There is a case for stipulating that Architects and Designers for healthcare projects should be able to demonstrate their knowledge and understanding of prevention and control of infection.

7.3 The specification of building materials, especially surface finishes, healthcare facility equipment etc should take account of the input from the Infection Control Specialist.

7.4 The Scottish Capital Investment Manual (SCIM) comprises a number of guidance booklets covering the following areas:

- Overview;
- Project Organisation and Management;
- Private Finance Guide;
- Business Case Guide;
- Management of Construction Projects;
- Commissioning a Healthcare Facility;
- Information Management and Technology Guide;
- Post Project Evaluation.

7.5 Other sources of information which should be consulted include Health Facilities Scotland procurement guidance PROCODE which provides an insight into the contracting aspects of health building projects, including the implementation of national policy and EU directives. PROCODE provides guidance on a wide range of procurement issues including the appointment of Works Contractors and Consultants and the use of various forms of contract.

7.6 Prevention and control of infection issues associated with procurement and construction need to be given appropriate priority and consideration. Recommendations and the incorporation of recommendations should be documented. It is therefore essential that the advice of Infection Control Specialists should be sought as a routine feature of the procurement and construction process and HAI-SCRIBE should be applied at the appropriate stages of procurement and construction. The involvement of Infection Control

Specialists and the application of HAI-SCRIBE is not restricted to certain levels of project expenditure but rather is applicable to all procurement and construction processes.

7.7 Health and safety considerations are an important feature at this stage and at least some of the health and safety considerations will influence final outcome in terms of prevention and control of infection. The duty of employers to protect employees also extends to patients and others who may be affected by inappropriate prevention and control of infection measures.

8. Evaluation of site for development

8.1 Due to the complexity of the management of HAI, especially in relation to the built environment, input from a wide variety of sources is necessary for success.

Selection of multi-disciplinary team of specialists for implementation of HAI-SCRIBE

8.2 HAI-SCRIBE aims to manage infection risks through the development of a prevention and control of infection questionnaire. The system highlights the need for a multi-disciplinary team of specialists with appropriate skills to ensure its implementation. This is an essential requirement in terms of the evaluation of the site for development. Inappropriate decisions, or a less than rigorous investigation of the site, may well result in infection problems being identified at a later stage when it may be very difficult or indeed impossible to remedy the situation. Remediation of the situation may also prove expensive and investment at this stage may pay dividends over the life of the facility.

8.3 The multi-disciplinary team of specialists may include, amongst others:

- an Architect;
- a Building Services Engineer;
- an Infection Control Specialist with experience/knowledge of the built environment;
- a Risk Manager;
- an Estates/Facilities Manager.

Record of decision-making

8.4 A record of significant decision-making should be maintained. Such a record is evidence of 'due diligence' and helps to ensure that prevention and control of infection issues are implemented. Good practice requires implementation of a risk management system such as HAI-SCRIBE, this being an accurate record of the process of hazard assessment and risk management. Signing off by the Infection Control Specialist at each stage of the development, including this stage of the evaluation of the site, should be considered an essential step.

Pollution/contamination

8.5 Pollution from external sources can contribute to the spread of infection within the built environment (e.g. ingress of *Aspergillus* spores or *Legionella* bacteria during earthworks). Limitation of external pollution can go some way to controlling the spread of infection within the built environment.

8.6 HAI-SCRIBE highlights in its question sets, the potential for infection risk when consideration is being given to a proposed site for development. Research into the history of the area being proposed for development, together with a rigorous

examination of existing industries and businesses, will highlight any potential for infection risk and the measures which may be appropriate to manage the infection risk. Failure to be rigorous in relation to the historical research of the area and the examination of existing industries in the area may result in infection risks not being identified until it is too late to effectively manage them. Specialist external advice is likely to be necessary.

8.7 There are other pollution/contamination issues which may also need to be identified and addressed, even if these are not infection risks e.g. land contaminated by chemicals, asbestos etc.

Topography of site

8.8 When considering the topography of the proposed site for development, issues such as the prevailing wind direction and the associated prevention and control of infection issues need consideration.

8.9 For example, the positioning of the healthcare development in relation to cooling towers in the area and the potential infection risk from entrainment of vapour plumes containing *legionella.*

Implication of choosing natural ventilation

8.10 Adequate ventilation in healthcare facilities is essential for fresh air supply, odour dilution and the removal of airborne contamination.

8.11 In relation to evaluation of a site for development, consideration should be given to how the foreseeable conditions of the site will affect the performance of the ventilation system chosen.

8.12 In areas where the functioning of the ventilation system is critical to the minimisation of HAI risks, a mechanical ventilation system is most likely to be appropriate. The possibility for contaminants to be introduced in the fresh air supply from sources such as earthworks or cooling towers should be considered.

8.13 Where ‘natural’ ventilation is considered, this falls into two broad categories; controlled and uncontrolled. Uncontrolled ‘natural’ ventilation is most frequently seen as opening windows. Its performance is not predictable and as such, it is inappropriate as a strategy for ventilation in areas where controlled conditions are required. Uncontrolled natural ventilation allows contaminants such as fungal spores to be introduced to the ventilated space in untreated air when windows are open. Conversely, when windows are closed, dilution of contaminants in the ventilated space will be greatly reduced.

8.14 Between these two extremes is controlled natural ventilation where the ventilation, whilst not provided through a conventional ducted ventilation system, is designed, engineered and maintained to provide predictable performance.

8.15 As such a system is likely to be more affected than a mechanical system by external influences such as weather conditions, its design will require specialist knowledge. This type of system may involve filtration of incoming air but will not generally involve other air treatment such as heating. The motive force for the air will often be the buoyancy of air at room temperature, however, this entails relatively low pressure differentials which will constrain the type of filtration used.

8.16 Although air-conditioning may seem a straight-forward solution to the control of the environment, it is expensive to run and not environmentally sustainable on a large scale. Within the working life of buildings being built now, restrictions in Carbon Dioxide emissions allowances are likely to preclude the routine use of air-conditioning. For this reason, sites which necessitate sealed, air-conditioned buildings should be avoided.

Impact of activities in the surrounding environment

8.17 Activities occurring in the surrounding environment can contribute to the spread of infection. For example, there may be construction/demolition works programmed in the neighbourhood which may present a risk e.g. fungal contamination arising from earthworks. Measures to limit these risks should be implemented.

Constraints of developing on a pre-determined site

8.18 In some cases the use of a particular site is unavoidable and in this case, steps must be taken to minimise any adverse conditions inherent on the site. HAI-SCRIBE highlights in its question sets the potential for infection risk arising from restraints on the development of a pre-determined site. For example, will lack of space limit the proposed development and any future expansion of the facility (e.g. to increase single room provision) and might this create or increase a risk of infection? Will the proposed development impact on the surrounding area in any way which may lead to restrictions being applied to the operation of the proposed facility which may in turn present potential for infection risk (e.g. storage and collection arrangements for healthcare waste).

Strategic planning

8.19 Infection Control Specialist input is essential at the strategic planning stage. It is never too early to have prevention and control of infection input.

8.20 To allow Infection Control Specialists to effectively participate in the planning process for both renovation and new-build projects, it is necessary for them to understand the process from its inception to completion.

8.21 A comprehensive approach to planning needs to include consultation with the appropriate specialists from inception through to post-project evaluation. The Project Team should include specialists as described in paragraph 3.20 of Section 3.

9. Design and planning stage

9.1 At the design and planning stage, it is crucial that hazards associated with infection risk should be identified and assessed, and measures taken to manage these risks. It is essential to 'design in' at the design and planning stage, measures which will eliminate or minimise the impact of identified hazards and effectively manage the risk of infection. Reference should be made to the question sets contained within HAI-SCRIBE.

Strategic planning and the role of prevention and control of infection

9.2 In the 'National Overview for Improving Clinical Care in Scotland: Healthcare Associated Infection (HAI); Infection Control', NHS Quality Improvement Scotland (QIS) prescribes that prevention and control of infection are considered as part of all service development activity. In the USA, the current authority for construction, design for federal and healthcare providers is the 2001 edition of 'Guidelines for Design and Construction of Hospital and Healthcare Facilities' published by the American Institute of Architects/Academy of Architecture for Health (2001) with assistance from the US Department of Health and Human Services; http://www.aia.org/aah_gd_hospcons The latest version strongly supports prevention and control of infection input at early planning and design stages.

9.3 For Infection Control Teams to effectively participate in the planning process for both renovation and new-build, it is necessary for them to understand the process from its inception to completion.

9.4 Where significant refurbishment is being considered, or the use of an existing patient facility is being planned, Infection Control Specialist input is essential at the strategic planning stage. It is never too early to have prevention and control of infection input.

9.5 To allow Infection Control Specialists to effectively participate in the planning process for both renovation and new-build projects, it is necessary for them to understand the process from its inception to completion.

9.6 The organisation of the Project Team involved in Strategic Planning is given in paragraph 3.22 of Section 3.

The planning process

9.7 The planning process, although refurbishment work may be different, is comprised of the following stages:

- the concept/feasibility study;
- sketch plans;
- the preparation of a business case to support the viability of the project;

- project funding;
- the design stage;
- project monitoring;
- commissioning the facility;
- post-project evaluation.

Table 2 highlights the infection control input required at each stage.

9.8 Its aim is to prompt those with overall responsibility for managing capital schemes or Private Finance Initiative/Public Private Partnerships (PFI/PPP) to include prevention and control of infection advice at the right time in order to prevent costly mistakes.

These points are expanded upon in more detail below.

Concept/feasibility study

9.9 The planning process starts with the identification of a 'need' by the users. The development of this need will involve feasibility studies to enable a design brief or output specification to be developed. The Infection Control Team should review operational policies and procedures at this stage and there may be 1/200 designs to give a broad overview of the scheme. The Infection Control Team needs to consider:

- the effect additional beds or departments will make to policies such as waste disposal, linen and catering, etc.;
- the effect of extra theatres on decontamination services, workflow, etc.;
- additional specialised areas that will probably require extra infection control and laboratory input as well as specialist advice which may not be available in-house e.g. bed space and size of departments, etc., plus engineering services needs such as ultra-clean ventilation, showers baths, etc.

Further details on this process can be found in Table 2.

Space planning

9.10 There are a number of issues in terms of design and layout which could contribute to the risk of transmission of micro-organisms. For example, the design of the ventilation system needs to inhibit contamination spread rather than contribute to it. The internal and external routes identified for removal of dirty laundry, waste food, healthcare waste, similarly need to be planned so as to inhibit rather than encourage contamination.

9.11 There should be adequate space within the healthcare facility for storage of consumables, for example, there should be adequate storage in theatres for small orthopaedic implants.

9.12 The location of departments, theatres, wards and rooms needs to take account of good prevention and control of infection practice and ensure that workflows are designed to inhibit infection spread.

9.13 It is very important that the design and layout of the healthcare facility should inhibit the spread of infection. Reference should be made to HAI-SCRIBE and its question sets in relation to this.

9.14 Workflow systems should facilitate travel from clean to dirty to clean but never back again to clean. This principle is important in terms of limiting infection spread.

9.15 Correct workflow systems must be maintained throughout the building project. Input from Infection Control Specialists is essential at the planning stage of the project, requiring close collaboration between Infection Control Specialists and the Design Team. This is especially important in the planning of specialised units, for example, theatres and critical care.

9.16 Most healthcare departments have clean-to-dirty area flow systems. Workflow is a basic element of good prevention and control of infection practice and this needs to be reflected when the built environment is being planned.

Sketch plans

9.17 The remaining 1/200 designs will be available at this stage and the Infection Control Team needs to give a broad view of prevention and control of infection issues such as:

- missing rooms;
- wards without ancillary areas.

Additional considerations at this point will include:

- storage;
- ancillary areas;
- single rooms;
- isolation rooms;
- changing facilities;
- lifts;
- pneumatic delivery systems.

The business case

Outline business case

9.18 The preparation of a business case is the process that supports NHS Board submissions for funding of new capital projects. A business case must convincingly demonstrate that the project is economically sound, is financially

viable (affordable to the NHS Board and purchasers) and will be well managed. In addition, a business case for any investment should show that it will benefit patients. An overview of the capital investment process is given in the Scottish Capital Investment Manual (SCIM).

9.19 The involvement and support of a wide range of managers and staff is vital to the success of the business case, both to determine the requirement and scope of the investment and also to participate in subsequent stages of planning. It is important therefore at this stage to identify and involve key people who have a direct interest in the end product. This will include members of the Infection Control Team along with other leading clinicians, nursing managers and departmental heads. Specifically at this stage, Infection Control Teams need to:

- establish the goals of prevention and control of infection. What prevention and control of infection risks are especially important for each specific context;
- agree the agenda for prevention and control of infection design and planning;
- communicate prevention and control of infection imperatives throughout the course of the project, but especially at the initial stages;
- monitor the progress of the building/refurbishment project in relation to compliance with infection control specifications;
- determine available resources that can be used and recognise the cost benefits of not cutting corners on prevention and control of infection issues.

9.20 Normally the input from the Project Team should be managed by the Project Director. For larger and more complex schemes, a Project Manager reporting to the Project Director may be appointed to conduct the detailed work and manage the Project Team.

Issues to be addressed by the Infection Control Team

9.21 The Infection Control Team must ensure that prevention and control of infection implications are not compromised by reducing or overcrowding in clinical areas. The issues frequently addressed will include costs and space constraints which will impact on areas such as:

- storage and equipment cleaning areas;
- ventilation;
- hand hygiene facilities;
- furnishing;
- appropriate finishes;
- isolation rooms/rooms used to segregate patients;
- specific products with infectious implications;
- applicable regulations;

- domestic services room.

Detail planning

9.22 It is at this stage, when the outline business case is presented, that the 1/50 designs will be available. There will probably be two stages to the consultation process:

1. Early on in this period the Infection Control Team will need to discuss location of rooms for correct workflow/prevention and control of infection practice, i.e. wards, theatres and patient passage through out-patients or primary care facilities, etc.
2. Later there will be a need to discuss the finer details such as where fixtures and fittings are located, what type of flooring, cupboards or storage systems are to be used, and ventilation in theatres, etc.

9.23 The Infection Control Team will also need to think about the prevention and control of infection issues around:

- workflow;
- hand-wash basins: types, numbers and location;
- fixtures/fittings/flooring;
- wastewater and sewage/body fluid disposal;
- ventilation;
- heating and lighting;
- water systems;
- suction/medical gases;
- storage systems;
- ward kitchens/pantry.

9.24 The business case process should highlight the variables that drive the facility's requirements with regard to prevention and control of infection. This is not always an easy task in the initial stages of a project. Table 4 gives a range of initial ideas.

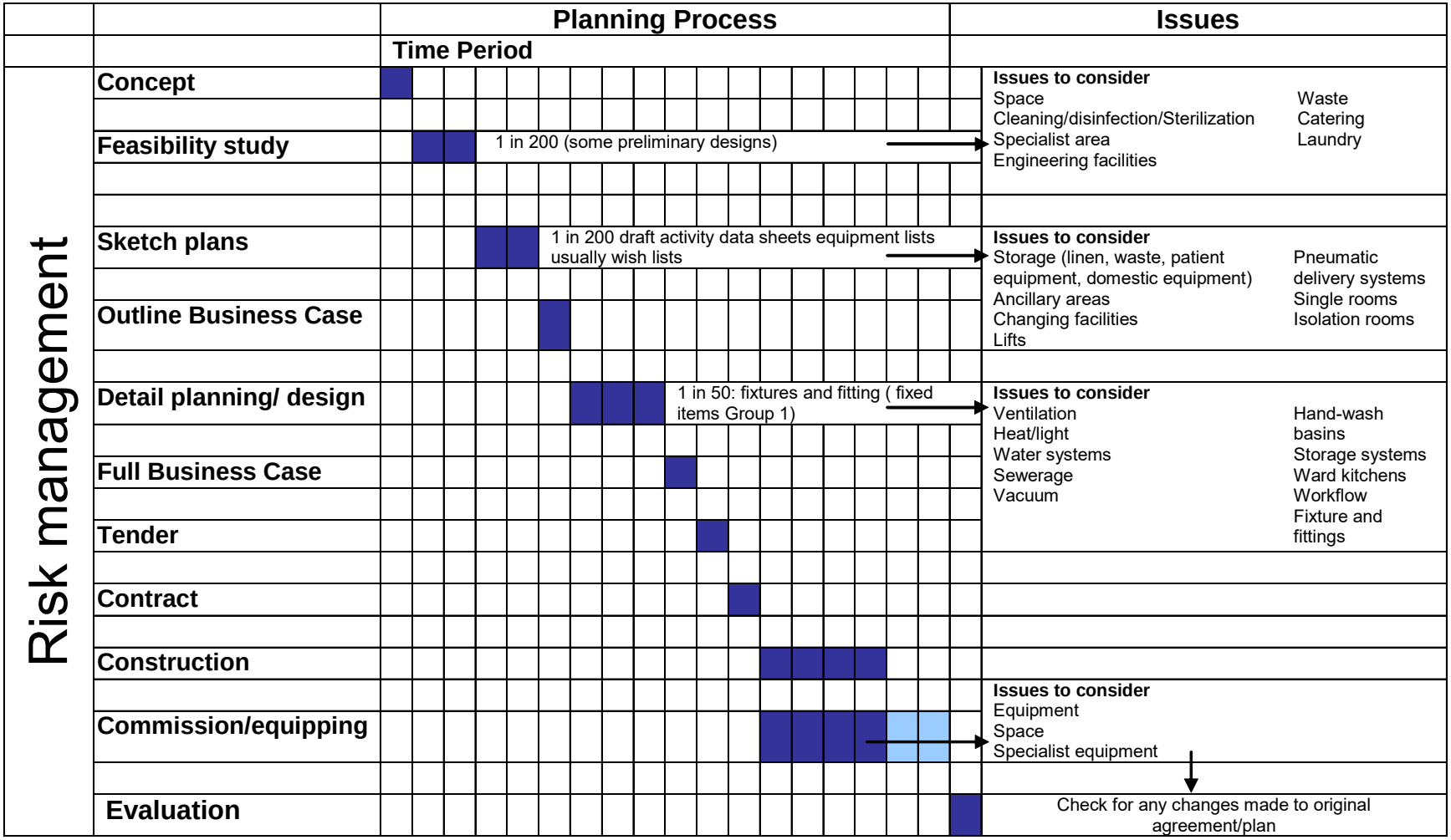

Table 2: Project Development Chart

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Typical Stages of Infection Control Input

1. **Concept/feasibility study:** Infection Control Team should review operational policies and procedures, e.g. 1/200 plans.

   Adding beds to ward area may mean extra sluice or side rooms.

   Adding extra theatres will need a review of decontamination services for instruments.

   Additional specialised areas will need extra prevention and control of infection input.

2. **Sketch plans:** at this stage, the Infection Control Team needs to give a broad view of prevention and control of infection issues e.g. rooms missing, wards without ancillary areas such as disposal rooms or dirty utility.

3. **Detail planning/design:** (1/50 designs – early period)

   There is a need to finalise locations of rooms for correct workflows/prevention and control of infection practice, i.e. wards, theatres.

4. **Detail planning/design:** (1/50 designs – later period)

   Need to discuss finer details within rooms: location and type of fixtures and fittings, e.g. hand-wash basins/types of basins; airflows in theatres, flooring.

5. **Construction:** the Infection Control Team will need input here, particularly if the new build is attached to an existing healthcare building, to prevent risks to patients.

6. **Equipment:** decisions on equipment should be made as an ongoing process, but it is at this stage that it will be seen that previous equipment 'wish-lists' may not fit the rooms/departments or are now outdated. It is important that Infection Control Teams have input during this period (especially if it is a PFI/PPP build).

7. **Commission/equipping:** Infection Control Teams must have input during this stage if costly and dangerous mistakes are to be avoided.

8. **Evaluation:** this is an important stage in which lessons learnt can be highlighted for future projects, both within NHS Boards and throughout NHSScotland. Post-project evaluation is mandatory and results should be available to other Boards.

Table 3: The Key Stages of the Planning Process and examples of Infection Control input

Accommodation areas/internal environment/general services	Examples: Key issues and areas to be considered
Accommodation areas	
Bed areas: • Single-bed rooms	En-suite facilities.
• 4-bedded bays versus 6-bedded bays	• Doors on bays • En-suite facilities
Dirty utility/clean utility	Standardisation of rooms/ choice of equipment e.g. bed pan vs macerator. Space.
Workflow/layout	Standard ward area versus specialised area.
Bed Planning	Elective. Emergency.
Linen services and facilities	Internal laundry versus commercial laundry.
Catering/kitchen areas	Furnishing, fixtures and fittings plus workflow crucial for HACCP. Commercial systems e.g. cook-chill versus in-house systems.
ITU/HDU	Single rooms versus 4/6 bed bays.
Handwash basins	1 to 2 versus 1 to 4 versus 1 to 6 dependent on room types. Facilities to ensure compliance with hand hygiene guidance: sinks, taps, soap, gloves, aprons. Easily accessible for staff use.
Staff change areas/storage of uniforms	Type of uniform provided will dictate, i.e. 'greens' versus classic.
Decontamination facilities. CDU/LDU	Operational policy dictated by choice of decontamination strategy
Equipment	Bed/mattresses. Purchase versus hire. Endoscopes/instruments. Cleaning/disinfection requirement. Patient specific. Enough equipment available.
Priority areas	
• Critical care • UCV Theatres • Hydrotherapy • Mortuaries • SCBUs and maternity • Renal units • Oncology • Neurology • Paediatrics • Decontamination units • Pharmacy aseptic dispensary	Every specialist area will have different requirements and infection control issues so cannot be planned as standard departments.
Internal Environment	
Ventilation	Single rooms, bays, theatres, pacing rooms, treatment rooms, internal sanitary areas. Negative and positive pressure isolation rooms.
Heating/ventilation	Dust-free options, i.e. hidden heat panels versus radiators.
Lighting	Quantity. The use of sealed units.
Furnishings, fittings and artwork	Walls/floors/ceilings – hygiene versus aesthetics.
Water	Deadlegs. Water turnover. Appropriate temperature for hot and cold systems. Water coolers/fountains.
General services	
Disposal of waste	In-house versus commercial. Storage.
Communications	IT systems (timely information on pathology, etc, operational policies, infection control policies, procedures and training).
Emergency plans	Water storage if water cut off/heating/medical gases and vacuum/suction/emergency generator, ventilation, etc.

Table 4: Infection control issues to consider in the Capital Planning Process. (Note: this is not an exhaustive list)

(Shaded boxes include examples of issues related to prevention and control of infection which might need to be considered.)
1. Set the strategic context: • where are we now? • where do we want to be? • is it affordable?
• in-patient/day cases; • single room issues;
2. Define objectives and benefit criteria:
• facilities for patients with antibiotic resistant infections; • cost benefits of preventing healthcare associated infection.
3. Generate options.
4. Measure the benefits.
5. Identify/quantify costs.
6. Assess sensitivity to risk.
7. Identify the preferred option.
8. Present the outline business case.
9. Develop the preferred option: full business case.

Table 5: Typical steps in the business case process.

The HAI implications associated with using private finance

Dealing with HAI in PFI/PPP Projects

9.25 The Scottish Executive Health Department encourages the consideration of the strengths of the private sector and the use of privately raised capital. There are essentially two broad criteria against which all schemes are assessed: 'value for money' and 'assumption of risk'. NHS Boards are expected to explore the private finance alternative whenever a capital investment scheme is being considered. The goals of PFI/PPP are to:

- achieve objectives and deliver services more effectively;
- use public money more efficiently;
- respond positively to private sector ideas;
- increase competition.

Key factors in PFI/PPP

9.26 The contract between the NHS and the private sector supplier is critical and it is important that the service representatives/key stakeholders, and particularly in this instance, the Infection Control Team are clear about the options available and the evidence to back up any decisions they advise on. The Infection Control Team will need to make sure that certain criteria are embedded into the contract in such a way that important decisions on design or build do not go ahead without being 'signed off' by them. They should ensure that they have:

- access to all relevant and up-to-date plans and information on operational policies;
- access to any meetings deemed relevant to them or timely minutes from those meetings that they cannot attend;
- access to sites and departments as building work progresses, e.g. environmental rounds with checklists based on project objectives;
- regular communication between both internal Project Manager and the PFI/PPP team;
- involvement in decision making for any category of equipment the PFI/PPP team will purchase;
- involvement in any contracts for support services such as catering, cleaning, linen, decontamination unit, etc., that the PFI/PPP team may be providing;
- access to certain high risk areas for any microbiological testing deemed necessary, e.g. theatres, isolation/segregation rooms, pharmacy and decontamination unit, clean rooms;
- responsibility for HAI and actions to be taken, such as testing and remedial works, and that these terms are clearly specified in the contract.

Design stage

9.27 It is at the design stage that Infection Control Teams will need to follow up any input they have had in the initial brief. Sketch plans should be available to them to explain how the brief fulfils their requirements at the 1/200 and 1/50 plan stages of the project. Suggestions for improvement in operability are encouraged at this stage. (For an approximate time-scale, see Table 2.)

9.28 Consideration should also be given to the impact on existing local facilities, e.g. ventilation, water supplies, etc.

Design and structure issues

9.29 The Infection Control Team will need to consider:

- if the facility is designed to support prevention and control of infection practice;

- design, number and type of isolation rooms (i.e. source or protective environments);
- heating, ventilation, and air-conditioning systems including filtration;
- mechanical systems involving water supply and plumbing;
- number, type and placement of hand-hygiene fixtures, clinical sinks, dispensers for soap, alcohol hand-rub, paper towels, and lotion;
- sharps disposal unit placement;
- accommodation for Personal Protective Equipment;
- surfaces: ceiling tiles, walls, counters, floor covering and furnishings;
- utility rooms: soiled, clean, holding, workrooms;
- storage of movable and modular equipment;
- clinical waste;
- linen (clean)/laundry (used);
- storage of used medical devices prior to transfer to CDU and storage for sterile medical devices.

Adapted from Bartley (2000).

9.30 Equipment schedules for Groups 2 and 3 based on room data sheets/layouts are prepared at this stage. (Further information can be found in Appendix 1.) Items available for transfer should also be identified which will allow schedules for new equipment to be prepared and costed and considered for compatibility with existing equipment. This is an important area for input by the Infection Control Team if costly mistakes are not to be made. (Further information can be found in Appendix 1.)

9.31 The purchase of equipment for Groups 2 to 4 will not normally take place until the operational commissioning period. However, it is important during the construction and equipment supply stage that there is involvement by the Infection Control Team in discussion of Group 2 equipment. Some Group 2 equipment may require to be fitted by the main Contractor and all may have significant design implications. This will ensure that this equipment is compatible with prevention and control of infection needs and also that proper inspection and testing can be agreed. (Further information can be found in Appendix 1.)

9.32 Technical commissioning of the building, services and equipment should include any areas that require inspection and testing to demonstrate compliance with prevention and control of infection standards, i.e. theatres, hydrotherapy pools, isolation/segregation rooms and clean rooms in pharmacy and Central Decontamination Units (CDUs). There is a legal requirement for compliance in CDUs and pharmacies.

9.33 Commissioning of the building services is frequently curtailed to meet deadlines or put in the hands of inadequately qualified or experienced personnel. This is

invariably to the detriment of user satisfaction, operational efficiency, HAI risk and running costs and should be avoided at all costs.

Tender/contract

9.34 The Infection Control Team should help review the tenders/contracts to assess the competence in relation to the technical nature of the build.

Monitoring the project

Construction (new build)

9.35 If the project is a new-build, monitoring will not normally be required by the Infection Control Team until the healthcare premises are at a stage when site visits can be arranged. Although Infection Control input is needed throughout the development of the healthcare facility, at this point it is important for the Infection Control Team to visit the site as soon as possible to familiarise themselves with the layout of the various departments. This will help them to detect any unidentified problems or ones caused by design changes.

Construction (new-build attached to existing site or refurbishment)

9.36 Infection Control Specialists agree that involvement of Infection Control Teams in refurbishment projects is important not only for ensuring that 'designed-in' prevention and control of infection is achieved, but also for assessing the potential risks to patients in existing buildings from dust, dirt and pathogens.

9.37 Measures that may limit the spread of dust, dirt and pathogens during construction include the following:

- undertake work in winter as the risk is lower for *Aspergillus* spp. and other fungal infections;
- clean and vacuum areas under construction and the surrounding areas frequently;
- place adhesive floor strips outside the door to the construction area to trap dust, these should be replaced regularly to remain effective;
- seal windows, doors and roof-space to control dust;
- wet-mop the area just outside the door to the construction area daily or more often if necessary;
- use a high-efficiency particulate air (HEPA) filtered vacuum to clean areas daily or more often if necessary e.g where there is a greater risk of infection spread or a greater need for control of infection;
- transport debris in containers with tightly fitting lids, or cover debris with a wet sheet;
- remove debris as it is created; do not let it accumulate. Use dust extraction equipment where feasible;

- remove debris through a window when construction occurs above the first floor;
- do not haul debris through patient-care areas;
- remove debris after normal work hours through an exit restricted to the construction personnel;
- designate an entrance, a lift and a hallway that the construction workers must use and which are not used by patients, visitors or healthcare workers;
- shampoo carpets when the construction project is completed;
- commission hotel services with regard to cleaning during construction projects.

(Adapted from Carter and Barr, 1997.)

9.38 There is a need to ensure that Infection Control Teams document advice given on building developments and that this advice is followed and recorded. Similarly, Carter and Barr (1997) advise that a daily checklist is maintained during the progress of the construction project (see Table 6 below).

Barriers	
Construction signs posted for the area	Yes/No
Doors properly closed and sealed	Yes/No
Floor area clean, no dust tracked	Yes/No
Air handling	
All windows closed behind barrier	Yes/No
Negative air at barrier entrance	Yes/No
Negative air machine running	Yes/No
Project area	
Debris removed in covered container daily	Yes/No
Trash in appropriate container	Yes/No
Routine cleaning done on job site	Yes/No
Traffic control	
Restricted to construction workers and necessary staff only	Yes/No
All doors and exits free of debris	Yes/No
Dress code	
Appropriate for the area (e.g., Theatres, CDU)	Yes/No
Required to enter	Yes/No
Required to leave	Yes/No

Table 6: Daily construction survey (Carter and Barr, 1997)

Surveillance and monitoring during renovation or construction work

9.39 Routine bacteriological sampling of floors, walls, surfaces and air is rarely indicated (Ayliffe et al, 2000), but there have been several documented outbreaks due to construction work. In 1995 there was widespread contamination of potable water with *Legionella pneumophila* during a period of major construction resulting in two fatal cases of healthcare associated *legionellosis* (Mermel et al., 1995). Multiple outbreaks of healthcare associated *aspergillosis* have also been described, including one specifically attributed to hospital renovation (Flynn et al., 1993). Mermel et al. (1995) suggest that heightened surveillance and preventive measures may be warranted during periods of excavation on hospital grounds or when potable water supplies are otherwise shut down and later depressurised.

9.40 NHS Estates (Wearmouth, 1999) advises:

"*Where vulnerable patients may be placed at risk, it is important that an appropriate risk assessment be carried out with the microbiologist/infection control officer [doctor] at an early stage in advance of any demolition works or disturbance/alterations to the building fabric/ventilation systems.*"

9.41 Since the airborne spores of *Aspergillus* spp. can travel significant distances, this will apply generally to all works in the immediate vicinity or within the boundary of the healthcare site. It is strongly advised that any recommendations by the Microbiologist/Infection Control Doctor should be incorporated into the building or engineering works so as to minimise risk.

9.42 Surveillance and monitoring during renovation or construction work may prove difficult; environmental assessment to detect *Aspergillus* spp. and to confirm epidemiological investigations may not be within the remit of all Infection Control Teams. However, implementation of adequate prevention and control of infection measures during construction are, and have been proven to be, an effective means of protecting highly susceptible or high risk patients from environmental contaminants (Thio *et al*., 2000).

Commissioning/equipping the healthcare facility

9.43 Upon completion of construction, the facility must be brought into use; the complexity of the task involved generally means that a Commissioning Manager and Commissioning Team will be needed. Senior managers, specialist teams and users should be fully involved in the process. The commissioning entails:

- drafting operational procedures;
- establishing baseline and future staffing profiles;
- establishing baseline and future revenue budgets;
- establishing final equipment requirements;
- identifying policy issues for referral to the Commissioning Team or the construction project team;
- identifying staff training needs;

- establishing the occupation programme for each user function, for incorporating into the overall masterplan.

9.44 Members of Infection Control Teams with an understanding of the commissioning process should ensure that they are included in any working groups in which infection prevention and control will have an impact, or in which requirements to modify services may have repercussions on other aspects of the prevention of infection.

9.45 The Infection Control Team may also need to be involved in processes for:

- transfer of facilities;
- phased or staged occupation;
- decorating;
- strategy for equipping;
- selection of equipment;
- storage and subsequent cleaning/disinfection of any furniture or equipment;
- commissioning hotel services for cleaning;
- site visits;
- artwork;
- furnishing and fittings;
- interior finishes and fixtures;
- post-handover period;
- decommissioning of redundant facilities;
- period of handover to operational management.

Post-project evaluation

9.46 The purpose of the post-project evaluation is to improve project appraisal, design, management and implementation. Although post-project evaluation is mandatory, it is a learning process and should not be seen as a means of allocating blame. There are three stages:

1. Project appraisal.
2. Monitoring and evaluation of project.
3. Review of project operations. It is at the third stage when it is useful for the Infection Control Team to be included in the evaluation teams that are reviewing project objectives. The outcomes (activity and its consequences) of the project will not be amenable to evaluation until the facility has been in use for some time.

Successful post project evaluation is aided by independence from the Procurement Team.

9.47 It is important that the project is evaluated in terms of its original objectives, not in light of any new legislation or development. Performance indicators may be used if these can be measured retrospectively. Control of infection related to measurable objectives may include:

- bed turnover;
- re-admission rates;
- incidence of day surgery;
- activity data;
- infection rates;
- patient satisfaction surveys, etc;
- process measures – air sampling, audit.

9.48 Reference should be made to HAI-SCRIBE and its question sets relating to the design and planning stage of any development.

Logistics

9.49 In addition to the issues raised in paragraph 9.10 'Space planning', the design of the healthcare facility must realistically consider the logistics of a functioning facility. It is essential that systems are in place which will inhibit the spread of infection and that resources and personnel are managed so they do not contribute to the risk of infection.

Examples of logistical issues to consider include:

- the delivery and distribution of materials and people via connecting corridors and lifts;
- the collection, transportation and storage pending removal or disposal of waste materials;
- clinical workflows.

9.50 These issues require careful planning and design which recognise the potential for infection spread through the mismanagement of such issues.

Sizing of space

9.51 At the time of writing this document, NHSScotland bed spacing requirements are under review. Bed spacing should be consistent with current guidance provided by Health Facilities Scotland (formerly NHSScotland Property and Environment Forum); Scottish Health Planning Note (SHPN) 04: 'In-patient accommodation: options for choice'.

9.52 There should be sufficient single rooms to prevent the spread of infection both to and from patients as a result of being 'housed' in open ward areas. Boards should audit use of single rooms to promote best use.

9.53 Initial planning and design in new builds needs to include numbers of beds and the appropriate space required between beds in accordance with the type of clinical intervention to be undertaken in the immediate patient environment.

9.54 Multiple beds in a single area should be kept to the minimum number possible, as this will assist in the prevention of cross-infection. Single rooms would appear to be the optimum solution, but other considerations such as cost and staffing levels may create pressure to reduce the proportion of single rooms.

9.55 Design, accessibility and space in patient areas all contribute to ease of cleaning and maintenance.

9.56 Spacing must take into account access to equipment around the bed and access for staff to hand-hygiene facilities. Sufficient space for equipment (e.g. hoists) is a health and safety issue for staff and patients.

9.57 Healthcare facilities must provide enough sanitary facilities and showers/bathrooms to ensure easy access, convenience and independence where possible.

9.58 Toilet facilities should be no more than 12m from the bed area or dayroom.

9.59 The work area around a patient needs to take account of the equipment which is nowadays routinely used in a healthcare facility and the patient space therefore needs to be sufficient to allow easy cleaning of that space and the equipment in it. Greater patient space may also reduce the risks of contact and airborne infection spread although the scientific evidence for this is limited. The design and planning needs to take account of current patient space guidance and the need to accommodate larger patients and patients requiring particular treatments/therapies and associated equipment.

9.60 Mode of transmission of infection should be taken into account when bed space and size of facility are being discussed. This includes direct transmission, indirect transmission via fomites (e.g. door handles, clothing, instruments, kidney dishes etc) and airborne transmission.

9.61 The principle should be to maintain sufficient space for activities to take place and to avoid transmission of organisms either by air or by contact with blood or body fluid or equipment. The exact space needed will vary according to numbers and activity of staff, type of patient, and environmental factors such as ventilation and humidity.

Particular issues for consideration include:

- patient groups;
- transmission of micro-organisms:
  - avoiding cross-infection;
  - the environment and its role in cross infection;
  - shared equipment;

  - movement of patients.
- management of issues:
  - clinical pressures;
  - best use of single rooms;
  - avoiding unnecessary movement of patients between areas.

Bed density

9.62 With an increase in the prevalence of antibiotic–resistant bacteria and immuno-compromised in-patients, there is an increasing need for en-suite single rooms and negative or positive pressure isolation rooms.

9.63 Provision of isolation/single rooms used to segregate patients will help prevent the spread of micro-organisms, especially those transferred by the airborne route or those easily disseminated into the immediate patient environment.

9.64 The provision of adequate space around the bed can significantly improve the quality of the patient's experience and aid the clinical and healing process. Clinicians and carers need adequate space around the bed, arranged in a functionally suitable way, to undertake their work efficiently and safely, making the most effective use of resources. Facilities should also serve the psychological needs of patients and their families providing a place of safety and privacy.

Access for maintenance

9.65 Surfaces should be easy to clean and therefore should be free of internal corners, cracks, crevices etc. which would make cleaning more difficult.

Ducting of services helps to achieve easy cleaning of surfaces but it is important to have sufficient, suitably sited access points for maintenance of the ducted services. The planning and design stage of the project must identify the access points for ducted services and those must be accessible with minimal or no disruption to the building surfaces or to patients.

9.66 Cleaning and maintenance of the ducts themselves must also be easily achieved with minimal infection risk.

9.67 There should be no ducted services where easy access is not available. Access for maintenance must not inhibit the safe efficient normal operation of the ward or department.

Departmental issues

9.68 There are some departments in a healthcare facility where infection risk is higher. These should be situated so as not to further increase the risk of infection.

9.69 For example, inappropriate transferring of cleaning equipment to different areas may be combated by use of colour coded/clearly labelled zoned areas where

movement of domestic staff and equipment is controlled by swipe cards. Departments with susceptible patients should be located and serviced to minimise risk of contamination from departments where patients are an infection risk.

Storage

9.70 Adequate storage should be provided for patients' possessions, sterile supplies, non-sterile supplies or for domestic services equipment and patient care equipment. This can help limit the spread of infection of frequently handled items, minimising contamination. Separate storage areas may be needed depending on the kind of item being stored.

9.71 Inadequate provision of storage facilities can mean that inappropriate sites e.g. corridors and clinical areas, are used for storage of equipment. This can lead to unnecessary contamination both of equipment and, subsequently, from equipment.

9.72 Storage of Personal Protective Equipment (PPE) and ready access to clean PPE is important to encourage its use. There should be appropriate clinical waste bins for disposal of PPE once worn.

Patients

9.73 Lockers and wardrobes are intended for the storage of patients' personal possessions and clothing. They should be made of an impervious material that is easy to clean with no crevices or corners where dust or debris could accumulate, resulting in a reservoir for infectious agents. They should also be sufficiently robust to withstand the prolonged use of recommended decontamination agents. The lockers should be provided with castors to allow easy access for daily cleaning and castors should also be cleaned. Deep cleaning of lockers is required on a routine basis to ensure all surfaces including the underside of the locker are free from spillages. Further guidance can be found in the NHSScotland National Cleaning Specification produced by the HAI Task Force.

Domestic Services Room

9.74 Domestic cleaning equipment and supplies must be stored in separate purpose built areas. There must be a dedicated domestic services room and store for the provision of such must be adhered to (further assistance can be found in SHPN 40: 'Common Activity Spaces'). There should be sufficient space in these areas to allow cleaning equipment to be thoroughly cleaned after use.

The areas are required to have:

- good ventilation;
- adequate space for domestic staff to clean and decontaminate small pieces of equipment and furniture e.g. domestic and clinical waste bins;

- adequately sized rooms to accommodate all activities taking place in the area;
- non-slip safety flooring fitted with coving between the floor and the wall to prevent accumulation of dust and dirt in corners and crevices;
- a large sink with fitted worktops and splashback and a lockable cupboard;
- a separate hand-wash basin fitted with a mixer tap but without a sink plug and fitted with dispensers for soap, alcohol gel, hand towels and handcream;
- foot operated waste bins;
- wall protection around the area where the domestic cleaning equipment is stored;
- adequate provision for the storage of supplies;
- a door stay and door lock.

Linen cupboard

9.75 Each ward should have an area for the storage of clean linen, which in new builds should be purpose designed. The areas used for the storage of clean linen should ensure that linen is not exposed to contaminants.

The areas are required to have:

- good ventilation;
- adequate lighting;
- impervious flooring that is easy to clean and fitted with coving between the floor and the wall to avoid accumulation of dust and dirt in corners and crevices;
- slatted shelving to ensure free flow of air.

9.76 If linen trolleys are used to store linen within the ward area, they should be managed so that:

- they are kept tidy and closed to ensure that linen is not exposed to dust;
- linen bags are not left open or lying on the floor with the potential for exposure to dust, which may potentially carry micro-organisms;
- appropriate procedures are in place to allow cleaning of linen trolleys.

Soiled Linen Storage

9.77 The following types of linen should be segregated at source before sending to the laundry:

- used linen;
- heat labile linen;

- known or suspected infected linen, which should be placed in a water soluble bag before placing it in the linen bag.

9.78 The layout of laundry areas must be designed to ensure that high standards of cleaning can be maintained. Finishes to walls, floors, work surfaces and equipment must be capable of withstanding regular cleaning and the impact of mechanical cleaning equipment. The area should be large enough to allow access for decontamination trolleys.

Equipment Store

9.79 All healthcare premises require a storage area for large pieces of equipment such as beds, mattresses, hoists, wheelchairs and trolleys, which are currently not in use. Ideally this should be an equipment library with centralised storage, cleaning facilities and trained staff.

9.80 This storage area will not only protect the equipment from contamination and dust which may potentially carry micro-organisms, but also allow free access to floors and shelves for cleaning.

9.81 The layout of these areas must be designed to ensure that equipment is stored safely and securely to comply with manual handling requirements. The area should be fitted with good lighting and finishes to walls, floors, work surfaces and doors to protect against foreseeable mechanical damage; equipment must be capable of withstanding regular cleaning.

Waste Disposal

9.82 There are stringent legislative controls and clear working guidelines for the management of healthcare waste. Guidance on which can be found in SHTN 3: 'Management and disposal of clinical waste'. Good design can minimise problems with segregation, storage and disposal. Identification of categories and the means of segregation of clinical and special waste form the key elements of a waste disposal strategy. In addition, compliance with the National Waste Strategy (SEPA) is essential to reduce the volume of waste going to landfill. Consequently the recycling of Domestic Waste should be an integral part of the Healthcare Facilities Waste Management Strategy.

9.83 Space at ward level is needed for suitable waste containers for all types of waste generated, including recyclates.

9.84 Healthcare waste should be securely stored away from unauthorised personnel. Therefore any new developments, or upgrading, must include a secure disposal store at the entrance of each ward or department, or, alternatively, provide a store to service a floor or area to facilitate safe segregation of all types of waste.

Waste Disposal Room

9.85 The waste disposal room is the temporary storage point for all items of supplies and equipment which have to be removed for cleaning, reprocessing or disposal, for example linen, central decontamination unit items, all types of waste and sharps.

9.86 The waste disposal room should be of an adequate size for all activities taking place within the area. Other requirements include:

- good ventilation;
- non-slip safety flooring fitted with coving between the floor and the wall to prevent accumulation of dust and dirt in corners and crevices. The floor must be capable of withstanding regular cleaning and the impact of mechanical floor cleaning;
- a large sink;
- a separate hand-wash basin fitted with a mixer tap but with no sink plug and fitted with dispensers for soap, alcohol gel, hand towels and handcream;
- wall protection on all walls and doors;
- wall finishes which should be impermeable and easily decontaminated;
- double door fitted with protective covering to allow easy access for secure and appropriate waste containers and an access control lock.

Cleaning facilities

9.87 Cleaning schedules must be prepared and in place and these schedules should take account of infection risk. Where building works are being carried out, the cleaning schedule may need to be reassessed. The cleaning schedule should be strictly adhered to and a nominated person should sign off satisfactory completion of the cleaning schedule. The cleaning schedule will identify cleaning which should be carried out after use, daily, weekly, etc.

Cleaning equipment

9.88 This will include:

- a range of equipment which must be in good working order and properly maintained including floor scrubbing machines, polishing machines, vacuum cleaning machines, etc;
- sinks for cleaning equipment which should be exclusively for that purpose and should be large enough to adequately clean the pieces of equipment;
- the provision of large sinks in areas where contaminated wastewater or blood or body fluids are disposed of.

Cleaning agents

9.89 The appropriate cleaning agents must be used. When choosing appropriate cleaning agents, various factors should be considered, for example:

- detergents loosen dirt and grease but do not kill bacteria;
- disinfectants kill bacteria;
- hot water and steam kill bacteria.

Laundry facility

9.90 Laundry facilities, whether ward based or centralised should provide;

- suitable space for laundry machinery;
- suitable storage for used linen and for separation of used and laundered linen;
- storage space which is designed to prevent odours from migrating from storage areas to adjacent areas;
- storage space designed to accommodate trolleys etc used in the transportation of linen;
- appropriate facilities to allow the segregation of used linen, heat labile linen and infected linen, in appropriate containers which are clearly identifiable;
- suitable facilities to allow compliance with hand hygiene practices;
- a laundry policy to ensure infection risks are minimised.

Changing facilities

Patient changing facilities

9.91 The increase in day case patients has increased the number of changing facilities required.

9.92 In areas such as out patients, imaging, day surgery, endoscopy and minor injuries units, it will be necessary to provide changing/storage facilities if clothing has to be removed and kept safe.

9.93 Flooring in these areas should be non–slip, easily cleaned and appropriately wear resistant. All surfaces must be able to withstand regular cleaning with both detergent and disinfectant products. All cubicle/screens must be able to withstand washing procedures at disinfectant temperature i.e. 3 minutes at 71°C or 10 minutes at 65°C.

9.94 All soft furnishings must be covered in an easily cleaned impervious material within all clinical and associated areas. Soft furnishings which are damaged should be removed for repair or disposal. The use of tape for repair is inappropriate. The fire resistance of furnishings and all fabrics must comply with SHTM 87: ‘Textiles and Furniture’. Cleaning processes should be developed to ensure that fire resistance is not compromised.

9.95 Hand-wash basins, sanitary facilities and showers should be provided in these areas.

Staff changing facilities

9.96 Changing facilities should be provided for staff to encourage them to change out of their uniform in the workplace. This is particularly important if the staff member is working in a clinical area or CDU. Facilities should be provided

which allow staff to store their personal possessions safely. Locker sharing can reduce storage requirements.

9.97 Sanitary facilities and showers should be provided for male and female staff in these areas.

9.98 The distance from the working area may affect how often staff use the facilities. However, in the interest of the personal security and safety of staff, staff changing areas should be sited in the main area of the healthcare facility if not very close to (or within) the ward. Changing areas and showers should also be provided for staff who have become contaminated.

9.99 Staff should change from their outdoor clothing into their uniforms in the changing facilities provided.

9.100 By providing staff changing facilities with adequate areas for storage of clothing e.g. lockers, staff will be able to change from their staff uniforms into their outdoor clothing on site. This practice should encourage staff to travel home in their own clothes, not their uniform.

9.101 Staff must have easy access to a hand-wash basin and showering facilities in the event of a spillage, accident or contamination.

9.102 The Watt Group Report (2002) stated that specific guidelines and facilities (washing, showering and cleaning/changing uniforms) should be available in every hospital for the decontamination of staff who become grossly contaminated by blood or body fluids.

Maintenance Staff

9.103 Separate clothing should be provided for maintenance staff to change into when moving between clinical and non-clinical areas. Consideration should also be given to providing changing facilities for maintenance staff, service engineers etc who may have to change into scrub suits and dedicated footwear for work carried out in clean areas.

Uniform changing

9.104 Best practice suggests an area should be provided in staff changing where staff can order clean uniforms. In this area, staff should also be able to collect their laundered uniforms and dispose of soiled uniforms for onward processing at the laundry.

Bed space area

Patient mobility

9.105 Patient mobility is considered vital for aiding recovery and maintaining physical health and hygiene. It is well understood that this helps reduce length of stay and physical complications in the recovery period.

9.106 The provision of sufficient space is essential for nurses and therapists to work, to accommodate wheelchairs and walking aids, and to assist the mobility of patients. Guidance on which can be found in SHPN 04: 'In-patient Accommodation: Options for choice'.

Clinical treatment

9.107 Many of the activities that previously took place in a treatment room now take place at a patient's bedside and therefore additional space is required for equipment and for clinical procedures to take place. It should be noted that treatment rooms may provide a cleaner environment in which less activity takes place during procedures.

Moving and handling

9.108 Moving and handling of patients is a major cause of back injury and other musculo-skeletal disorders amongst staff. To avoid such injury, patients should be moved using equipment designed specifically for the purpose. Sufficient space is therefore required to manoeuvre this equipment around the bed. Manual handling equipment can contribute to the transmission of micro-organisms if not adequately cleaned and stored.

Family support and visiting

9.109 Visits from family and friends are important for the well-being of patients. There should be sufficient space around the bed to allow for seating without disturbing patients in other bed spaces or the flow of nursing care. Adequate toilet facilities should also be in place to limit the risk of infection from visitors using the patient's en-suite facilities. Insufficient seating round the bed space area can lead to prevention and control of infection issues.

The Chief Medical Officer has introduced five tips for the public visiting patients in hospital to help in reducing cross infection. These are:

- think about keeping patients safe before you visit someone in hospital. If you, or someone you live, with has a cold or diarrhoea, or if you feel unwell, try to stay away until you are better;
- wash and dry your hands before visiting a hospital ward, particulary after going to the toilet. If there is alcohol hand gel provided at the ward door or at the bedside, use it;
- ask ward staff for advice before you bring in food or drink for someone you are visiting in hospital;
- if you visit someone in hospital, don't sit on their bed, and keep the number of visitors to a minimum at any one time. Never touch dressings, drips, or other equipment around the bed;
- if you think NHS premises are not as clean as they should be, let the Sister/Charge Nurse know. If you think a healthcare worker has forgotten to wash their hands, remind them about this.

Accessibility for staff

9.110 Poor access around the bed is stressful for staff who have to work, often under pressure, within limited space, entailing more potential for accidents, mistakes and delays. Moving and setting up equipment takes valuable time and this is hindered by limited space. Gaining access to bedhead controls and monitoring equipment also requires sufficient space.

9.111 In multi-bed areas there should be sufficient space around each bed for staff to carry out procedures without disturbing patients in adjacent beds and to provide a degree of auditory privacy. There is now a great deal more activity taking place at, or close to, the bedside which falls into three categories:

- clinical treatment and care;
- personal care;
- support duties including cleaning.

Cleaning

9.112 There needs to be space to allow the easy movement of beds and equipment to facilitate cleaning. Access for cleaning must be considered a key design factor for planners and architects designing new buildings or refurbishments.

Storage

9.113 Adequate space to store equipment away from the bed space is necessary, as inappropriately stored equipment can interfere with cleaning and create a reservoir for micro-organisms.

Fixtures and fittings

9.114 Fixtures and fittings should be easy to clean. Their design needs to take account of cleanability e.g. the surface material, access to all surfaces, etc. Complex dismantling to enable cleaning to be achieved is a disincentive to effective cleaning. Involvement of Domestic Managers in selection of fixtures and fittings is advised.

9.115 Fixtures and fittings should be movable as far as possible to ease cleaning.

Walls

9.116 Smooth, hard, impervious surfaces are recommended in clinical areas as they are easier to clean and bacteria cannot readily adhere to them (Bartley, 2000; Ayliffe et al, 1999). Design should ensure that surfaces are easily accessed, will not be physically affected by detergents and disinfectants and will dry quickly.

Ceilings

9.117 Smooth, hard, impervious surfaces are recommended in theatres and isolation rooms. Caution should be used when considering the use of ceilings to

produce visually appealing areas as they can be difficult or time-consuming to access for cleaning, for example hidden lighting or box-work.

9.118 False ceilings may be associated with accumulation of dust or fungi and can harbour pests. It is therefore essential that buildings are checked on completion to ensure that no unwanted materials from the building works remain and that there is no access for pests (Ayliffe et al, 1999). Ceilings with removable tiles or perforated ceilings can allow dust to fall onto the area below during maintenance work. This type of ceiling should therefore be avoided in isolation rooms, operating theatres and treatment rooms (Ayliffe et al, 1999).

9.119 Pipes and cables running through walls above false ceilings should be sealed so far as is practicable.

Doors

9.120 All bays and single rooms used to segregate patients require doors if they are to be used for cohort nursing or isolation nursing. They should have smooth handles which can be easily cleaned, will not be physically affected by detergents and disinfectants and will dry quickly.

Windows

9.121 Windows, although not directly a prevention and control of infection issue, allow patients in isolation/segregation to feel less shut off from the world and have been shown to add to the therapeutic process where there is pleasant view.

9.122 Glass partitions, instead of solid walls, enable patients to see what is happening in the ward but there will also be a need to allow for patient privacy at times. Double-glazed windows with integral blinds are practical and solve a range of cleaning problems.

9.123 Windows in operating theatres, treatment rooms and isolation/segregation rooms should be fixed and sealed.

9.124 Avoid ledges as in cottage-style windows because this will allow for the accumulation of dust; ledges also require a significant cleaning commitment.

Radiators

9.125 Radiators have been implicated in outbreaks of infection with meticillin resistant *staphylococcus aureus* and are often difficult to clean because they are enclosed in bay windows or in protective covers to prevent burns. They should be smooth, accessible and cleanable.

9.126 Pipework should be contained in a smooth surfaced box that is easy to clean; pipework sited along a wall can become a dust trap and can be impossible to clean.

9.127 Pipes and cables running through walls above false ceilings should be sealed as far as is practicable.

9.128 Radiators should be smooth, accessible and easy to clean. Pipework should be boxed or enclosed with surfaces which are easy to clean.

Work surfaces

9.129 Surfaces should be designed for easy cleaning.

9.130 Surfaces near plumbing fixtures should be smooth, non-porous and water-resistant.

9.131 They should be free of fissures, open joints and crevices that will retain or permit the passage of dirt particles.

9.132 All joints must be sealed (Bartley, 2000).

9.133 Horizontal surfaces can become contaminated therefore regular cleaning is required.

9.134 All surfaces must be able to withstand regular cleaning with both detergent and disinfectant products.

9.135 Surfaces should be designed for easy cleaning, free of fissures, open joints and crevices. Surfaces should withstand regular cleaning with detergents and disinfectants. (Further guidance can be found in the NHSScotland National Cleaning Services Specification produced by the HAI Task Force.)

9.136 Internal corners should be coved. Horizontal surfaces not intended for storage e.g. tops of lockers, should be sloped.

Recommendations

9.137

1. The quality of finishes in all areas should be of a high standard. Guidance on the selection of finishes is provided in several SHTMs, SHPNs and SHBNs.
2. Soft furnishings must be covered in an impervious material within all clinical and associated areas.
3. Flooring should be easily cleaned and appropriately wear-resistant.
4. The use of carpets is not advised within any clinical or associated area. Attractive vinyl flooring materials are available which can provide aesthetic appeal.
5. All joints and crevices should be sealed.
6. Curtains must be able to withstand washing processes at disinfection temperatures.
7. Window blinds should be used with caution; the need for regular cleaning in clinical areas must be considered.
8. All surfaces should be designed for easy cleaning.
9. Smooth, hard, impervious surfaces should be used for walls.

10. All surfaces, fittings, fixtures and furnishings should be designed for easy cleaning and durability.

Equipment

9.138 The selection of equipment which can be easily decontaminated both internally and externally is critical. The use of soft 'difficult to decontaminate' fabrics should be avoided where possible. The design of equipment should also be considered, as intricate design details are often difficult to clean properly.

9.139 Equipment that is in direct contact with patients has been implicated in infection outbreaks (Irwin et al, 1980). Equipment that is within the immediate patient environment has been shown to be a potential source of cross-infection. Fixtures and fittings, if difficult to access or clean on a regular basis, fall into this category and must be included as a potential reservoir of infection when risk assessment is undertaken. Design should ensure that surfaces are easily accessed, will not be physically affected by detergents and disinfectants and will dry quickly.

Cleanability

9.140 Decisions about finishes, design, fixtures and fittings at the planning and procurement stages must take account of their cleanability, i.e. recognition of the importance of finishes etc being cleaned and kept clean. Finishes etc, which are difficult to clean are less likely to be properly cleaned and kept clean.

9.141 The quality of finishes etc in all areas should be of a high standard so that there is ease of cleaning and the fabric of the building stays intact and impervious over its life cycle.

9.142 Particular points to consider include the use of:

- hard flooring in clinical areas;
- flooring which can be easily cleaned and is appropriately wear-resistant;
- coving between the floor and the wall to make cleaning easier;
- limited joints which should be welded or sealed;
- floor finishes, such as vinyl, which are impervious and can be easily cleaned;
- flooring which must be securely anchored. Lifting of the floor can create reservoirs of infection;
- surfaces such as wood, tiles and unsealed joints which should be avoided because they are more difficult to clean;
- flooring of a material which is unaffected by detergents and disinfectants;
- flooring in areas subject to traffic which, when wet, should have high slip resistance;
- carpets, these should not be used in clinical areas.

9.143 The use of dividers or screens that can be manoeuvred on wheels can be of benefit in ITU areas. The use of these dividers requires consideration at the planning stages as extra space is required both for their use between beds and for storage. It is also important that they are easily cleanable.

Electrical supply

9.144 Guidance on the supply of electricity can be found in SHTM 2007: 'Electrical services: supply and distribution'. If the ventilation system is used to control airflows to minimise cross infection, this system should be on a dedicated power supply which is clearly marked and designed to avoid accidental isolation. Where practical, power supplies should be classed as essential.

Electrical power services and sockets

9.145 Sufficient 13-amp switched and shuttered socket outlets should be provided in corridors and in individual rooms to enable domestic cleaning appliances with flexible leads (9 metres long) to operate over the whole department.

9.146 Where possible, socket outlets should be flush-mounted or in trunking systems to prevent the build up of dust.

Ventilation

9.147 In specialised applications such as isolation rooms or decontamination facilities, it is important to be able to monitor the effectiveness of the ventilation systems by means of visual indication such as pressure gauges. Where visual indication is provided, it is essential that the procedures for checking and recording the reading, if necessary, are clearly laid down and staff are adequately trained in the operation of the system and action to be taken in the event of system failure.

9.148 Isolation rooms which have a ventilation system capable of providing either positive or negative pressure within the room are not generally recommended. This is because investigations of failures of such systems have identified lack of staff awareness of the purpose and functioning of the system as key factors.

9.149 Guidance on the use of ventilation systems is given in SHTM 2025: 'Ventilation in Healthcare Premises' and Scottish Hospital Planning Note 13: 'Sterile services department'.

9.150 Consideration should be given to room layouts and the relationships between rooms and should be such that they avoid cross infection. Similarly, so as to avoid cross infection, Domestic Services Room (DSR) and service rooms should be located away from clinical or patient areas and extract outlets should be directed away from air intake vents.

Hot and cold water supplies

9.151 Guidance on hot and cold water supplies can be found in SHTM 2040: 'The control of legionellae in healthcare premises: a code of practice' and SHTM

2027: 'Hot and cold water supplies: storage and mains services'. Guidance on water filtration can be found in SHTN 2: 'Domestic hot and cold water systems for Scottish Healthcare premises'. Safe and effective hot and cold water supplies are paramount in healthcare premises to maintain a safe and comfortable environment for patients and staff, and for treatment at all levels of clinical and surgical care. Water must be supplied at an appropriate temperature and pressure, for example:

- water being supplied to hand-wash basins, baths etc should not cause scalding of the user;
- water being supplied to the DSR and or Pantry should be at a higher temperature however these need to be clearly marked as providing "VERY HOT WATER";
- systems should be designed to ensure continued circulation of water where practical;
- systems should be insulated to avoid heat transfers from hot supplies to cold;
- dead legs in pipework should be avoided;
- consideration should be given to the space and plumbing required for chemical treatment of water systems e.g.
  - compatibility of chlorine dioxide treatment;
  - the necessity for reverse osmosis plant in renal dialysis or sterile supplies units;
- careful consideration should be given to the frequency of use of fixtures especially where infrequent use may result in legionella control problems e.g. showers, sinks, long pipe runs.

9.152 Contamination of the water supply has been recorded as a cause of disease and death in both the public health arena and the hospital setting. It is important, therefore, that drinking water in healthcare settings is safe, readily available to patients and is palatable to encourage drinking. The new EU Drinking Water Directive, which is transposed into UK law by the Water Supply (Water Quality) (Scotland) Regulations 2001, contains new provisions to ensure that the drinking water supply within buildings to which the public has access remains wholesome and is not adversely affected by the domestic plumbing system.

9.153 Access to chilled water, which is plumbed directly off the mains, may be important when patients are feeling unwell, pyrexial or the ambient temperature is high. Patients who are ill become dehydrated and may need to increase their fluid intake.

9.154 A plentiful supply of water for other uses such as personal hygiene, hand hygiene and cleaning of the environment and equipment is also needed. Storage of this water requires careful consideration and can present problems if not dealt with appropriately.

9.155 Systems employed in the storage and conveyance of water for human consumption, and or use, should be designed and installed in order that the growth of harmful organisms, and hence the risk to people, is minimised.

9.156 Systems must incorporate measuring devices to monitor salient parameters accurately and allow trend logging to demonstrate the efficiency and sufficiency of the control measures employed. The number, type and location of the measuring devices should provide data that is representative of the whole system. Whilst it is desirable to increase the availability and access to drinking water and hand hygiene appliances, the provision of such must not encourage the incidence of water within sections of systems which may have a tendency to stagnate. Low flow and no flow of water within systems particularly where temperature variation may occur as a result, must be minimised as far as reasonably practicable to ensure the conditions that will encourage the growth of harmful organisms are avoided as far as possible.

Storage of water and policies for maintenance

9.157 Many organisms, such as species of nontuberculous *Mycobacteria*, *Pseudomonas* and *Legionella*, have been isolated from hospital water systems. Guidance on the control of *Legionella* in water systems can be found in the Health & Safety Executive's approved Guidance Note L8: 'Legionnaire's disease: the control of *Legionella* bacteria in water systems' and SHTM 2040: 'The control of legionellae in healthcare premises - a code of practice'. Problems associated with *Legionella* have been documented in healthcare premises however these problems have been minimised by:

- cleaning water storage tanks;
- maintaining a consistently high temperature in hot water supplies or introducing a form of online disinfection such as chlorine dioxide or ionisation if lower temperature hot water is used to avoid the need for thermostatic mixing valves (see Health & Safety Executive L8, Scottish Health Guidance Note 'Safer' Hot Water and Surface temperatures and SHTM 2040: 'The control of legionellae in healthcare premises - a code of practice');
- regular maintenance of plant;
- removing plumbing dead-legs;
- keeping cold water systems cold;
- minimising water storage.

9.158 In large hospitals, storage tanks are often necessary to ensure adequate supplies of water. Findings of *Aeromonas hydrophila* in seasonal trends by Picard and Goullet (1987) suggests that monitoring the water supply, especially during the summer months, is valuable. They also discuss the importance of keeping storage tanks clean and designing storage facilities to minimise excessive cold water temperatures, which should then reduce the tendency for multiplication of not only *A. hydrophila* but also *Legionella spp*.

9.159 Good practice requires that hot and cold water pipework are separated (i.e. not in the same ducting) to a sufficient margin to avoid heat transfer to the cold water supply. Hot and cold water pipes should not be installed in the same space e.g. voids or ducts where a sufficient margin of separation cannot be provided between pipes to prevent heat transfer. It has also been suggested that there is a need for testing, following a survey of bacteriological quality of water from hospitals by Hunter and Burge (1988).

9.160 Guidance on hot and cold water systems can be found in SHTM 2027: 'Hot and cold water supply, storage and mains services'.

Provision of single room facilities

9.161 With an increase in the incidence of antibiotic-resistant bacteria and immuno-compromised in-patients, there is an increasing need for en-suite single rooms and negative or positive pressure isolation rooms. Single rooms with en-suite facilities allow for easier management of infection than wards. The current trend is for new facilities to have more single rooms than previously with some parts of the UK planning on a basis of at least 50% single rooms. Provision of isolation/single rooms will help prevent the spread of organisms, especially those transferred by the airborne route or those easily disseminated into the immediate patient environment. En-suite single rooms also provide greater privacy and are preferred by many patients.

9.162 Many patients with an infection require physical isolation. However, often patients cannot be isolated because of a shortage of single rooms and isolation rooms. The key to effective isolation on acute general wards is the provision of single rooms with en-suite sanitary facilities. Single rooms reduce the risk of cross-infection for both non-airborne and airborne diseases and help to lower the incidence of HAI. Most patients on acute general wards can be isolated/segregated in single rooms with en-suite facilities. All single rooms in new-build hospitals should have en-suite facilities so that they can, among other reasons, be used to isolate/segregate patients.

9.163 Historically, isolation/segregation in general wards has been provided in single rooms, sometimes without en-suite facilities. Rooms without en-suite facilities often cannot be used to isolate patients effectively.

9.164 Ventilated isolation suites with en-suite facilities can also be provided. They may have a ventilation system that provides a positive pressure in the room to protect the patient from infection, or a negative pressure to prevent a patient from infecting others, or the ventilation may be switchable from positive to negative. These rooms rely on staff being able to assess the type of ventilation required when a patient arrives on the ward and, for switchable systems, knowing how and when to select the correct ventilation mode. Patients can be put at risk if the ventilation mode is not set correctly and as such the provision of isolation rooms which are switchable from positive to negative air pressure is no longer recommended because of the risk to people inside and outside the room in the event of the setting being incorrect.

9.165 There are four main reasons for caring for patients in single rooms:

- patient susceptibility to infection from other sources;
- patient presents an infection risk to others;
- non-medical, for example patient preference;
- clinical but not infection-related.

9.166 In terms of infection control, only patients in the first two categories require isolation. Patients in the latter two categories can be cared for in standard single en-suite rooms used to segregate patients. In order to simplify the use of isolation facilities, two room designs for isolating patients in acute general settings are discussed:

- single room with en-suite facilities;
- enhanced single room with en-suite facilities and ventilated anteroom (isolation suite).

Single room with en-suite facilities

9.167 A single room with en-suite sanitary facilities having extract ventilation is a simple, cost-effective way to provide isolation/segregation and will meet the needs of most patients on general wards. The room does not require any specialist knowledge or action by the nursing staff to operate it. When not being used for isolation the room can be used for general nursing.

Enhanced single room with en-suite facilities and ventilated lobby (isolation suite)

9.168 An enhanced single room with a positive pressure ventilated entry lobby and en-suite facilities with extract ventilation provides both source and protective isolation. The positive pressure lobby ensures that air from the corridor does not enter the isolation room, and that air from the room does not escape into the corridor. This simple design enables the suite to be used for either source or protective isolation without the need for switchable ventilation or special training for staff. It also provides safe isolation/segregation for patients whose condition is unknown.

Advantages

9.169 Both rooms are suitable for caring for patients not in isolation but who require a single room for other reasons. In addition, both room designs are simple in concept, safe in operation, and do not require the nursing staff to have any specialist ventilation knowledge.

9.170 On occasions, it may be necessary to prioritise the use of the available isolation and single rooms used to segregate patients. In such situations, consideration must be given to cohort nursing of patients within small 2/4 bed bays.

9.171 The focus of single/isolation rooms discussed in this part of the document include:

- the role of isolation/single rooms in preventing cross-infection;
- cohort nursing;
- quantity and design;
- negative/positive isolation rooms;
- hand-hygiene facilities;
- sanitary facilities;
- storage of personal protective equipment;
- size and layout;
- visibility/location;
- furnishings and fixtures;
- finishes;
- floors;
- walls;
- ceilings;
- doors;
- windows;
- engineering requirements.

The role of isolation in preventing cross-infection

9.172 The primary aim of prevention and control of infection is to prevent the spread of infection between patients, visitors and staff by the control or containment of potentially pathogenic organisms. Many of these organisms can be controlled by basic prevention and control of infection practices such as hand-hygiene and environmental hygiene, but isolating/segregating the source patient can only effectively contain certain organisms.

9.173 'Negative pressure' isolation rooms are essential for infections transmitted by the airborne route: it has been reported that isolation of infected patients prevents cross-infection in outbreaks of tuberculosis (Louther et al, 1997). For other infections, a patient can be accommodated in a single room which can segregate the patient.

Cohort nursing

9.174 When an index case of infection is followed by several secondary cases, it may be necessary to cohort nurse a group of patients in a bay if insufficient single rooms are available. This can be more easily achieved where wards are divided into small bays (two or four beds per bay) which can be isolated/segregated further by closure of doors at the entrance/exit and which

also have en-suite facilities. When prevention and control of infection guidelines are adhered to, research has demonstrated that cohort nursing can successfully control and contain infection in hospital (Cartmill et al, 1994; Zafar et al, 1998; Green et al, 1998; Karanfil et al, 1992; CDC, 1995, 1997).

9.175 There is currently no definitive guidance on size, ventilation or the equipping of isolation rooms. NHSScotland SHPNs for relevant departments such as wards, theatres and other specialised areas and SHTM 2025: 'Ventilation in healthcare premises', give advice on natural ventilation, general extract ventilation and ventilation for specialised areas.

9.176 Experience has shown that many hospitals find the present allocation of isolation/single rooms inadequate to deal with the increasing numbers of infected and immuno-compromised patients (Langley et al, 1994; Wiggam and Hayward, 2000). Hospitals with 10% of their bed contingent as single rooms often find that this number is inadequate to cope with every infectious patient. Where this is the case, risk assessment needs to be used to inform decisions regarding which patients to nurse in single rooms.

Hand-hygiene facilities

9.177 Hand-hygiene and the use of Personal Protective Equipment (PPE) are key to preventing the spread of infection. Sufficient hand-wash basins must be supplied in a room used to isolate patients (and attached ante-room) and single room. This is in addition to the basin provided for patient wash facilities. Elbow taps for clinical hand-wash basins are preferred and the touch-free control of water flow will further aid the control of infection, although maintenance implications need to be considered.

Sanitary facilities

9.178 Personal hygiene contributes to the prevention of cross-infection and is improved if patients have their own bath or shower, WC and hand-wash basin. Single rooms should therefore be provided with en-suite sanitary facilities. An en-suite single room should also be able to accommodate a hoist for lifting patients.

Size and layout

9.179 Additional facilities may be required for the care and treatment of patients in isolation rooms/single rooms, especially if the isolation is likely to last for some time. The facilities required may include the storage of:

- supplies retained in the room;
- personal clothing and possessions;
- essential domestic cleaning equipment held in en-suite sanitary facilities.

9.180 Where possible, the opportunity should be taken to size the room so that the bed can be placed parallel to the external wall, thereby allowing the patient to enjoy a view of the outside. An intercommunication system, while not essential,

is desirable as this allows the patient verbal contact without compromising their isolation.

Visibility/location

9.181 If patients are to stay in an isolation/single room or bay, it is important that they are able to see staff from their beds. Staff should also be able to see the patient in case of an emergency. This reduces the psychological problems of isolation/segregation. Providing outside views using windows with low sills can also reduce the sense of containment.

Furnishing and fixtures

9.182 In isolation/single rooms/small bays where infectious patients are nursed, it is important that there is enough space to easily clean furnishings and fixtures.

Finishes

9.183 Ledges, recesses and tight angles where dust particles can be trapped should be avoided to allow ease of cleaning. It should be ensured that detergents and disinfectants will not physically affect surfaces and that they will dry quickly.

Floors

9.184 Carpets are not advisable in isolation/single rooms as carpets may prolong the survival of certain micro-organisms.

Walls

9.185 Wall finishes should be impermeable and easily wiped over if necessary.

Ceilings

9.186 These should have homogeneous plastered surface with flush-mounted recessed lights, ventilation grilles and other ceiling fixtures, where possible. Removable ceiling tiles in a grid layout are not advised for isolation rooms.

Doors

9.187 The corridor door to the room should be one and a half leaf and contain a large vision panel. A means of obscuring the vision panel should be included within the door.

9.188 Doors should have smooth handles which can be easily cleaned, will not be physically affected by detergents and disinfectants, and will dry quickly.

Windows

9.189 These will need to be lockable when the specialised ventilation is turned on. Curtains to provide privacy should be controlled within the room.

Engineering requirements for isolation rooms

9.190 Provision of mechanical ventilation systems is important in controlling the required direction of air movement between isolation rooms and the adjacent corridor.

9.191 For negative pressure isolation rooms, there should be a readily visible monitor independent of the air supply/extract system. This is best achieved by monitoring the pressure differential between the patient room and corridor or lobby. This differential should preferably be monitored continuously, i.e. a pressure sensor linked to an alarm at the nurses' station should the pressure drop below a pre-set limit. The alarm should have a built-in delay of a few seconds so that it does not activate every time the door is opened. For negative pressure isolation rooms, there should be an interlock system such that supply ventilation is cut off if the extract ventilation fails. There should be a clear indication to users that the ventilation has failed.

9.192 For isolation rooms with both negative and positive pressure ventilation, the mechanism for switching from one to the other should be lockable. As mentioned previously, it should be noted that this option of having isolation rooms with switchable ventilation is not generally recommended as infections have been transmitted through patients being cared for in a positive pressure room when they should have been in a negative pressure room. Staff should be properly trained on how to use the mechanism. With regard to the en-suite sanitary facility, the extract ventilation should be designed to work in conjunction with the main ventilation system.

9.193 General space/heating requirements can be met by the same method as for 'standard' single rooms. Care should be taken in selection of the heat emitter, as it needs to be easily cleaned and should not have inaccessible corners.

9.194 To reduce dust contamination and ease cleaning, luminaires should be recessed, dust-excluding and fully accessible from below.

9.195 Planned maintenance and monitoring programmes must be established for ventilated rooms to ensure the design criteria is maintained and met at all times. Although it is impossible to give specific maintenance frequencies, each unit must be included in a planned preventative maintenance schedule that includes pressure/air flow monitoring equipment.

Hand-hygiene facilities

Clinical Sinks

9.196 Hand-hygiene is the single most important factor in the prevention of healthcare associated infection (Ayliffe et al, 2000).

9.197 It is known that compliance with hand-hygiene guidelines have led to a significant reduction in the carriage of potential pathogens on the hands and can result in reduction of patient morbidity and mortality from hospital acquired infection (Pittet et al, 2000).

9.198 The absence of conveniently placed sinks often leads to non-compliance with hand hygiene guidelines. Good departmental design, with sufficient, appropriately placed hand-wash basins can increase compliance.

9.199 Thus, the importance of facilities to encourage hand hygiene should be high on the list of priorities when designing and planning new healthcare premises or refurbishment of existing premises is being undertaken.

9.200 This part of the document discusses:

- design;
- sink provision;
- water/taps;
- hand-hygiene dispensers;
- hand drying.

Design

9.201 Sinks in clinical areas must be suitable for that purpose (not of a domestic design). Hotel-style sinks are not appropriate.

9.202 The dimensions of a clinical sink must be large enough to contain splashes and therefore enable the correct hand-hygiene technique to be performed (Bartley, 2000).

9.203 The sides of the sink should be curved to prevent splashing.

9.204 Hand-wash sinks should be sealed to the wall or placed sufficiently far from the wall to allow effective cleaning of all surfaces.

9.205 Waterproofed sink splash-backs should be included to prevent wall damage and allow ease of cleaning (Ayliffe et al, 1999).

9.206 Clinical sinks should not have a plug or a recess capable of taking a plug. A plug is an unnecessary source of infection (especially *Pseudomonas* spp.) and can discourage staff from washing their hands under running water, particularly if mixer taps are not available.

9.207 Overflows are difficult to clean and become contaminated very quickly, serving as reservoirs of bacteria. They should therefore be avoided (SHPN 04: 'In-patient accommodation – options for choice').

Sink provision

9.208 Hand hygiene facilities must be readily available in all clinical areas. There must be sufficient sinks to encourage and assist staff to readily conform to hand hygiene protocols (Boyce et al, 2000; Feather et al, 2000; Carter and Barr, 1997; Dancer, 1999; Department of Health, 2000; Harris et al, 2000; Larson and Killien, 1982; Pittet, 2000). Inconveniently located hand hygiene facilities are

one of the main reasons that healthcare staff do not comply with hand hygiene protocols (Larson and Killien, 1982; Pittet, 2000).

9.209 There is a need to review the numbers and placement of sinks, as well as their dimensions (Kesavan et al, 1998; Bartley, 2000). Guidelines for the appropriate numbers of sinks in clinical areas have been identified (SHPN 04: 'In-patient accommodation - options for choice'). This guidance suggests a minimum of one sink per single room or small ward area and one sink per six beds in a large multi-occupied room. However, to encourage good practice and give reasonable access, it is recommended that there should be:

- ideally, in **intensive care and high dependency units (critical care areas)**, one hand-wash basin at the front of each bed space;
- one sink between four patients in **acute, elderly and long-term care** settings; and
- one sink between six patients in **low-dependency** settings, for example mental health units and learning disability units.

9.210 In **primary care** and **out-patient** settings where clinical procedures or examination of patients/clients is undertaken, then a sink must be close to the procedure, ideally in the same room or in a cubicle section of the room.

Water/taps

9.211 Health and safety regulations (The Workplace [Health, Safety and Welfare] Regulations, 1992) require that both hot and cold running water should be available in areas where employees are expected to wash their hands.

9.212 Hands should always be washed under running water; mixer taps allow this to be practised in safety in healthcare settings where water temperatures are high to combat *Legionella* spp.

9.213 Taps should be elbow, knee or sensor-operated (SHPN 04: 'In-patient accommodation - options for choice') for hand hygiene.

9.214 Taps should be easy to turn on and off without contaminating the hands. Infrared taps are an alternative but these are expensive and can pose problems with cleaning and flushing (Bushell, 2000).

9.215 Taps discharging into a shallow sink or directly into a drain hole can cause splashing which disperses contaminated aerosols. Thus, the tap outlet flow should not point directly into the sink outlet (Ayliffe et al, 2000).

9.216 Swan-neck tap outlets must not be used, as they do not empty after use. Strainers and anti-splash fittings at outlets should not be used as they easily become contaminated with bacteria.

Hand hygiene dispensers

9.217 Skin disinfectants and soaps must be wall-mounted near the sink so that the user can operate the dispenser properly without risking contamination. Soap

dispensers should not be refillable but be of a disposable, single cartridge design.

Alcohol based hand rubs

9.218 Alcohol-based handrubs have an important role, especially when access to hand-wash basins is difficult (Pittet, 2000). Unlike soap dispensers, these do not necessarily have to be placed by sinks. Alcohol based handrubs are a key aid in the prevention and control of infection. It is recognised that these materials are highly flammable and an appropriate fire risk assessment should be carried out with consideration given to the storage of these products. Ingestion of the product by certain patient groups has also been reported. The National Patient Safety Agency in England (2004) has stated that personal dispensers should be used where there is an increased likelihood of patient ingestion. Risk assessment should be carried out on the use of alcohol based handrubs, the location and size of dispensers and the storage and disposal of new stock, giving consideration to the likelihood of ingestion especially in high risk ward areas and clinical units.

Hand drying

9.219 Hand drying is of equal importance in maintaining hand hygiene as wet surfaces can transfer micro-organisms more effectively.

9.220 Paper hand-towels dry hands rapidly and dispensers can be used by several people at once. They are considered to be the lowest risk of cross-infection and are the preferred option in clinical practice areas (Bushell, 2000). The dispensers should be conveniently placed by hand-wash sinks.

9.221 The use of paper towels in rolls should be discouraged. They are difficult to tear off without contaminating the remaining roll (Gould, 1994; Hoffman and Wilson, 1994).

9.222 To discourage the use of reusable towels, towel rails should not be installed next to clinical hand-wash basins. Fabric towels are recognised as a source of cross contamination and are not recommended in clinical practice (Blackmore, 1987).

9.223 Hot-air dryers should not be used in clinical areas as warm air currents dry hands slowly and can be used by only one individual at a time. This results in queues and the temptation to dry hands on clothing (Bushell, 2000).

9.224 Foot-pedal-operated bins with a waste bag should be provided by each clinical hand-wash basin (Gould, 1997).

9.225 A minimum of one hand-wash sink in each single room is required. En-suite single rooms should have a hand-wash basin in the en-suite facility in addition to a clinical hand-wash basin in the patient's room.

9.226 Isolation rooms/single rooms used to segregate patients should have a hand-wash sink in the ante-room, isolation room and en-suite facilities.

9.227 Ideally, in intensive care and high dependency units (critical care areas), consideration should be given to providing one hand-wash basin for each bed space.

Catering/food hygiene

9.228 There are many important requirements to be considered when planning a new catering facility, whether this is a new build or an upgrade of an existing building. In the planning and design of such a facility it is essential that professional input is obtained from a number of sources, particularly the Local Environmental Health Office, NHS Infection Control, Health & Safety.

9.229 It is important that the following areas are considered:

- the size of the facility must first of all be established and this is generally based on the estimated daily production requirements (size should be 'fit for purpose' and not restricted by the space available);
- style of food production and service to be used e.g. cook/serve, cook/chill, bulk or plated service. The patient type and layout of the hospital site can heavily influence this decision and will assist in the choice of equipment.

9.230 To enable ease of maintenance, the general fabric of the internal building should be given careful consideration with suitably finished surfaces for floors and walls. Consideration should be given to the following:

- general ventilation is a key factor to be considered including environmental temperatures of workspace;
- the design should be based on a logical flow pattern for production and service e.g. goods inward > checking and storage > preparation > production > service/distribution > returns > etc;
- safe holding and handling of food requires careful consideration when designing refrigeration/chilling/freezing requirements;
- satisfactory facilities must be made available for catering staff changing in accordance with guidance (e.g. HBN 10: 'Catering department'. Comments on use in Scotland can be found in SHHD/DGM 86/43), with specific planned arrangements for hand hygiene both prior to entering and whilst in the catering/food handling area;
- to aid compliance with the relevant Food Safety Legislation, a competent Hazard Analysis and Critical Control Point (HACCP) system must be developed. This should be developed in conjunction with the Local Environmental Health Department;
- attention should be given to planning for adequate segregated storage capacity e.g. chilled foods, raw, cooked, dry goods, dairy foods, disposable goods, cleaning materials, waste material awaiting uplift, etc;
- in the area of preparation facilities, attention must also be given to segregated temperature controlled areas particularly for chilled food handling.

9.231 Patients can be particularly vulnerable to the effects of food-borne infection. This is usually traced to a bacterial source and problems can arise from contamination from food handlers, utensils and work surfaces as well as incorrect or inadequate food hygiene precautions. It is important that management control systems, for example HACCP (Hazard Analysis and Critical Control Point): see the Department of Health's (1993) 'Assured safe catering – a management system for hazard analysis', good practices and the conditions in which the food is stored, prepared, processed, distributed and served all enable high standards of hygiene to be achieved and readily maintained.

9.232 To facilitate appropriate standards of personal hygiene for staff, there should be hand-wash basins in each preparation area and in the cooking and serving areas. Non-touch taps should be specified, and liquid soap and paper towels should be provided. Basins should be sited where they cannot splash onto food preparation equipment.

9.233 Once a decision has been taken on the style of cooking and service to be adopted, consideration should then be given to equipment choice. It is essential that equipment is chosen which will facilitate ease of cleaning, with mobility being a feature wherever possible.

9.234 Equipment selection should be carried out with as much research as possible into the technology available. Key features to take account of when planning equipment selection include:

- carefully specify requirements;
- use National Contracts available;
- carry out detailed tendering process with realistic time-scales;
- budget for preventative maintenance contracts for all production and service equipment, with particular emphasis on the ability of the equipment to maintain acceptable food temperatures during transit. Plan to include spare capacity in the stock of trolleys in order to allow for breakdown and removal from service for maintenance and cleaning.

Ward kitchens, pantries and therapeutic kitchens

9.235 Equipment purchased must conform to the standards in the Food Safety Act 1990 (Scotland). This includes the need for a separate hand-wash basin and finishes used for the floors, walls, etc. The size and design will vary according to the overall decision for food preparation in the premises. If a cook-chill system or regeneration of frozen food is to take place, the kitchen will need to be larger to house the regeneration oven and will need additional ventilation.

9.236 Catering facilities at ward level require careful consideration. During the course of the day, a wide range of catering procedures will take place in the ward kitchen/pantry areas. These procedures are normally carried out by either nursing or domestic services staff with the majority of the tasks carried out relating to the preparation of 'between meal' snacks and beverages and the washing up of crockery, cutlery and glassware. The ability to be able to

maintain a clean environment is of paramount importance and the ward kitchen should be designed to facilitate this.

9.237 Space required will vary according to the number of beds which the facility will serve and the style of food service will also dictate the space required. e.g. bulk food service or plated meals. A bulk food service may require crockery from all meals to be washed at ward level whilst the plated service will normally see crockery from the three main meals returned to the main hospital kitchen for wash-up, with only between meal snacks and beverage crockery washed at ward level. The ward kitchen should be designed to allow sufficient space to allow a number of staff to work in the area at the same time and to accommodate the required level of storage and equipment.

9.238 The ward equipment to be selected should be of industrial standard to ensure that it is capable of dealing with the heavy demands made on it. Domestic type appliances should be avoided, particularly refrigerators, ice-making machines, dish-wash machines and hot water boilers. Advice from the Infection Control Team should be sought prior to the purchase of equipment.

The following points should be complied with:

Refrigerators: The size of the unit selected should be capable of holding the routine daily supplies. This will be influenced by whether or not a 'pergal' milk dispenser is used in the kitchen or if the refrigerator is required to hold quantities of carton milk. An industrial unit will be more capable of handling the larger quantities of chilled food with a more effective recovery time for chilling of the unit given the frequent opening of the door and loss of temperature. The unit selected should be capable of maintaining a chill temperature of below 4 degrees centigrade.

Dish-wash machine: As with the refrigerator, this should be of industrial standard with the ability to achieve a rinse temperature of 82^0C. The machine should also be capable of operating with an automatic dosing system of wash and rinse products. Storage facilities should also be provided for safe keeping of the wash and rinse products.

Ice-making machine: The type selected should be capable of automatic dispensing of ice and without a storage reservoir, which requires the users to scoop ice from a stock which may have been made too far in advance. Ideally they should be plumbed from the mains water supply to ensure biofilms are minimised.

Hot water boilers: A thermostatically controlled water boiler should be provided for the preparation of beverages in preference to the use of kettles, particularly in kitchens that supply a service to a ward area.

Microwave: If sited in the ward area, should not be used to cook or reheat food intended for consumption by patients.

9.239 Sufficient storage facilities should be provided to accommodate the range of food and non-food supplies held at ward kitchen level. This is normally held in

base storage units and wall mounted cupboards with adequate provision of standard height work-surfaces. Attention must be given to establishing sufficient numbers of electrical sockets to accommodate electrical equipment.

9.240 The general environment should contain adequate levels of ventilation to handle the heat and steam generated by the main kitchen equipment. The floor surface should be easy to clean and preferably of a high slip-resistance. Walls and other surface should be impervious for ease of cleaning.

Occupational Therapy kitchens

9.241 In some hospitals, dedicated kitchen areas are required for use by Occupational Therapy staff for the rehabilitation of patients. The most important factor to consider for these areas is that they should simulate as closely as possible the kitchen conditions found in a standard household environment. However, the need for ease of cleaning, repair and maintenance is a priority.

9.242 The space required will vary from single to multi-use and this requires to be established by consultation with Occupational Therapy staff. Adequate provision should be made for ease of access, taking into account space for patients in wheelchairs and with walking aids. The layout of work-surfaces etc should be decided in consultation with the Occupational Therapist.

9.243 In terms of equipment, the kitchen should be fitted with the normal range of kitchen appliances and these should be of normal domestic size and not industrial specification. These include both electric and gas cookers with oven, microwave oven and fridge. Occupational Therapy staff should be consulted to determine the need for any other items of fixed equipment. Provision should also be made for sufficient numbers of electrical sockets (at worktop level) to accommodate the use of additional kitchen appliances such as toasters, mixers/blenders, kettles, etc.

9.244 The general environment should be to a standard that will facilitate ease of cleaning with no provision for curtains or carpets. The floor surface should be of vinyl with an impervious wall finish and appropriate ventilation in the cooking area. The facility should also be well fitted with a range of domestic type kitchen cupboards, worktops and wall mounted storage units. The level required should be determined by consultation with Occupational Therapy staff.

10. Construction/Refurbishment Stage

Introduction

10.1 During the construction or refurbishment of facilities, a range of circumstances prevail which present significant problems and opportunities in terms of prevention and control of infection. It is also at this stage where lifetime prevention and control of infection problems can either be built in or out depending on the profile and resources given to prevention and control of infection issues. This Section considers the main issues and highlights actions to minimise infection risks during and after the construction phase.

Construction and waste

10.2 Each year in Scotland approximately 6.28 million tonnes of waste are produced by the construction industry (SEPA 2000) and for projects attached to existing healthcare facilities this can cause considerable risk to susceptible patients due to increased risk of fungal spores being released into the air. It is important that this dust and debris is controlled and disposed of safely. Major earthworks are also a recognised factor in legionella infections.

10.3 Barrier systems should be erected and fit-for-purpose closed waste containers supplied.

10.4 Waste produced by the construction industry relating to projects at healthcare facilities, can give rise to infection problems, especially for susceptible patients, and careful planning is required if the potential for infection risk is to be designed out.

10.5 The clinical implications which arise when the system for managing construction waste goes wrong, or is simply not in place, include increased risks to immuno-compromised patients from incorrect transporting and disposal of the waste.

Methods of control

10.6 Construction work in a healthcare facility inevitably generates dirt and dust and with it certain micro-organisms which have the potential to harm immuno-compromised patients. This is especially true of *Aspergillus fumigatus*, a ubiquitous fungus which is spore producing and which is transmitted by inhalation or contact. Dust and debris control is essential along with the need for increased and regular cleaning during and after completion of the building project.

10.7 Designated entry and exit areas should be identified for use and, where appropriate, dedicated lifts should also be identified for use.

10.8 Input from Infection Control Specialists is essential in the planning of the building project as well as during, and on completion of, the construction work. HAI-SCRIBE should be applied as appropriate.

Issues to be considered include:

- refurbishment/new build project;
- workflow;
- infection risk/patient movement;
- specialised areas like theatres, critical care, laundry, treatment areas.

10.9 The prevention and control of infection measures to be considered will apply equally to new build and refurbishment projects.

10.10 Correct workflow systems must be maintained throughout the building project. Input from Infection Control Specialists is essential at each stage of the project, requiring close collaboration between Infection Control Specialists and the Design Team. This is especially important in the planning of specialised units like theatres and critical care facilities.

10.11 Most healthcare departments have clean-to-dirty workflow systems. Workflow is a fundamental of good prevention and control of infection practice and this needs to be reflected when the built environment is being considered. There is often an issue of space being at a premium and there is therefore the temptation to try to fit everything in. It is important to resist this temptation as problems caused by this may last the lifetime of the facility. The healthcare facility should be large enough to adequately accommodate activities taking place within it.

10.12 HAI-SCRIBE highlights the range of construction activities commonly undertaken in healthcare facilities and assesses the degree of risk in relation to population groups.

10.13 In order to ensure the risk of infection is minimised during construction works, consideration must be given to:

- the patient population group being treated;
- the type of construction work being carried out;
- the risk associated with these two factors.

Risk Management methodology

10.14 Kennedy (1996) developed a methodology which assesses the risk of infection from construction works and has highlighted the range of precautions needed to eliminate or manage this risk. Although this system was developed for use in the United States it can be applied to the redevelopment and refurbishment of healthcare facilities within NHSScotland.

Risk to patients of infection from construction work in healthcare premises by clinical areas		
Group 1	**Lowest risk**	1. Office areas. 2. Unoccupied wards. 3. Public areas.
Group 2	**Medium risk**	1. All other patient care areas (unless included in Group 3 or Group 4). 2. Outpatient clinics (unless included in Group 3 or Group 4). 3. Admission or discharge units.
Group 3	**High risk**	1. A & E (Accident and Emergency). 2. Medical wards. 3. Surgical wards (including Day Surgery) and Surgical outpatients. 4. Obstetric wards and neonatal nurseries. 5. Paediatrics. 6. Acute and long stay care of the elderly. 7. Patient investigation areas, including: • Cardiac catheterisation; • Invasive radiology; • Nuclear medicine; • Endoscopy. Also (indirect risk) 8. Pharmacy preparation areas. 9. Microbiology laboratories (risk of pseudo-outbreaks and unnecessary treatment).
Group 4	**Highest Risk**	1. Any area caring for immunocompromised patients*, including: • transplant units and outpatient clinics for patients who have received bone marrow or solid organ transplants; • oncology units and outpatient clinics for patients with cancer; • burns units. 2. All Intensive Care Units. 3. All operating theatres. Also (indirect risk) 4. CDUs (Central Decontamination Units).

*__Immunocompromised patients__ are those patients whose immune mechanisms are deficient because of immunologic disorders (e.g. human immunodeficiency virus [HIV] infection or congenital immune deficiency syndrome), chronic diseases (e.g. diabetes, cancer, emphysema, or cardiac failure), or immunosuppressive therapy (e.g. radiation, cytoxic chemotherapy, anti-rejection medication, or steroids). Immunocompromised patients who are identified as high-risk patients have the greatest risk of infection caused by airborne or waterborne micro-organisms. Patients in this subset include persons who are severely neutropenic for prolonged periods of time (i.e. an absolute neutrophil count [ANC] of ≤ 500 cells/mL), allogeneic HSCT patients, and those who have received the most intensive chemotherapy (e.g. childhood acute myelogneous leukaemia patients). (CCDR 2001.)

Immunosuppresive conditions identified as risk factors for construction-related nosocomial fungal infections include graft-versus-host disease requiring treatment; prolonged neutropenia or granulocytopenia because of cytoxic chemotherapy; prolonged use of antibiotics; and steroid therapy. Other risk factors for the development of aspergillosis include dialysis and mechanical ventilation, smoking and patient age, the very young and very old being at greater risk Grauhan and colleagues reported that the risk of a fungal infection increases in patients who exhibit three or more risk factors ($p<0.001$). (CCDR 2001.)

Table 7: Highlights the different population groups being treated in the healthcare facility and the degree of risk associated with them.

Type 1	**Inspection and non-invasive activities.** Includes, but is not limited to, removal of ceiling tiles for visual inspection, painting which does not include sanding, wall covering, electrical trim work, minor plumbing and activities which do not generate dust or require cutting of walls or access to ceilings other than for visual inspection.
Type 2	**Small scale, short duration activities which create minimal dust.** Includes, but is not limited to, installation of telephone and computer cabling, access to chase spaces, cutting of walls or ceiling where dust migration can be controlled.
Type 3	**Any work which generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies.** Includes but is not limited to, sanding of walls for painting or wall covering, removal of floor coverings, ceiling tiles and casework, new wall construction, minor duct work or electrical work above ceilings, major cabling activities, and any activity which cannot be completed within a single work shift.
Type 4	**Major demolition and construction projects** Includes, but is not limited to, activities which require consecutive work shifts, requires heavy demolition or removal of a complete cabling system, and new construction.

Table 8: Indicates the types of construction work being carried out within the healthcare facility

	Construction Project Type			
Patient Risk Group	***TYPE 1***	***TYPE 2***	***TYPE 3***	***TYPE 4***
Low Risk	**Class I**	**Class II**	**Class II**	**Class III/IV**
Medium Risk	**Class I**	**Class II**	**Class III**	**Class IV**
High Risk	**Class I**	**Class II**	**Class III/IV**	**Class IV**
Highest Risk	**Class II**	**Class III/IV**	**Class III/IV**	**Class IV**

Table 9: Estimates the overall risk of infection arising and will indicate the class of precaution that should be implemented.

Protection of sensitive areas

10.15 Having highlighted the overall degree of infection risk, appropriate control measures can be implemented to manage or eliminate the risk of transmission. Table 10 highlights the appropriate prevention and control of infection precautions.

	During construction of a project	*Upon completion of a Project*
Class I	1. Execute work by methods to minimise raising dust from construction operations. 2. Immediately replace a ceiling tile displaced for visual inspection.	Clean areas.
Class II	1. Provide active means to prevent airborne dust from dispersing into atmosphere. 2. Water mist work surfaces to control dust while cutting. 3. Seal unused doors with duct tape. 4. Block off and seal air vents. 5. Place dust mat at entrance and exit of work area. 6. Remove or isolate HVAC system in areas where work is being performed.	1. Wipe work surfaces with disinfectant. 2. Contain construction waste before transport in tightly covered containers. 3. Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area. 4. Remove isolation of HVAC system in areas where work is being performed.
Class III	1. Remove or Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers ie plasterboard, plywood, plastic, to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilizing HEPA equipped air filtration units. 4. Contain construction waste before transport in tightly covered containers. 5. Cover transport receptacles or carts. Tape covering unless solid lid.	1. Do not remove barriers from work area until completed project is inspected by the Board's Safety Department and Infection Control Department and thoroughly cleaned by the Board's Environmental Services Department. 2. Remove barrier materials carefully to minimise spreading of dirt and debris associated with construction. 3. Vacuum work area with HEPA filtered vacuums. 4. Wet mop area with disinfectant. 5. Remove isolation of HVAC system in areas where work is being performed.
Class IV	1. Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers ie plasterboard, plywood, plastic to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilizing HEPA equipped air filtration units. 4. Seal holes, pipes, conduits, and punctures appropriately. 5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave the work site. 6. All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area. 7. Do not remove barriers from work area until completed project is inspected.	1. Remove barrier material carefully to minimise spreading of dirt and debris associated with construction. 2. Contain construction waste before transport in tightly covered containers. 3. Cover transport receptacles or carts. Tape covering unless solid lid. 4. Vacuum work area with HEPA filtered vacuums. 5. Wet mop area with detergent to remove physical soiling before disinfecting area. 6. Remove isolation of HVAC system in areas where work is being performed.

Table 10: Describes the required Infection Control Precautions depending on class of risk (Adapted from Kennedy, 1997)

Ventilation of work site/pressurisation

10.16 Physical barriers erected to allow work activity should be robust and take account of the work activities and potential for damage that can breach this barrier. The work area, where practical, should be at a negative pressure with respect to the clean working areas. Avoid extract outlets discharging into the same areas as clean air intakes. Regular planned inspection of the site, visual airflow or pressure indicators and alarms should be considered.

Procurement

10.17 Infection Control Specialist input is essential at the procurement stage of any construction/refurbishment project. This input is initially required when consideration is being given to the selection of Architects and Designers. There is a case for stipulating that Architects and Designers for healthcare projects are suitably qualified in terms of their knowledge and understanding of prevention and control of infection.

10.18 The specification of building materials, especially surface finishes, healthcare facility equipment, etc should take account of input from the Infection Control Specialist.

Commissioning of systems and equipment

10.19 The work plan should allow for a phased approach to commissioning of systems. Once an area has been commissioned, it needs to be cleaned and sealed off. Equipment can then be cleaned and laid out providing access is strictly controlled prior to final handover.

Validation and verification of equipment

10.20 The Health and Safety files need to be complete and hold all necessary manuals and commissioning certificates. Any reusable medical device requires decontamination information and all necessary instructions. These should be obtained prior to purchase to ensure that the available decontamination facilities are able to deal with the device.

Planning for expansion

10.21 At the planning stage, the Planning and Design Team must ensure input from the Infection Control Specialist. This input would cover the proposed facility expansion and the measures to be put in place during the course of the construction project.

10.22 The prevention and control of infection input at the planning and design stage will mirror that for new build situations and reference should be made to Sections 8 and 9.

10.24 Reference should also be made to the appropriate question sets of HAI-SCRIBE.

Decant facilities

10.25 Major refurbishment or expansion projects would ideally benefit from the availability of a decant facility where patients could be transferred during the course of the construction work. Such a decant facility would also be very useful during the course of an infection outbreak to allow additional isolation/segregation capacity or in the case of an infection outbreak in the community additional patient capacity.

10.26 Given scarce resources and the need to apply health economics, the provision of decant facilities may be regarded as a desirable luxury. However, when consideration is given to the situations in healthcare facilities where a decant facility would be of real value in minimising the risk of infection spread, it may be appropriate to make some decant capacity available.

Environmental sampling/inspection

Physical monitoring

10.27 Physical monitoring of the healthcare environment including temperature, humidity, air change rates, leak rates, direction of air and water flow, particle counts and filter efficiency testing methods can help ensure that environmental conditions in the healthcare facility are such that they do not contribute to the spread of infection.

10.28 No single test can be relied upon to provide the whole picture and trends rather than individual readings are most useful. Areas such as theatres, positive and negative pressure rooms, sterile preparation areas in pharmaceutical facilities, sterile services etc. will have specific guidance for testing regimens. These are used mainly to determine that the area is fit for the desired purpose. In the event of any problem, these records are useful to determine investigation pathways.

10.29 Conditions likely to promote microbial contamination include high moisture levels in air, particularly when associated with high air temperature. Stagnant air, possibly through poor ventilation, can contribute to fungal contamination whilst excessive air turbulence can increase airborne particulate levels and contribute to the dispersal of micro-organisms.

10.30 The maintenance of the environment is important to ensure that areas are intact, functioning properly and in a state such that they can be cleaned properly.

10.31 Water testing in a variety of situations (e.g. endoscope washer-disinfectors and steam for autoclaves) may require chemical and endotoxin testing as well as tests for conductivity and hardness.

10.32 Visual inspection must be part of physical monitoring to ensure for instance that filters are fitted correctly, that surfaces are smooth, impervious, free of cracks and joins, and without the accumulation of dust which may harbour fungi and bacteria.

Microbial monitoring

10.33 In terms of quality assurance, microbial sampling of the air, water and surfaces of the healthcare facility has an important role to play in helping combat the spread of infection within the built healthcare environment. NHS Healthcare Bodies should have a formal protocol for the monitoring of the built healthcare environment with regard to the control of infection. When sampling of the area is carried out, the laboratory should have appropriate accreditation for carrying out the sampling. Some sampling may have to be performed in response to an investigation of an outbreak of infection. Results obtained should be interpreted using scientifically established baseline values for comparison e.g. Health and Safety Executive guidelines. On completion of analysis, actions to be implemented should be based on the results obtained.

10.34 The microbial monitoring protocols should be developed by the Infection Control Team, with input from other disciplines and bodies as appropriate. Areas where the built environment is suspected of contributing to the spread of infection or where construction or refurbishment work is proposed, should be referred to the Infection Control Team for consideration of monitoring and advice as appropriate.

10.35 Helpful advice is available from the United States in the CDC publication 'Guidelines for Environmental Infection Control in Health-Care facilities'. This document states that biological monitoring of the healthcare facility should occur in the following four situations (CDC 2003):

- to support the investigation of disease or infection where environmental reservoirs or fomites have been implicated epidemiologically in the transmission of the disease or infection;
- for research purposes to provide information on the spread of infection within the built healthcare environment;
- to monitor a potentially hazardous situation;
- for quality assurance purposes as part of a quality control programme or to evaluate a change in prevention and control of infection.

10.36 Microbiological and other methods of sampling have an important role to play in training and education of healthcare staff.

Methods of microbial sampling

10.37 There are several types of microbial sampling methods. Conventional culture methods of microbial diagnosis are generally restricted by the amount of time it takes for qualification or quantification to occur. Culture techniques take a minimum of 18 hours to carry out and in some instances can take as long as 6 weeks.

10.38 There are a variety of methods and media available but many are poorly assessed and validated. In many circumstances there are no standards or set protocols for testing. Contact plates, swabs, enrichment versus selective media and sensitivity of the method needs to be assessed in order to allow

interpretation. It is important to know why the sampling is being carried out and the procedures to be implemented if abnormal results are found. Environmental sampling can place a heavy burden on clinical laboratories which may not be set up, funded or accredited for non-clinical sampling.

10.39 Non-culture techniques do not require pathogen multiplication and can be a more rapid method of detection. These methods are being utilised with increasing frequency, including techniques such as:

- antigen detection techniques e.g. Elisa;
- toxin detection techniques e.g. endotoxin assay;
- ATP(Adenosine Tri-phosphate) detection techniques e.g. bioluminescence, used in the food industry as a rapid hygiene test for surfaces;
- residue protein detection tests (ninhydrin tests);
- soil tests;
- cleaning efficacy tests;
- molecular techniques.

External specialist advice in the use of these and other rapid techniques is likely to be necessary.

10.40 Special consideration should be given to specialised areas such as control of Legionella. There is often specific guidance on such areas such as:

- Scottish Health Technical Memorandum (SHTM) 2040: 'The control of Legionellae in healthcare premises - a code of practice';
- Health and Safety Executive (HSE) guidance note L8 'Legionnaires Disease: The control of legionella bacteria in water systems. Approved code of practice and guidance'.

11. Operation/on-going maintenance

Importance of maintenance

11.1 Good design and equipment selection will ensure future maintenance is easy and cost effective. A planned maintenance system should be set up to start at the same time as handover or occupancy. A record of Planned Preventative Maintenance needs to be kept. Regular reviews of the building fabric should be undertaken as accidental damage to smooth surfaces makes effective decontamination difficult to achieve. The use of soft, difficult to decontaminate fabrics must be, as far as possible, avoided.

Access for maintenance

11.2 Where practical, maintainable elements should be located in separate plant rooms with easy access to plant and final connection through walls into clinical areas. Plant and services should be located behind panels that should be easily accessed with quick release fixings. Care should be taken when running services on the surface to avoid ledges where dust can collect. Equipment should be serviced *in-situ* where this helps to avoid cross infection. If equipment has to be removed from the area, consideration should be given to decontamination before and after servicing has been carried out.

Catering/food hygiene

11.3 All healthcare establishments must comply with requirements in the Food Safety Act 1990 (Scotland) and food hygiene regulations made under this Act. Reference should also be made to the Cook Chill Guidelines (DoH, 1989) and any other relevant legislation.

Ancillary areas

11.4 It is important that ancillary areas are of an appropriate standard and do not put the user at risk of cross-infection.

11.5 The evidence used is based on guidance from NHS Estates, England. Prevention and control of infection issues will depend on:

- the use of the ancillary area;
- who will have access; and
- the type of activity to be carried out there.

11.6 Ancillary areas include:

- dirty utility/sluice;
- clean utility/sterile products;
- treatment room;

- disposal room;
- day room/patient waiting area;
- play area;
- nappy-changing area;
- visitors toilets.

Dirty utility room

11.7 A dirty utility room should include facilities for:

- the cleaning of dressing trolleys and other items of equipment;
- testing urine;
- disposal of liquid waste; and
- temporarily holding items requiring reprocessing or disposal.

11.8 Space and facilities for holding and reprocessing of bed-pans, urinals and vomit bowls are required where in-patients are looked after (further guidance can be found in SHTM 2030: 'Washer Disinfectors'). Central Decontamination Units (CDUs) returns can also be held here, along with storage of sani-chairs, commodes and linen bag carriers.

11.9 Hand-hygiene facilities are necessary plus the provision of a 'slop-hopper' for disposal of body-fluid waste (SHPN 04: 'In-patient accommodation - options for choice') and a separate deep sink for decontaminating nursing equipment.

Clean utility room

11.10 A clean utility room is required where drugs and lotions may be stored and prepared. A working supply of clean and sterile supplies may be held and dressing trolleys prepared. Clinical hand-hygiene facilities are required.

11.11 In primary care facilities, the room should be located adjacent to the treatment area. It is important that planners think about the type of storage facilities provided; there must be sufficient storage area for sterile supplies equipment and other clean supplies to keep supplies off the floor. They must be able to be cleaned easily and quickly while protecting clean stores and equipment from dust and contamination.

11.12 Sterile and clean supplies should be stored away from any source of water splashing. Suitable storage will ensure packaging is not damaged while accessing supplies.

Treatment room

11.13 A treatment room may be required for in-patient examination or investigations on the ward. It will certainly be needed in primary care settings and will require different design features according to its planned use. For example, in areas where immunisation, redressing or surgical intervention and investigations take place the following points should be considered:

- adequate numbers of hand-wash basins should be provided;
- space should be available to allow for the storage of equipment and sterile supplies;
- carpets should be avoided.

Disposal room

11.14 The disposal room is the temporary storage point for all items of supplies and equipment which have to be removed for cleaning, reprocessing or disposal, e.g. linen, reusable medical devices.

Day room/patient waiting area

11.15 There is often conflict between the aesthetics of these areas and the prevention of contamination of the environment or furnishings. This is especially the case in waiting areas such as in Accident and Emergency departments, primary care and minor injury units (SHPN 04: 'In-patient accommodation - options for choice').

11.16 It is important that where blood and body-fluid spillages may occur, the environment should be able to be cleaned so that micro-organisms do not survive and should be able to withstand the use of high concentrations of aggressive disinfectants.

11.17 Flooring should be cleanable and be able to withstand the use of detergents and disinfectants. Carpets are not recommended where spillage is anticipated.

Play area

11.18 There are prevention and control of infection implications for toy cleaning (i.e. how they should be effectively cleaned) and storage (i.e. the provision of adequate toy storage facilities) plus issues for cleaning equipment and multiple use areas such as soft play areas and play mats.

11.19 Porous or fabric toys should be avoided, as they cannot easily be decontaminated on site.

Nappy-changing area

11.20 Provision of a nappy-changing area is a necessary addition to any healthcare premises.

11.21 Facilities for disposal of soiled nappies and for hand-hygiene are required along with a regular cleaning programme for equipment used.

11.22 The area for nappy-changing should have a surface which can be easily cleaned.

Visitors' toilets

11.23 These are heavily used and should provide sufficient space and be of a high grade of finish to maintain a good standard of hygiene.

11.24 There should be provision of disposal facilities for sanitary waste in both women's and mixed-sex toilets.

11.25 The number of toilets and hand-wash basins provided must be sufficient for the anticipated population.

Recommendations

11.26 Ancillary areas provided as part of a ward, department, primary care facility or community home must be easily accessible, fit for the purpose and safe, both from a health and safety perspective and a prevention and control of infection perspective.

11.27 The prevention and control of infection issues in an ancillary area must be included along with other design features and will depend on what the ancillary area is to be used for, who will have access, and what type of activity will be carried out there.

11.28 Ancillary areas must be easily cleaned, have facilities for hand-hygiene, disposal of fluid and clinical waste, if appropriate, and sufficient storage for supplies and equipment.

11.29 Clean and dirty areas must be kept separate and the workflow pattern and management of each area must be clearly defined.

Cleaning frequency/quality

11.30 The ability to effectively maintain a clean environment is essential in the planning and design stage of any new facility. This applies to the general fabric of the building, along with the equipment selected.

11.31 Cleaning of all fixtures, fittings and equipment should be managed by way of planned cleaning schedules, based on routine cleaning frequencies. This will not only ensure a clean environment but will also extend the working life of the facility.

11.32 In addition to the cleaning frequency schedules, attention must be given to ensuring that appropriate staff training is carried out.

11.33 In order to maintain a facility in good condition, the design must allow for protection to walls which can regularly be subject to repeated damage from trolley traffic. Plans should also be made at an early stage to have the area included on the routine maintenance programme in order to maintain a high standard and minimise deterioration of the fabric. (Further guidance can be found in the NHSScotland National Cleaning Specification produced by the HAI Task Force.)

Ventilation

11.34 Ventilation should dilute airborne contamination by removing contaminated air from the room or immediate patient vicinity and replacing it with clean air from the outside or from low-risk areas within the healthcare building.

11.35 The ventilation must be sufficient to maintain a comfortable environment for staff and prevent the premises and equipment from overheating. Artificial ventilation systems must be constructed to permit access for cleaning and maintenance. Conditions which give rise to condensation should be avoided as condensation will encourage the growth of mould.

11.36 Care should be taken when servicing ventilation systems as air-flows and pressure changes can allow contamination of clinical areas. Dust or contamination in the ductwork or within the plant rooms can find their way into the system. Fire dampers should be of the self-resetting type to avoid accidental disruption of airflow. Filters need to be changed at regular intervals and care needs to be taken to avoid contamination of the system due to overloaded filters collapsing. Regular checks of the ductwork and diffusers should form part of the maintenance plan. Microbiological monitoring and commissioning of specialised ventilation should be in accordance with guidance in SHTM 2025: 'Ventilation in healthcare premises'. Ventilation systems should be designed to allow removal of filters without contaminating filtered air space.

Ventilation in the clinical setting

11.37 Research has suggested that in specialised areas, ventilation can reduce the incidence of healthcare associated infection such as wound infections and communicable diseases (Ayliffe et al, 2000; Sanchez and Hernandez, 1999; Fox, 1997; O'Connell and Humphreys, 2000; Holton and Ridgway, 1993; Humphreys, 1993).

11.38 Effective ventilation in healthcare premises involves the dilution of the airborne contamination by removing contaminated air from the room or immediate patient vicinity and replacing it with clean air from the outside or from low risk areas within the healthcare building. The use of specialised ventilation systems mainly relates to high risk units such as operating theatres, special care baby units, burns units, high dependency and intensive care units and areas such as isolation rooms (negative pressure ventilation for infectious patients and positive pressure ventilation for immuno-compromised patients).

11.39 Health Facilities Scotland SHPNs and SHTMs along with Codes of Practice for design of buildings give advice on 'natural' ventilation, general extract ventilation and ventilation for specialised areas such as operating theatres, hydrotherapy suites, isolation rooms and are referenced under the respective specialised areas.

11.40 Wound infection has traditionally been a major cause of morbidity resulting from surgical procedures. Improvements such as ultra-clean theatre ventilation have contributed to reduced morbidity and mortality in specialised areas such as orthopaedics (Lidwell et al, 1982).

11.41 Airborne infections have been associated within treatment areas where patients are immuno-compromised, for example haematology wards, bone marrow transplant units (Alberti et al, 2001; Sherertz et al, 1987).

Cost implications

11.42 In some clinical areas, the decision to install sophisticated ventilation systems which need routine or constant monitoring must be balanced against the risks and costs of such controls. The evidence on which to base the risk analysis is usually either absent or controversial. Where air movement is induced by mechanical ventilation, the flow of air must be from clean-to-dirty areas (where these can be defined). Hoffman et al (1999) state that "*investment in mechanical air systems is large and as with many other areas of infection control, it is difficult to measure their true effectiveness when such a measure would be the absence of sporadic events implicating a failure of the system*".

Control and containment of infection

11.43 Ventilation of healthcare premises is considered in SHTM 2025: 'Ventilation in healthcare premises' which includes discussion of airflow and filtration:

- Humphreys (1993) states that whenever airborne infection is possible in theatres, the airflow must go from clean to contaminated areas, and not the opposite way;
- Isolation rooms can be equipped with appropriate ventilation, i.e. negative or positive air pressure (but preferably not both);
- information on planned maintenance of ventilation systems should be available ((see Health Facilities Scotland (formerly NHSScotland Property and Environment Forum) SHTM 2025: 'Vol. 4 – Operational management'));
- ultra-clean ventilation systems in operating theatres can reduce airborne contamination and subsequent wound infections more effectively in specialised areas such as orthopaedics;
- Wagenvoort et al (1993) demonstrated the problems associated with intermittent interruption of electricity to ventilation systems which shuts the system down briefly.

Clean air and ventilation systems

11.44 Controlling airborne infection in relation to prevention of cross-infection in healthcare buildings remains a controversial subject. Hoffman et al (1999) divided the acute ward environment into:

- the 'true environment', which comprises those organisms normally found in any non-hospital environment, for example fungal spores; and
- the 'special hospital environment' which consists mainly of organisms arising from patients, staff and visitors, for example tuberculosis.

11.45 The relative incidence of airborne infection in hospitals has been estimated to be about 10% (Schaal, 1991). However, this does not take into account such

factors as local respiratory pathogens, susceptibility of patients, climatic conditions, construction work, ventilation equipment and organisational policies in individual hospitals or wards.

11.46 The Control of Substances Hazardous to Health Regulations (COSHH) (1999) state that:

"Exposure to a biological agent shall be adequately controlled by designing work processes and engineering control measures so as to prevent or minimise the release of biological agents into the workplace."

11.47 The COSHH Regulations require work processes to be safe by design. However, in some cases such as multi-drug-resistant tuberculosis (MDRTB), both ventilation and Personal Protective Equipment (PPE) will be required.

11.48 Shutters, access doors or air direction slats, if fitted, should be easily accessible for cleaning or removal.

Heating

11.49 A heating element is likely to be an integral part of the ventilation system and should be easily controlled and maintained. Natural convection currents caused by heat loss needs to be considered when calculating airflows and direction of airflow.

Heating/temperature control

11.50 Special consideration should be given to the type of heating, cooling and general ventilation systems provided in patient care and clinical areas. The heating and ventilation strategy should be appropriate for the setting.

Heat emitters (radiators)

11.51 Health Facilities Scotland (formerly NHSScotland Property and Environment Forum) Scottish Health Guidance Note: ''Safe" hot water and surface temperatures' provides guidance on how to prevent patients burning themselves on heat emitters.

11.52 The SHGN recommends options to ensure safety as follows:

- guards/covers should be fitted;
- low surface temperature heat emitters should be used;
- temperature controls should fail to a safe position.

11.53 Of these options, covered heat emitters have raised the most prevention and control of infection concern. Heat emitter covers allow dust to build up beneath and inside the heat emitter grille. This dust has been found to contain MRSA (meticillin resistant *staphylococcus aureus)* and other potentially pathogenic organisms, and when heat emitters are switched on during the winter months, dust and bacteria are dispersed by heat convection to the ward area.

11.54 Where heat emitter covers are used, regular planned maintenance and cleaning should be undertaken to prevent the problems described.

11.55 When installing heat emitters, it is recommended that there be adequate space underneath the heat emitter to allow cleaning machinery to be used. These areas may suffer from a lack of planned maintenance and cleaning and, as such, can become heavily contaminated with dust and potentially pathogenic organisms.

Pipework siting and access

11.56 'Hidden' heating may provide a solution to the problems of cleaning as long as access is possible for regular planned maintenance and cleaning. Pipework running along a wall can easily trap dust. Pipework mounted on walls should be encased to facilitate easy cleaning.

Heating and ventilation grilles and diffusers

11.57 General heating/ventilation grilles and diffusers need to be accessed easily for inclusion in cleaning programmes by domestic staff. When infection outbreaks occur, it is essential that these fixtures and fittings are included in the remedial cleaning process. Therefore, the ability for them to be easily removed and cleaned away from the patient area is essential in limiting cross contamination. Cotterill et al (1996) and Kumari et al (1998) describe outbreaks associated with general ventilation grilles in an intensive care unit and an orthopaedic ward.

Supply and extract ductwork

11.58 Supply and extract ductwork should be installed in such a way that it can be accessed at pre-defined regular intervals and cleaned along their full length including all components.

Ceiling or wall mounted air-conditioning units

11.59 These can be extremely difficult to clean due to the fact their interstices can get very dusty. Any decision to install them should be taken with great caution and the need to close the ward/department to enable satisfactory cleaning to be undertaken also needs to be considered. Their use in high-risk areas should be undertaken with caution.

Water systems

Wash facilities

11.60 Due to the difficulty of cleaning of baths after each patient, showers are generally more acceptable to both patients and infection control personnel. However, showers have been implicated in outbreaks of infection due to *Legionella* spp. (Tobin et al, 1980). Such problems, however, can be minimised by proper planned maintenance.

11.61 WCs, bathrooms and showers should be designed and installed to aid cleanliness and prevent cross-contamination. Toilet facilities must have

facilities for hand-hygiene and SHPN 4: 'In-patient accommodation - options for choice' recommends that they should be no more than 12 metres from the bed area or dayroom.

11.62 Claesson and Claesson (1995) documented an outbreak of endometritis in a maternity unit caused by spread of *S. pyogenes* (sometimes referred to as Group A *streptococci)* from a showerhead and their conclusion was that showers, when used to clean the perineum following childbirth, pose a definite risk for post-partum endometritis. Again, proper planned maintenance should minimise this risk.

Protection of immuno-compromised patients

11.63 For areas with patients who have lowered immune responses, water fittings (washers, etc) should not support microbiological growth. Guidance can be sought from the Water Regulations Advisory Scheme (WRAS) (2001) 'Water Fittings and Materials Directory' and from BS 6920-1:2000 'Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water'.

11.64 Patients who have a lowered immune response are at risk from certain organisms found in water supplies in hospital, and as such, will need to be protected from this problem both in drinking water and wash-water facilities. Steinert et al (1998) and Miyamoto et al (2000) discuss the effects of plumbing systems on *Legionella* spp. in hospital hot-water systems and methods of disinfecting.

11.65 Graman et al (1997) demonstrated how an outbreak of healthcare associated legionellosis was traced to a contaminated ice machine. Manangan et al (1998) produced guidance on the sanitary care and maintenance of ice-storage chests and ice-making machines in response to the problems and requests for guidance from infection control professionals. Guidelines were also produced by Burnett et al (1994).

11.66 In another incident with an ice-making machine, an MDA Hazard Notice (Hazard (93) 42), was circulated following a report that leukaemia patients receiving chemotherapy treatment had developed septicaemia as a result of infection with *Stenotrophomonas maltophilia*. The source of this infection was traced to the storage cabinet of the ice-making machine in the ward. The Notice gave guidance for immediate action to ensure that ice is made directly from water that is of drinking quality.

11.67 Ice for the immuno-compromised should be made by putting drinking water into single-use icemakers, then into a conventional freezer.

11.68 Bosshammer et al (1995) carried out comparative hygienic surveillance of contamination with *Pseudomonas* spp. in a cystic fibrosis ward over a four year period and demonstrated how segregation of colonised and non-colonised patients was undermined through transfer of strains from a highly contaminated environment, that is, taps, sinks and wash basins.

11.69 Sniadack et al (1993) demonstrated how a pseudo-outbreak of *Mycobacterium xenopi* was attributable to exposure of clinical specimens to tap-water. This included rinsing of bronchoscopes with tap-water after disinfection; irrigation with tap-water during colonoscopy; gargling with tap-water before sputum specimen collection and collecting urine in recently rinsed bed-pans.

11.70 Showers have been implicated in outbreaks of legionellosis in a transplant unit (Tobin et al, 1980) and on an alcoholism rehabilitation ward (Burns et al, 1991).

11.71 Water has been implicated in outbreaks not only from drinking water sources but also when it has been used for processing specimens in equipment such as dialysis machines.

Wastewater

Wastewater and sanitation

11.72 Domestic sewage contains a large number of intestinal organisms and is therefore hazardous. It must therefore be disposed of via a safe system internally to the external wastewater sewerage systems for treatment.

11.73 This waste will include water and body fluids from sanitaryware such as toilets and bidets plus drainage systems from mortuary tables and waste disposal systems and washer-disinfectors.

11.74 Wastewater is generated from a huge number of tasks carried out in healthcare buildings, which range from domestic cleaning, hand-hygiene, specialised laundries, surgical operations and areas such as renal dialysis units. Most of the wastewater contains micro-organisms from blood and body fluids and therefore has the potential for cross-infection if not disposed of safely.

Sanitary facilities

11.75 These not only include WCs and bidets but also equipment to assist patients who are unable to use a WC such as commodes and bed-pans, plus the equipment to disinfect this equipment such as bed-pan washer-disinfectors and macerators. The importance of cleaning in and around sanitary areas has also been shown in investigations of outbreaks caused by *Clostridium difficile* (Zafar et al, 1998; Cartmill et al, 1994. (Further guidance on cleaning can be found in NHSScotland National Cleaning Specification produced by the HAI Task Force.)

11.76 Healthcare facilities have recently seen increasing numbers of patients with *C. difficile*, vancomycin-resistant enterococcus (VRE) and diarrhoea and vomiting due to small round structured virus (SRSV). The degree of environmental contamination appears to be a determining factor in healthcare associated infection with sanitary facilities acting as ‘hot spots’ for transmission.

Internal drainage system

11.77 An internal drainage system must use the minimum amount of pipework, retain water and be airtight at joints and connectors. It must be sufficiently ventilated to retain the integrity of water seals.

11.78 The design should comply with the relevant British Standards and Codes of Practice, including BS EN 12056 and the current Building Regulations. Recommendations for spatial and access requirements for public health engineering services are contained in CIBSE (Chartered Institution of Building Services Engineers) Guide G, 1999 and SHTM 2023:'Access and accommodation for engineering services'.

11.79 Provision for inspection, rodding and maintenance should be located to minimise disruption or possible contamination and manholes should not be sited within the building.

Waste disposal sinks

11.80 Sufficient and suitably located waste disposal sinks, for example slop-hoppers, should be provided to prevent contamination of hand-wash basins by disposal of wastewater.

Bed-pan washer-disinfectors/macerators

11.81 Where reusable bed-pans are used, ward areas require adequate and suitable bed-pan washer disinfectors that comply with SHTM 2030: 'Washer-disinfectors'. Wards housing certain specialised areas, for example urology wards, will need more than one bed-pan washer-disinfector. It should be noted that new BS and EN guidance will be issued on bed-pan washer-disinfectors.

11.82 Individual assessment of need should be made, as a uniform policy may lead to some areas being under-resourced. This also applies to the provision of macerators where disposable systems are used. Where macerators are used, there should be facilities to wash-disinfect bed-pan holders.

11.83 Rutala and Weber (1999) detail the role of disinfection and sterilization and discuss sanitary equipment in what they term 'non-critical item decontamination'. With the emergence of Vancomycin Resistant Enterococcus (VRE) as a healthcare associated pathogen during the past five years, urine containers and bed-pans have been implicated in outbreaks (Bonten et al, 1996).

11.84 Control or containment of these outbreaks depends on many factors, but not least the safe disposal of wastewater and sanitation and cleanliness of the equipment/environment.

11.85 Where fitted, bed-pan washer-disinfectors should be installed according to the Water Supply (Water Fittings) Regulations 1999 to prevent backflow and contamination.

Lighting

11.86 Lighting should be planned so that lamps can be easily cleaned with no edges or ridges where dust can gather. Lighting including emergency lighting should be maintained in good working order and maintenance records kept. Care needs to be taken when removing the diffusers as this is likely to disturb dust

and may lead to contamination of the clinical area. Regular cleaning of these fittings in clinical areas should form a part of the Maintenance Plan.

11.87 Lighting levels should be maintained according to the recommendations for specific areas such as wards (day and night), theatres, corridors, examination rooms, ancillary or utility rooms and specific areas such as critical care units so that observation of patients is achieved without glare (SHTM 2007: 'Electrical services, supply and distribution'). Additional task lighting needs to be provided in certain areas.

11.88 Location and design of luminaires should afford easy changing of lamps and frequent cleaning. They should be designed so that there are no ledges, ridges, etc. where dust can gather easily, build up and then be dispersed if the light is knocked or moved.

11.89 Light quality is as important as quantity and may help avoid mistakes such as invasive injuries during operative procedures or examinations.

11.90 Efficient lighting in all areas of wards or departments enables domestic staff to undertake cleaning more effectively.

Transportation

Movement/transfer of an infectious patient

11.91 Additional precautions should be observed and maintained when transferring a patient with an infection throughout the healthcare facility and during ambulance transport. It is important to limit movement and transportation of the patient only to that required for essential purposes.

11.92 If a patient is to be transferred it is essential to inform the receiving area of required precautions prior to patient transportation. Traffic in isolation/segregation areas should also be minimised.

Environmental control

11.93 Control of the physical environment includes monitoring parameters such as temperature, humidity and air change rates. Where practical, the environmental controls should be linked to a building management system capable of continual monitoring. Where this is not practical then regular testing of the system, appropriate to the application, will be required with appropriate records being kept.

Electrical supply and distribution

11.94 Guidance on supply and distribution can be found in SHTM 2007: 'Electrical services, supply and distribution'. Guidance on installation and testing is laid down in the current I.E.E. Regulations and should be followed with appropriate records being kept. Responsibility for ensuring commissioning and testing is carried out correctly lies with the building owner/occupier.

Bedhead services/patient entertainment

11.95 Bedside patient entertainment and communications systems may be provided by private companies.

11.96 The beside entertainment units are located in the wards at each bed. Cleaning of these units must comply with prevention and control of infection requirements and be approved by Infection Control personnel.

11.97 To this end, bedside entertainment units should be specifically designed with the healthcare facility environment in mind. All surfaces should be smooth, allowing effective cleaning with no areas that allow dirt to be trapped.

11.98 The system should allow each bedside entertainment unit cleaned to be logged, so that a detailed account of frequency and adherence to the cleaning specification is maintained.

11.99 A cleaning specification must be in place to ensure compliance with the Prevention and Control of Infection Procedures for cleaning areas and equipment in isolation rooms or bed areas where patients have a known infection. (Further guidance can be found in the NHSScotland National Cleaning Specification produced by the HAI Task Force.)

Medical gases: access and accommodation for services

11.100 Vacuum and suction equipment is a potential cross-infection risk. The delivery system is similar to that of gases, i.e. piped or via mobile equipment. The vacuum pipe system must be able to be isolated in case of incidents where pipework becomes contaminated with blood/body fluid. Contamination of piped vacuum systems can cause problems for Estates personnel. Access to the pipework may involve removal of the wall and ceiling fabric. The use of vacuum controlled units with overflow protection devices is essential to avoid contaminating the system with aspirated body fluid.

11.101 Guidance on the routine maintenance of Medical Gas equipment is laid down in SHTM 2022: 'Medical Gas Pipeline Systems'. SHTM 2022 gives guidance regarding piped medical gases and vacuum systems, and includes recommendations on:

- emergency procedures;
- power failure;
- access for cleaning contaminated vacuum systems;
- training and communication;
- maintenance and infection risk.

11.102 In some instances, surface mounted containment of pipework is unavoidable. If this is the case, regular cleaning of high-level ledges should be undertaken. Should any carry-over of body fluids occur within the piped vacuum system, advice should be sought from infection control. Again record keeping is critical

for these services. Before carrying out any maintenance work on vacuum systems and/or changing bacterial filters, the Infection Control Team should be informed so that advice can be given on any appropriate precautions to be observed.

Lifts

11.103 Routine maintenance of lifts is covered by SHTM 2024: 'Lifts'. Regular cleaning of the car should be undertaken, however, care should be taken during this procedure to isolate the automatic call function. Record keeping is critical for this service.

Laundry facilities

11.104 There should be separate storage areas for both clean linen and the storage of linen awaiting collection or laundering (see SHPN 04: 'In-patient accommodation - options for choice').

11.105 Due to the working environment for staff, professional advice needs to be taken from a number of authorities namely, Infection Control, Estates, Health and Safety, Fire Safety and Occupational Health.

11.106 Laundry requires to be thermally disinfected during the laundering process. Laundry from hospitals and healthcare facilities may be contaminated with blood or body fluids and may have been used on infected patients.

11.107 Segregation of linen is of the utmost importance to prevent cross contamination when it comes to dealing with laundry. Clean and dirty areas must be well controlled.

11.108 Linen requires segregation into four categories:

1. Used linen.
2. Soiled linen.
3. Infected linen, which should be placed in a water-soluble liner or bag before being placed into a laundry bag.
4. Heat labile linen.

11.109 Procedures must be in place to ensure all staff are trained in segregation within the ward/department and the laundry to ensure that there are safe work practices for handling of laundry.

11.110 When designing a healthcare laundry there should be clear workflow patterns in order that there is no cross over from clean to dirty areas. Dirty linen should come in and be able to be stored, short term, and then taken to be washed with the process continuing to the end of production, where a clean storage area will be available. It must be easy to identify which area of the laundry staff work in e.g. colour-coded uniforms.

Equipment

11.111 The correct choice of laundry equipment is important in order that thermal disinfection takes place during the laundering process i.e. that the correct temperatures are reached, and machinery must be maintained and calibrated regularly.

Cleaning

11.112 Space must be available around machinery, and safe access available to laundry and domestic staff, to allow the correct standards of cleaning to be maintained.

11.113 The laundry environment encourages dust and debris to develop and must be cleaned on a regular basis.

Ventilation

11.114 The ventilation strategy for a laundry facility should take into account the heat and dust generated in parts of the facility. Mechanical cooling should only be provided where other means of limiting temperature rise have been assessed and rejected on the basis of a full life-cycle cost analysis basis. The ventilation strategy must minimise the level of airborne contamination and dust and minimise the risk of cross infection.

Staff facilities

11.115 Hand hygiene facilities must be available throughout the laundry so that staff have access to this at all times during their working day. Adequate staff changing facilities with shower rooms should also be available in the event of spillage or contamination.

Waste handling

11.116 Waste is a major issue within the healthcare environment and there are many legislative controls and guidelines for the management of waste, to protect patients, visitors, staff and contractors working within this environment. (Further guidance can be found in SHTN 3: ‘Management and disposal of clinical waste’.)

11.117 Good design of waste management processes can minimise problems with waste segregation, storage and disposal.

11.118 This part of the document discusses the problems of waste management and the guidance which must be adhered to if patients, staff and contractors are to be protected. The reality is that the disposal of waste is often poorly managed and inadequately catered for in wards, departments and community healthcare establishments and this can lead to escalating costs and heightened risks to healthcare staff.

11.119 Following a study of hospital waste management on 13 hospital sites, the Audit Commission (1997) stated that on average an acute hospital of 500 beds

produces over 10 tonnes of waste per week. Some of the waste, such as paper, food scraps, flowers and bottles, is disposed of into the household waste stream and costs between £20 and £70 per tonne. The rest consists of clinical waste and special waste and costs considerably more to dispose of, typically between £300 and £500 per tonne.

11.120 Areas discussed include:

- identification/segregation;
- disposal/clinical bins;
- hospital waste;
- community waste;
- construction waste;
- final disposal;
- clinical implications.

Identification/segregation

11.121 Identification of categories and the means of segregation of clinical and special waste form the key elements of a waste disposal strategy. Waste is a risk not only to healthcare staff but also to their colleagues, patients, visitors and contractors. Increasing costs, litigation and damage to the environment are also areas for concern.

11.122 The means of segregation will depend on the ratio of clinical waste to non-clinical waste. Space at the ward/unit level is needed for suitable waste containers, whether the area served produces large or small amounts of clinical waste and household waste. Bins must be supplied in the appropriate areas according to amounts produced.

11.123 Current strategies for clinical waste management are outlined in SHTN 3: 'Management and disposal of clinical waste' along with the present legislative and regulatory framework and guidance. It should be noted that at the time of writing, waste legislation is changing rapidly.

Disposal/clinical bins

11.124 Clinical waste bin lids sustain the heaviest bacterial contamination and need to be capable of being suitably cleaned and disinfected, therefore, the use of bins with sack holders to allow for adequate cleaning is recommended.

11.125 Bins should be foot-operated only, and the foot pedal should be sturdy and durable.

Hospital waste

11.126 Storage in large 'Eurobins' in hospital streets (corridors) has been used for clinical waste. However, Eurobins are unsightly and should be removed where possible. Therefore, any new developments should allow for secure disposal

storage cupboards sited at the entrance to the ward or department, preferably with access from both ward and hospital street. Waste can then be stored in this area instead of cluttering up dirty utility rooms, which are often inadequate for this purpose, while awaiting collection by the portering staff.

11.127 These rooms can be combined with those for soiled linen and household waste, but must be clearly subdivided so that the three types of waste are separated from each other. This will assist rapid collection and should minimise the risks of items for reprocessing being accidentally taken for disposal by incineration.

11.128 The subdivided areas must be able to be cleaned in the event of spillage and must be able to contain any spillage that does occur. The hold area should be large enough to hold a wheelie-bin or similar depending on the waste management strategy chosen, which in turn would reduce handling and the subsequent risks to porters. A designated, secure collection bay is also necessary to hold bins until waste is either incinerated/compacted/treated on-site or transported off-site for incineration.

11.129 Staff handling of waste sacks after removal from waste bins must be avoided and any decanting of waste into larger bins must be automated where possible to minimise manual handling risks.

Community waste

11.130 In healthcare facilities such as nursing/residential homes and primary care settings, all waste must be contained in bags inside a lockable container.

11.131 The system and frequency of collection of waste for the particular area needs to be taken into account when planning facilities for temporary holding bays, etc. If located externally, the holding bay or bin must be washable, secure and rodent-proof.

11.132 There must be a strict routine for removing waste to ensure it does not remain uncollected for extended periods. Further guidance is given in SHTN 3: ‘Management and disposal of clinical waste’.

Construction waste

11.133 Each year in the UK, 70 million tonnes of waste are produced by the construction industry and for projects attached to existing healthcare facilities this can cause considerable risk to highly susceptible patients. It is important that this dust and debris are controlled and disposed of safely.

11.134 Barrier systems must be erected and closed waste containers supplied as necessary to avoid contamination of occupied areas.

11.135 Traffic control through designated entry and exit areas and dedicated lifts should be identified, if possible.

11.136 The management and minimisation of construction waste must be designed into the project.

Final disposal

11.137 Space at the ward/unit level is needed for provision of suitable secure waste containers, whether the area served produces large or small amounts of clinical waste. The storage facilities provided will vary with the type of healthcare facility and method of final disposal.

11.138 Final disposal is mainly achieved by the use of commercial, high temperature incinerators capable of meeting the increasingly tight emission limits set out by UK regulations.

11.139 Under the Environmental Protection Act 1990, certain types of clinical waste such as pharmaceuticals and chemicals must be incinerated at high temperature. However, much of what is usually designated as 'clinical waste' does not necessarily have to be burned but must be rendered safe.

11.140 Current strategies for clinical waste management are outlined in SHTN 3: 'Management and disposal of clinical waste' with the present legislative and regulatory framework and guidance. The Audit Scotland Baseline report (2001) entitled 'Waste Management in Scottish Hospitals' and the subsequent follow up report (2005) also contains an overview of waste management strategies.

11.141 In the past, in many cases, waste management has not been given the priority it requires and is still, in some cases, poorly handled and catered for within healthcare premises, both in the acute and the primary care setting. Thought must be given to adequate storage facilities for waste in a new build and when upgrading is taking place.

11.142 There are various categories of waste i.e. household waste going into the landfill waste stream, and such waste going for recycling or indeed confidential waste for destruction and clinical waste which must be rendered safe by heat treatment and where body parts and special waste are for disposal then this must be by incineration. (National contracts are in place meeting legislative compliance.) Thought must also be given to recycling particularly paper waste, which makes up a high percentage of our waste.

11.143 There must be appropriate space at ward level for suitable waste containers and multiple handling of waste should be avoided where possible. Dispose of waste as near to point of use as possible.

11.144 The correct number of bins should be in place for the amount and types of waste being produced and these bins should be foot operated and suitable to be cleaned and disinfected. Classification/guidance on types of waste and appropriate storage can be found in SHTN 3: 'Management and disposal of clinical waste'.

11.145 Storage areas for waste should be at the entrance to a ward or department with easy access for portering staff to pick up, not in dirty utility rooms, which in existing establishments do not provide enough space. Ideally these areas should be able to store wheelie bins, sharps boxes, magpie boxes for glass and

aerosols, dirty linen in order that all waste is in one place, easily identifiable and easily collected by portering staff.

11.146 The storage area should be easily cleaned and spillages easily dealt with. For example, sheet vinyl on the floors and particularly covering the walls should be encouraged to avoid damage and contamination.

11.147 When waste leaves the storage area it should be taken to its final destination where it can be held in a designated storage bay before it is incinerated, compacted, treated on site or taken off site for incineration or heat treatment.

11.148 Within primary care and community settings, waste must be kept in a lockable container, bin store etc and the appropriate frequency of collection agreed at the time of planning the premises in order that the store is large enough to cope with the amount of waste generated.

11.149 As before, the area is required to be easily maintained and kept clean.

Access to decontamination facility

11.150 Access to the decontamination facility should be such that it does not contribute to the spread of infection. As such, there should be appropriate decontamination facilities provided centrally for decontamination of reusable medical devices and the system in operation should comply with the current guidance on decontamination facilities and procedures. Not all items reprocessed centrally will be sterilized, for some forms disinfection will be the end point.

Decontamination equipment

11.151 Decontamination is the combination of processes which include cleaning, disinfection and sterilisation used to render a reusable medical device safe for reuse on patients and for handling by staff. This part of the document discusses the importance of decontamination of reusable medical devices and the evidence which can be used as a useful checklist for planning areas in the built environment.

11.152 For maintenance and validation, follow the guidelines laid down by the Infection Control Manager and the relevant SHTMs; 2030, 2031 and 2010. Record keeping forms a critical part of the management of decontamination for these types of equipment.

11.153 The effective decontamination of medical devices is essential in reducing the risks to patients from healthcare associated infection and minimising the potential iatrogenic transmission of Transmissible Spongiform Encephalopathies (TSEs), that is, Creutzfeldt–Jakob Disease (CJD), variant Creutzfeldt–Jakob Disease (vCJD), Gerstmann–Sträussler–Scheinker Disease (GSS) etc.

11.154 At each stage in the decontamination process, consideration should be given to location, facilities, equipment, management and policies/procedures.

11.155 Areas discussed in this part of the document include:

- decontamination and healthcare associated infection;
- transmission of TSEs including vCJD;
- decontamination assessment tools;
- decontamination facilities and accommodation.

Decontamination and healthcare associated infection

11.156 It has been demonstrated that 10% of in-patients acquire a hospital acquired infection (now referred to as healthcare associated infection) at any one time (Plowman et al 1999), the most common being urinary tract infection, surgical wound and lower respiratory tract infection.

11.157 There are common risk factors which cause infection, but it is not known how many infections could be prevented by improving decontamination procedures; however, it is known that failure in decontamination processes can result in a range of infections.

11.158 Saksena et al (1999) reported that transfer of infectious material had been demonstrated in inadequately decontaminated instruments. Scottish Healthcare Supplies Hazard Notice (SC) 95/02, referred to water contaminated with *Pseudomonas aeruginosa* being used to flush the lumens of a microsurgical hand-piece, which subsequently suffered ineffective sterilization before use. Three patients who had undergone surgery at the same time were found to be infected.

11.159 The possibility that TSEs might be spread from person to person in healthcare situations may arise for a number of reasons:

- classical CJD has been transmitted from person to person by medical procedures;
- abnormal prion protein has been demonstrated in the lymphatic tissue (including tonsils) of patients with established vCJD;
- abnormal prion protein has been demonstrated in the appendix of a patient who subsequently developed vCJD;
- abnormal prion protein may not be inactivated by normal sterilization procedures.

11.160 Research which gave rise to these concerns includes the identification of the abnormal form of prion protein reported in the appendix removed from a patient some months before he went on to develop clinical signs of vCJD (Hilton et al, 1998). This was the first time that the presence of abnormal prion protein had been detected in peripheral tissues before the onset of clinical disease. Furthermore, in another study (Hill et al, 1999), lymphoreticular tissues (tonsils, spleen and lymph nodes) from patients with neuropathologically confirmed vCJD were found to be positive for the abnormal protein associated with prion diseases.

11.161 The Spongiform Encephalopathy Advisory Committee (SEAC), which advises the Government on BSE/CJD issues, has advised that rigorous implementation of washing, decontamination and general hygiene procedures are key measures in reducing the risk of vCJD transmission via surgery. A risk assessment model developed by the Department of Health (DH) at SEAC's request and updated in June 2005 confirms this: 'Assessing the risk of vCJD transmission via surgery: an interim review', available on the DH website at http://www.dh.gov.uk/assetRoot/04/11/35/42/04113542.pdf.

Decontamination facilities and accommodation

11.162 If decontamination is to be undertaken in a safe and effective manner which reduces risk and contributes to a reduction in healthcare associated infection, then it must be carried out in a suitable environment, with validated automated processes, managed and operated by trained staff.

11.163 Centralised reprocessing of surgical instruments is the preferred option and local reprocessing should be the exception rather than the norm. Accommodation provided for decontamination should be designed and operated in a manner that does not contribute to the overall bio-burden of the instruments being processed. SHPN 13: 'Sterile Services Department' provides advice and guidance on provision of central sterile supply accommodation. Where local provision is required then it must be carried out to the same standard as central reprocessing. Further information on Local Decontamination Units can be found on the Health Protection Scotland (HPS) website http://www.show.scot.nhs.uk/scieh/infectious/hai/decontamination/haidecon.htm.

11.164 When designing clinical accommodation, consideration should be given to providing adequate and appropriate storage for centrally provided sterile supplies. If sterile supplies are stored inappropriately, then sterility can be compromised and contamination can occur.

Drainage

11.165 Care needs to be taken to ensure access for dismantling and cleaning of drainage if required. The use of glass traps will allow for monitoring of critical areas as necessary. Where it is important to maintain hygiene conditions within drainage systems, or integrity of water seals, regular flushing programmes should be implemented.

Sanitation

11.166 Regular maintenance of all sanitaryware is essential. Glazed surfaces free from cracks are easier to maintain. Care should also be taken where surface mounted equipment forms ledges at high levels which need to be cleaned regularly.

Environmental sampling

Physical monitoring

11.167 Physical monitoring of the healthcare environment including temperature, humidity, air change rates, leak rates, direction of air and water flow, particle counts, filter efficient testing methods, can help ensure that environmental conditions in the healthcare facility are such that they do not contribute to the spread of infection.

11.168 No single test can be relied upon to provide the whole picture and trends rather than individual readings are most useful. Areas such as theatres, positive and negative pressure rooms, sterile preparation areas in pharmaceutical facilities, sterile services etc will have specific guidance for testing regimens. These are used mainly to determine that the area is fit for the desired purpose. In the event of any problem, these records are useful to determine investigation pathways.

11.169 Conditions likely to promote microbial contamination include high moisture levels in air, particularly when associated with high air temperature. Stagnant air, possibly through poor ventilation, can contribute to fungal contamination whilst excessive air turbulence can increase airborne particulate levels and contribute to the dispersal of micro-organisms.

11.170 The maintenance of the environment is important to ensure that areas are intact, functioning properly and in a state such that they can be cleaned properly.

11.171 Water testing in a variety of situations (e.g. endoscope washer-disinfectors and steam for autoclaves) may require chemical and endotoxin testing as well as tests for conductivity and hardness.

11.172 Visual inspection must be part of physical monitoring to ensure for instance that filters are fitted correctly, that surfaces are smooth, impervious free of cracks and joins, and there is no accumulation of dust which may harbour fungi and bacteria.

Microbial monitoring

11.173 In terms of quality assurance, microbial sampling of the air, water and surfaces of the healthcare facility has an important role to play in helping combat the spread of infection within the built healthcare environment. NHS Healthcare Bodies should have a formal protocol for the monitoring of the built healthcare environment with regard to the control of infection. Some sampling may have to be performed in response to an investigation of an outbreak of infection. Results obtained should be interpreted using scientifically established baseline values for comparison e.g. Health and Safety Executive guidelines. On completion of analysis, actions to be implemented should be based on the results obtained.

11.174 The microbial monitoring protocols should be developed by the Infection Control Team, with input from other disciplines and bodies as appropriate. Areas where the built environment is suspected of contributing to the spread of infection, or where construction or refurbishment work is proposed should be referred to the Infection Control Team for consideration of monitoring and advice as appropriate.

11.175 Helpful advice is available from the United States in the CDC publication 'Guidelines for Environmental Infection Control in Health-Care facilities'. This document states that biological monitoring of the healthcare facility should occur in the following four situations (CDC; 2003):

- to support the investigation of disease or infection where environmental reservoirs or fomites have been implicated epidemiologically in the transmission of the disease or infection;
- for research purposes to provide information on the spread of infection within the built healthcare environment;
- to monitor a potentially hazardous situation;
- for quality assurance purposes as part of a quality control programme or to evaluate a change in prevention and control of infection.

11.176 Microbiological and other methods of sampling have an important role to play in training and education of healthcare staff.

Methods of microbial sampling

11.177 There are several types of microbial sampling methods. Conventional culture methods of microbial diagnosis are generally restricted by the amount of time it takes for qualification or quantification to occur. Culture techniques take a minimum of 18 hours to carry out and in some instances can take as long as 6 weeks.

11.178 There are a variety of methods and media available but many are poorly assessed and validated. In many circumstances there are no standards or set protocols for testing. Contact plates, swabs, enrichment versus selective media and sensitivity of the method needs to be assessed in order to allow interpretation. It is important to know why the sampling is being carried out and what will need to happen if abnormal results are found. Environmental sampling can place a heavy burden on clinical laboratories which may not be set up, funded or accredited for non-clinical sampling.

11.179 Non-culture techniques do not require pathogen multiplication and can be a more rapid method of detection. These methods are being utilised with increasing frequency, including techniques such as:

- antigen detection techniques e.g. Elisa;
- toxin detection techniques e.g. endotoxin assay;
- ATP(Adenosine Tri-phosphate) detection techniques e.g. bioluminescence, used in the food industry as a rapid hygiene test for surfaces;

- residue protein detection tests (ninhydrin tests);
- soil tests;
- cleaning efficacy tests;
- molecular techniques.

11.180 Special consideration should be given to specialised areas such as control of Legionella. There is often specific guidance on such areas as the:

- Scottish Health Technical Memorandum (SHTM) 2040: 'The control of Legionellae in healthcare premises - a code of practice';
- Health and Safety Executive (HSE) guidance note L8 'Legionnaires Disease: The control of legionella bacteria in water systems. Approved code of practice and guidance'.

Decant facilities

11.181 Ideally, decant facilities should be readily available where, for example, construction/refurbishment works are being carried out. Where practical, consideration should be given to vacating areas and screening of clinical areas. If decant facilities are not available then additional cleaning and regular inspection will need to be put in place along with the use of ventilation or pressure differentials to control the work area and avoid cross contamination.

Replacement of internal surfaces

11.182 Regular inspections of surfaces are important to ensure that smooth, easy to clean surfaces are maintained. Damaged surfaces can harbour dust and contamination and soft difficult to clean finishes should be avoided.

Redecoration

11.183 Where practical, whole areas should be decorated at the same time. If not practical, consider smaller areas of work that are screened off from the rest of the area. Finishes which are difficult to clean should be replaced with suitable alternatives, smooth, easy to clean surfaces.

12. Demolition

12.1 Work of this type will require a building warrant and a Decommissioning Team should be established. The Decommissioning Team needs to include a Planning Supervisor and consideration should be given to the likely spread of dust/dirt which the works will cause. Issues such as limitation of airborne fungal contamination need to be considered.

Decontamination of buildings and equipment

12.2 Buildings should be thoroughly cleaned after all furniture etc has been removed. There are some airborne decontamination methods which should be considered to minimise the risk prior to demolition. Equipment should be decontaminated prior to reuse elsewhere or final disposal.

Effect upon adjacent healthcare premises

12.3 There are health and safety issues which the Decommissioning Team will have to consider with the advice of the Planning Supervisor. Additional cleaning may be required due to the additional dust likely to be caused. Ventilation filters in areas likely to be subject to a high airborne dust load should be checked and changed if necessary, prior to demolition works starting. An overloaded filter can collapse and cause contamination. Filters should also be checked and changed if necessary once work is complete.

Planning for demolition works

12.4 Prevailing wind direction and the distance of the demolition works from occupied areas are key considerations when planning demolition works.

12.5 The demolition Project Plan should contain details of measures to be taken to minimise contamination of other areas. The person responsible for each control measure should also be named.

12.6 On completion of the work, the success or otherwise of the control outcomes should be formally assessed and the lessons learned disseminated widely, including outwith the organisation, for the benefit of colleagues involved in similar projects.

13. Decontamination prior to disposal of site

Decontamination of building and site

13.1 Any site to be disposed of will need to be clean and free of infection risk. It may be necessary to use a decontamination system such as fumigation. If such a procedure is carried out, records of site decontamination need to be kept and made available on request. Advice on disposal policies should be gained from Estates staff. Ash and clinker may also have been buried on the site and there may have been fuel leaks etc. These need to be identified to prospective purchasers.

Decontamination of land

13.2 There have been instances of hospital sites with dangerous materials such as clinical waste and asbestos disposed of within the hospital site. Decontamination of the site intending to be disposed of is the responsibility of the healthcare body. Contaminated land may need to be disposed of as special waste and can be extremely expensive as the soil removed must also be classified as special waste.

13.3 Current legislation constrains producers of waste to manage and dispose of it by means consistent with the hazard posed by the waste, through facilities approved for treatment of the particular category of waste e.g.

- ash and clinker may have been buried on site;
- fuel stored may give rise to fuel leaks;
- old sewers if not properly closed off can back flow into remaining premises and cause contamination with effluent.

13.4 Burying or long-term storage of waste on a healthcare site is likely to constitute an offence. Issues need to be identified to prospective purchasers.

14. Appendices

Appendix 1: Equipment groups

Appendix 2: Glossary

Appendix 1: Equipment groups

Equipment supplied for new building schemes can be one of four categories:

Group 1

Group 1 items are specified at the design stage and are supplied and fixed under the terms of a building/engineering contract and funded within the works cost. These are generally large items of plant/equipment which are permanently wired/installed, i.e.

1. Specialised equipment items best suited to central purchasing arrangements.
2. Excluded from this Group will be items subject to late selection due to considerations of for example, radio diagnostic equipment. Taps and basins also fall into Group 1 equipment.

Group 2

Items which have implications in respect of space/construction services and are installed under the terms of building engineering contracts, but are purchased by the Client under a separate equipment budget e.g.:

- paper towel dispensers;
- soap/scrub dispensers;
- shelving;
- washer/disinfectors;
- washing machines.

Group 3

Items which have implications in respect of space and/or construction/engineering services and are purchased and delivered/installed directly by the Client e.g.:

- small refrigerators;
- furniture;
- ventilators;
- monitors;
- trolleys.

Group 4

Items which may have storage implications but otherwise have no impact on space or engineering services e.g. medical devices.

Appendix 2: Glossary

Airborne Infection: A mechanism or transmission of an infectious agent by particles, dust or droplet nuclei suspended in the air (Last, 1995).

Aspergillosis: A fungal infection caused by *Aspergillus spp*., commonly found in soil, decaying vegetable matter, damp cellars, building materials and ventilation systems. The most common mode of transmission is by the airborne route, for example dispersal of contaminated aerosol. In fact, airborne *aspergillosis* is a risk to patients with highly compromised immunity.

Contact transmission has been reported, for example a recent cluster of cases in Manchester suggested a contaminated stockinette was the source of infection. The density of *Aspergillus* spp. spores in hospital air is increased considerably during construction, and there is evidence that healthcare associated aspergillosis is caused by contamination of ward air from outside. Hospital ventilation systems can draw in contaminated outside air because of either malfunction or inadequate mechanical ventilation and air filtration (Manuel and Kibbler, 1998; Cornet et al, 1999; Mahieu et al, 2000; Richardson et al, 2000; Thio et al, 2000).

Cleaning: The process of physically removing contamination including soil, dust, large numbers of micro-organisms and the organic matter that protects them.

Cohort Nursing: Placing patients infected with the same micro-organism (but with no other infection) in a discrete clinical area where they are cared for by staff who are restricted to these patients.

Communicable disease: An illness due to a specific infectious agent or its toxic products that arises through transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or the inanimate environment.

Contact: Association with an infected person or animal or a contaminated environment such that there is an opportunity to acquire the infection.

Contamination: The presence of an infectious agent on a body surface; also on or in clothes, bedding, toys, surgical instruments or dressings, or other inanimate articles or substances including water and food. Contamination does not imply a carrier state.

Cross-infection: An infection either due to a microbe that came from another patient, member of staff or visitor in a healthcare establishment or due to a microbe that originated in the inanimate environment of the patient.

Decontamination: The combination of processes which include cleaning, disinfection and sterilization used to render a reusable medical device safe for reuse on patients and for handling by staff.

Dead-legs: In a water supply and distribution system, pipes that are capped off or rarely used, or regions of pipework which are not scavenged by flow.

Disinfection: The reduction of the number of micro-organisms to a safe or relatively safe, level but not usually the destruction of pores.

Fomites: Articles that convey infection to others because they have been contaminated by pathogenic organisms. Examples include hospital equipment, instruments, kidney dishes, hospital bed tables.

Fungi: Unicellular, multicellular or syncytial spore-forming organisms that feed on organic matter; includes yeasts and moulds (Baril, 2000). The most common fungal infections are caused by *Candida* spp. (see, for example, O'Connell and Humphreys, 2000).

Healthcare associated infections: Infections that a patient acquires during a visit to, or that is related to a stay in a healthcare facility.

Heat labile: That which is likely to be damaged or destroyed by the normal heat disinfection process.

Iatrogenic infection: Infection that arises as an unwanted consequence of a medical intervention.

Immunocompromised patient: A patient whose immune response is deficient because of an impaired immune system.

Indirect contact: A mode of transmission of infection involving fomites or vectors. Vectors may be mechanical or biological.

Non-touch (taps): Includes foot or knee-operated, or infrared sensor taps.

Pathogen: A bacterium, virus, or other micro-organism that can cause disease.

Prion: An infectious protein to which several so-called slow virus diseases (for example Creutzfeldt-Jakob Disease, scrapie and bovine spongiform encephalopathy) are attributed. The word was coined in 1982 by S. Prusiner, from *pro*teinaceous *in*fectious particles, reversing the order of the vowels.

Reservoir (of infection): Any person, animal, plant, soil or substance, or a combination of these, in which an infections agent normally lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such a manner that it can be transmitted to a susceptible host: the natural habitat of the infectious agent (Last, 1995; Dancer, 1999).

Single room / En-suite single room / Isolation room/Bay: For the purposes of this document, the following terminology is used:

1) **Single room:** This is a room with space for one patient and usually contains as a minimum: a bed; locker/wardrobe and clinical hand-wash basin, plus a small cupboard with worktop.

2) **En-suite single room:** As above but with any combination of en-suite facility i.e. shower, shower and toilet, bath and toilet or just toilet etc.

3) **Isolation room:** As in 1 and 2 but with either negative pressure ventilation for infectious patients (source isolation) or positive pressure for immunocompromised patients (protective isolation). May or may not have a lobby or en-suite facility.

4) **Bay:** Any room that contains more than one bed (i.e. two-bedded bay; three-bedded bay; four-bedded bay; six-bedded bay, etc) which may or may not have en-suite facilities.

Spore: Some species of bacteria, particularly those of the genera Bacillus and Clostridium, which are significant cause of infection in humans, develop highly resistant structures called spores when they are exposed to adverse conditions, such as a lack of nutrients or water. Spores are resistant to disinfectants and to high or low temperatures. They may remain viable for many years but when the environment conditions improve the spores germinate and the bacterial cell inside starts to multiply again.

Sterilisation: The process of removing or destruction of micro-organisms including spores.

Thermostatic mixing valves: Valves that mix the hot and cold water of the system to provide water at a predetermined temperature.

Transmissible Spongiform Encephalopathy (TSE): Name for a group of fatal degenerative brain diseases that causes sponge-like abnormalities in brain cells. TSE diseases are associated with accumulation of abnormal prion protein in the brain.

Transmission: Any mechanism by which an infectious agent is spread from a source or reservoir to a person. Modes of transmission of infection include direct transmission involving direct transfer of micro-organisms to the skin or mucous membranes by direct contact; indirect transmission involves an intermediate stage between the source of infection and the individual, for example infected food, water or vector-borne transmission by insects; airborne transmission involving inhaling aerosols containing micro-organisms, for example legionnaires' disease of tuberculosis (Last, 1995; Donaldson and Donaldson, 2000).

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16. Acknowledgements

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From:	Henderson, Ronnie
To:	Inverarity, Donald
Cc:	Mackenzie, Janice; McMahon, Alex; Sutherland, SarahJane; GORDON, David; Currie, Brian
Subject:	IPC SITE VISIT 20/03/19
Date:	21 March 2019 13:30:26

Hi Donald,

It was good to meet yesterday and have the opportunity to reassure and clarify how the project team are addressing concerns raised by IPC. As discussed I will produce a table of water sampling test results showing positive for Legionella and/or P.Aeruginosa. I am presently reviewing the certificates on the data management system to identify the relevant ones and I will get these to you as soon as possible but no later than Monday 25th March.

I have summarised the main points of discussion and evidence seen:

1. Attendees:

   Janice McKenzie(JM), Ronnie Henderson(RH), Alex McMahon(AM), Donald Inverarity(DI), Sarah Jane Sutherland(SJS), David Gordon(DG) (Bouygues)

2. Introduction:
   - JM/RH felt that the walkround had been arranged specifically to address concerns over water safety and ventilation issues post press articles about QEUH. DI had thought that the HAI SCRIBE handover audit was to take place.
   - DI expressed concern that this HAI SCRIBE audit had not taken place before handover
   - RH/JM explained that although handover had occurred there were still significant ongoing construction works affecting areas that would automatically result in a HAI SCRIBE failure in terms of NHSL being able to occupy the affected spaces clinically.
   - Theatre validation was discussed and DI agreed to forward report from St John's for reference
   - It was agreed that SJS/RH/JM carry out the desktop elements of the HAI SCRIBE audit and discuss phasing of the site visit elements to coincide with completion of site works. SJS to send JM her availability over next 2 weeks for a planning meeting to agree how this will be done
3. Water Safety Management:
   - RH explained the sampling process and current status of results and water management
   - The group visited the location of a known outstanding P. Aeruginosa positive and the implications were discussed
   - RH agreed to forward test results showing positives for Legionella and Pseudomonas as well as subsequent clear results and the area and clinical specialty affected
   - DG explained BYES approach and the next steps after they receive a clear set of results from MPX
4. Ventilation:
   - RH explained the commissioning and validation that had taken place for both isolation rooms and theatres and that records were available on the project data storage system
   - The group visited an isolation room, the theatre suite and a ventilation plantroom where RH and DG explained the ventilation philosophy for each area
   - The group visited external areas to view pest prevention measures and active

measures to prevent ingress of pigeon droppings were demonstrated

- RH explained that both isolation and theatre validation would be re done once construction works were completed

5. Outstanding issue from previous visit:
    - The group visited room 1-L1-068 where DI had identified an openable window in an isolation room. JM explained that this had been identified previously by the room review team and as demonstrated had now been resolved. DI was satisfied that this had been addressed.

If I have incorrectly interpreted anything or have missed something relevant, please get back to me and I will amend

Regards

Ronnie

Ronnie Henderson
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[redacted]

OFFICIAL:SENSITIVE
Yes

Paper no: HSCMB/85/2019
Meeting date: 10 July 2019
Agenda item: 5

Standing items and Updates

Title:	NHS Board Performance Escalation Framework - NHS Lothian

Background and Key Issues:	Recent identification of issues around the new Royal Hospital for Children and Young People are considered in the context of wider performance and other issues related to NHS Lothian. This paper provides an overview of external support that the health board has received / is receiving around unscheduled and scheduled care. It also provides an update on recent issues relating to mental health and the Royal Edinburgh Hospital.

Action(s) Required:	HSCMB is asked to take account of the issues identified in the paper in deciding whether: a) NHS Lothian should be formally escalated to Stage 3 or above within the NHS Board Performance Escalation Framework; b) what, if any, additional action or support is required as a consequence of that decision.

Author: Yvonne Summers/Tracy Slater **Date: 9 July 2019**	**Director: John Connaghan** **Date: 9 July 2019**

What are the current challenges?

Edinburgh Children's Hospital

On June 28 the Board Medical Director, Nurse Director and Finance Director attended a meeting at the new hospital to discuss progress and process around theatre ventilation as part of the pre-hospital opening sign-off. On Monday afternoon (4.30) 1 July, a further teleconference took place regarding the theatre progress and at this point an issue relating to paediatric critical care ventilation was raised. The Medical Director who was in attendance escalated this to the Chief Executive, by email, for his return from leave on 2 July.

The Chief Executive picked the escalation up on Tuesday 2 July and on the same day informed the Board Chairman and the Director General for Health & Social Care. As a result, the Cabinet Secretary took the decision to halt the planned move of the Edinburgh Children's Hospital and the Department of Clinical Neurosciences for the time being. It is expected that it will take at least six months for the problem to be resolved, but further work is required to test and validate the proposed solution and estimated timeline.

In the meantime, the Cabinet Secretary has asked that an external series of checks is undertaken, led by Health Facilities Scotland and Health Protection Scotland, to ensure that all the relevant technical specifications and standards applicable to the new Edinburgh Children's Hospital are being followed and implemented.

The Cabinet Secretary has also commissioned follow up work to audit the full decision and build process to identify how and where this ventilation problem initiated and why it has not been identified until this week.

What is the ask of Management Board? (box will expand as you type)

Management Board is asked to take account of the issues identified above and to:

a) Take a view on whether NHS Lothian should be formally escalated to Stage 3 or above within the NHS Board Performance Escalation Framework (see Annex 1);

b) Identify what, if any, additional action or support is required as a consequence of that decision.

ANNEX 1

NHS Board Performance Escalation Framework

Stage	Description	Response
Stage 1	Steady state "on-plan" and normal reporting	Surveillance through published statistics and scheduled engagement of ARs/MYRs
Stage 2	Some variation from plan; possible delivery risk if no action	Local Recovery Plan – advice and support tailored if necessary. Increased surveillance and monitoring Scottish Government. SG Directors aware.
Stage 3	Significant variation from plan; risks materialising; tailored support required	Formal Recovery Plan agreed with Scottish Government. Milestones and responsibilities clear. External expert support. Relevant SG Directors engaged with CEO and top team. DG aware.
Stage 4	Significant risks to delivery, quality, financial performance or safety; senior level external support required	Transformation team reporting to Director General and CEO NHS Scotland.
Stage 5	Organisational structure / configuration unable to deliver effective care.	Ministerial powers of Intervention.

ANNEX 2

NHS LOTHIAN ANNUAL REVIEW 2017/18

MAIN ACTION POINTS

The Board must:

- Continue to deliver on its key responsibilities in terms of clinical governance, risk management, quality of care and patient safety
- Keep the Health & Social Care Directorates informed on progress towards achieving all access targets in line with agreed improvement trajectories, including the outpatient target, cancer targets and mental health access targets
- Continue to implement the actions agreed as a result of the Academy of Medical Royal Colleges report; improving and maintaining performance in relation to unscheduled care performance
- Continue to work with planning partners on the critical health and social integration agenda, including effectively addressing the delayed discharge challenge
- Continue to review, update and maintain robust arrangements for controlling Healthcare Associated Infection
- Continue to achieve financial management targets
- Agree a new remit for the Area Clinical Forum and ensure that there is provision for appropriate attendance at, and regular meetings of, the Forum.
- Keep the Health & Social Care Directorates informed of progress with its significant local health improvement activity, including against the smoking cessation target
- Keep the Health & Social Care Directorates informed of progress with local service redesign plans, in line with the national policy
- Provide a written update to the Scottish Government on progress against the above actions by 30 June 2019

Publication - Advice and guidance

NHS Scotland: support and intervention framework

Last updated: **27 November 2023** - see all updates
Directorate: Chief Operating Officer, NHS Scotland Directorate
Part of: Health and social care

The NHS Scotland support and intervention framework is one of the key elements of our evidence-based approach to monitoring performance and managing risk across the NHS in Scotland.

The framework is overseen by the National Planning and Performance Oversight Group, a sub-group of the Government's Health and Social Care Management Board. The framework applies to NHS territorial boards only. Arrangements for national NHS boards are covered by separate arrangements.

The framework provides five stages of a 'ladder of escalation' that provides a model for support and intervention by the Scottish Government. These stages are summarised in the table below:

Stage	Stage description	Support and intervention(s)
Stage 1 - steady state	NHS boards are delivering in line with agreed plans. Normal reporting arrangements in place.	The annual delivery plans, produced by all boards, form the basis against which performance is assessed throughout the year. Surveillance through official statistics published by Public Health Scotland and scheduled

Stage	Stage description	Support and intervention(s)
		engagement of NHS board annual reviews/mid-year reviews
Stage 2 - enhanced monitoring	Some variation from agreed plan (s), possible delivery risk if no remedial action is taken	A NHS board-led support package or recovery programme agreed and implemented. Increased surveillance and monitoring by Scottish Government. Scottish Government Directors aware.
Stage 3 - enhanced monitoring and support	Significant variation from plan, risks materialising, Scottish Government commissioned tailored support package is required	Formal approach incorporating significantly enhanced support and scrutiny and likely to include a level of external support. Relevant Scottish Government Directors engaged with NHS Board Chief Executive Officer and top team. Director General Health and Social Care aware.
Stage 4 - senior external support and monitoring	Significant risks to delivery and tailored support is not producing the required improvements. Senior level external support required.	Senior level external support reporting to an Assurance Board chaired by Scottish Government. Assurance Board reports direct to the Chief Operating Officer for NHS Scotland and Director General Health and Social Care. Onus remains on the NHS board to deliver the required improvements.
Stage 5 - statutory intervention	The level of risk and organisational dysfunction is so significant that the NHS Board requires direct intervention using statutory powers of direction.	Ministerial powers of Intervention

Stage 1 and stage 2

The designation of a board as stage 1 or stage 2 is a policy specific process. Stage 1 is when boards are steady state and on track with their annual delivery plans. Stage 2 is an informal support stage, where SG is providing support and guidance, but not intervening in the board. This stage is intended to avoid reaching the threshold for stage 3 or higher. These designations are managed by Scottish Government policy leads directly with individual boards. A board may be at stage 1 ('steady state') in relation to one aspect of its operations and at stage 2 in another.

Stage 3 and stage 4

Stages 3 and 4 are formal escalations. This is when requirements for specified action by the board along with enhanced monitoring arrangements are put in place. No statutory powers are being exercised and, as such, the board Chief Executive is expected, in their capacity as Accountable Officer, to co-operate and provide leadership; to ensure the effectiveness and delivery of the Recovery Programme.

The decision to move a board to stage 3 is made by the Health and Social Care Management Board (HSCMB) which may be prompted by awareness of a known weakness or the identification of an increasing level of risk in relation to a particular NHS board. In relation to stage 4, the decision sits with the DG Health and Social Care, where consideration of the board's position within the Framework would normally be prompted by a board failing to deliver on the recovery actions agreed at stage 3 or the identification of significant weaknesses considered to pose an acute risk to financial sustainability, reputation, governance, quality of care or patient safety.

Stage 5

The decision to escalate a board to the highest stage in the framework is taken by the Cabinet Secretary for Health and Sport with advice from the HSCMB. Escalation to stage 5 involves the exercise of Ministers' powers of intervention under the National Health Service (Scotland) Act 1978. Escalation to stage 5 should not be viewed as part of the normal progression of a board on the framework; it should only be used in exceptional circumstances

Current positions of NHS boards

Of the 14 territorial health boards in Scotland, there are currently six territorial health boards who have been escalated to stage 3 or above within the framework. This is the stage at which boards are considered to require a higher level of support and oversight from Scottish Government and other senior external support.

The six territorial NHS boards currently escalated to at least stage 3 are:

- NHS Ayrshire and Arran
- NHS Borders
- NHS Forth Valley
- NHS Highland

- NHS Orkney
- NHS Tayside

Current stages and primary factors for the six territorial NHS Boards formally escalated

Territorial NHS board	Current stage	Primary factors influencing escalation
NHS Ayrshire and Arran	3	Financial management and position
NHS Borders	3	Financial management and position
NHS Forth Valley	4	Governance, leadership and culture
NHS Highland	3	Financial management and position
NHS Highland	3	Mental health performance
NHS Orkney	3	Financial management and position
NHS Tayside	3	Mental health performance

First published: **10 June 2021**

Last updated: **27 November 2023 -** hide all updates

27 November 2023

Updated current position of health boards section and table to include NHS Orkney.

28 September 2023

Renamed to NHS Scotland support and intervention framework and all text updated to reflect latest position.

12 May 2023

Updated to reflect the de-escalation of NHS Lothian to stage 2.

10 February 2023

Table amended to reflect that Lothian updated to stage 2 for paediatric audiology.

23 November 2022

Updated current position of health boards section and table.

16 June 2022

Updated level for NHS Greater Glasgow and Clyde.

Was this helpful?

- ◯ Yes
- ◯ No
- ◯ Yes, but

Water and ventilation issues in RHCYP and DCN

The testing and quality assurance work prior to the move into RHCYP/DCN is not yet sufficiently complete and demonstrating adequate assurance to support the finalised move date. This will be subject to daily work and checks this week. A final decision about the move of patients will need to be made by Wed 3 July.

Water quality

- Testing of outlets taking place with necessary corrective actions.
- The building commissioning standards for handover and occupation differ from the HPS guidance about testing regimes in particular areas where more vulnerable patients are (augmented care areas).
- This has resulted in some lack of clarity between estates and IC.

Ventilation for theatres, critical care and isolation rooms

- Air sampling carried out to date has been negative.
- The independent tester was on site at the end of last week and submitted a report on Friday morning outling issues and faults with all 10 theatres.
- No written report on isolation or critical care areas has been received.
- A minimum of four theatres with fit for purpose ventilation are required for safe occupation.
- Any intrusive corrective engineering work will require replating of air samples (48 hour form sample to result)

A meeting was held on Friday 28 June internally between estates, execs (SG AMcM and TG) and RHCYP team (BC, ED, FM) to discuss the two issues and agree a plan to address them. Additional tests and results are expected this week for water quality in augmented areas with any appropriate corrective action undertaken

A second meeting was held between NHS L, IHSL and Multiplex and Bouyges, with a follow up call at 4pm after further discussion with engineering colleagues and the independent tester. It was agreed that from 1st July, all relevant engineers and sub contractors will work through on theatre at a time (starting at RHCYP end

Water quality: A brief paper summarising the testing regime, corrections and any consequences for safe patient care will be prepared when testing is complete and presented at HCG on 9 July

Ventilation: Twice daily conference calls will be held from 1st July will be held to maintain an overview of progress

TG/AMcM 01.07.19

Anna Falconer

From: Elliot E (Beth) on behalf of DG Health & Social Care
Sent: 03 July 2019 12:45
To: Wright M (Malcolm)
Cc: DG Health & Social Care
Subject: FW: 2019-20 - Health Finance and Infrastructure - Edinburgh Children's Hospital - June 2019

From: Morrison A (Alan) [redacted]
Sent: 03 July 2019 12:09
To: DG Health & Social Care [redacted]
Cc: Connaghan J (John) (Health) [redacted]; McLaughlin C (Christine) [redacted]; McCallum R (Richard) [redacted]; Roche R (Rowena) [redacted]
Subject: RE: 2019-20 - Health Finance and Infrastructure - Edinburgh Children's Hospital - June 2019

Malcolm/John

I believe Tim Davison has phoned you to summarise the outputs from this morning's meeting between HFS, HPS, NHS Lothian and myself to consider the risks associated with the move of ICU to new RHCYP the following issues were raised.

The main risks we identified were:

- Major concerns raised about the risk of doing the permanent solution with patients in situ.
- Concern about impact on national capacity if beds are taken out during works.
- The level of duct replacement works – based on experiences, sceptical about timeframes and suggestions of simplicity by the contractor.
- Further evidence is required before we are satisfied that the proposed permanent solution is deliverable.
- Design, buildability, maintenance, cost certainty and timescale of proposed permanent solution is still quite uncertain
- Some information from contractor is verbal and more tangible and testable detail is required.
- Other concerns / assurances needed from the contractor include:
    - Heat levels
    - Humidity levels
    - Noise at outlets, diffusers
    - Pressure regime during works being maintained
    - Fire damper implications
    - Working practices whilst the building is occupied to be demonstrated (all documentation including method statements and HAI SCRIBE).

There is still a lot unknown factors including:

- The safety implications of running the facility with 4 air changes rather than 10.
- Risks of modifying the building whilst occupied.
- The safety of the environment in which the patients are currently occupied ie is the new facility with 4 changes an hour still safer than the current site?
- Viability of proposed permanent solution has not been sufficiently tested or challenged.

Given the information available, the consensus was that, with unknown risks associated with moving patients and then modifying the ventilation of the building, combined with the 'believed safe' environment of the current facility,

the safety of patients would be better served by delaying the move and modifying the ventilation in the new building, before moving patients.

>>>
In addition John asked about why this was not identified earlier. As part of the settlement agreement, NHS Lothian agreed that ventilation for general wards could be 4 changes per hour. They should have specified that critical care beds were not part of that derogation, but they didn't so the contractor has used this as evidence that only 4 changes an hour were required. When the first test was undertaken, the critical care beds 'passed' the test because the tester was looking to see whether 4 changes an hour was being achieved. At that point no-one realised that they were testing it against the wrong benchmark.

Clearly NHS Lothian should have been clearer in the settlement agreement and they should have picked up that the original test was not correct, so they will be looking at this to understand what went wrong. For context, the settlement agreement included 80 amendments to the original document, so it will be a lengthy, technical and complex document that will not be easy to review.

Malcolm you also asked the following questions:

Why was testing not carried out earlier – it was (see directly above)
What has been the involvement of HPS and HFS to date? – no official involvement as typically HFS are not involved in projects unless they go wrong. Engagement with the project team at an informal level only eg sharing information on what happened in Glasgow.
What requirement is there for them to be involved - we now have NDAP – national design assessment process which was developed as a means of helping Boards describe a clear path between the business objectives for a project and the necessary qualities of the building development. However the sick kids predates that development and HFS' role has been minimal.
What is the role of HPS and HFS when it comes to new builds. – NDAP is a HFS function and does not include HPS, though there are plans to involve them.

Alan

Alan Morrison
Health Finance and Infrastructure
Scottish Government Health and Social Care Directorates
[redacted]

-----Original Message-----
From: Henderson C (Calum) [redacted] On Behalf Of DG Health & Social Care
Sent: 03 July 2019 08:20
To: Morrison A (Alan) [redacted]
Cc: DG Health & Social Care [redacted]; Connaghan J (John) (Health) [redacted]; McLaughlin C (Christine) [redacted]; McCallum R (Richard) [redacted]; Roche R (Rowena) [redacted]
Subject: RE: 2019-20 - Health Finance and Infrastructure - Edinburgh Children's Hospital - June 2019

Alan

In advance of meeting the Cab Sec, Malcolm has asked the following:

Why was testing not carried out earlier

What has been the involvement of HPS and HFS to date?
What requirement is there for them to be involved What is the role of HPS and HFS when it comes to new builds.

Thanks

Calum

-----Original Message-----
From: Downie J (Jack) [redacted] On Behalf Of Cabinet Secretary for Health and Sport
Sent: 02 July 2019 18:47
To: Morrison A (Alan) [redacted]; Cabinet Secretary for Health and Sport [redacted]
Cc: DG Health & Social Care [redacted]; Connaghan J (John) (Health) [redacted];
Wright M (Malcolm) [redacted]; McLaughlin C (Christine) [redacted];
McCallum R (Richard) [redacted]; Roche R (Rowena) [redacted]; Hutchison D
(David) [redacted]
Subject: RE: 2019-20 - Health Finance and Infrastructure - Edinburgh Children's Hospital - June 2019

Alan,

Thanks for this, Ms Freeman can discuss this with Malcolm tomorrow at their 1-1. In the meantime and in advance of that meeting, she has asked what testing has been conducted across all site areas so far and what the findings have been? Their 1-1 is at 1330 therefore I would be grateful if you can provide this information by lunchtime.

Thanks,
Jack

-----Original Message-----
From: Morrison A (Alan) [redacted]
Sent: 02 July 2019 16:53
To: Cabinet Secretary for Health and Sport [redacted]
Cc: DG Health & Social Care [redacted]; Connaghan J (John) (Health) [redacted];
Wright M (Malcolm) [redacted]; McLaughlin C (Christine) [redacted];
McCallum R (Richard) [redacted]; Roche R (Rowena) [redacted]; Hutchison D
(David) [redacted]
Subject: 2019-20 - Health Finance and Infrastructure - Edinburgh Children's Hospital - June 2019

Jack

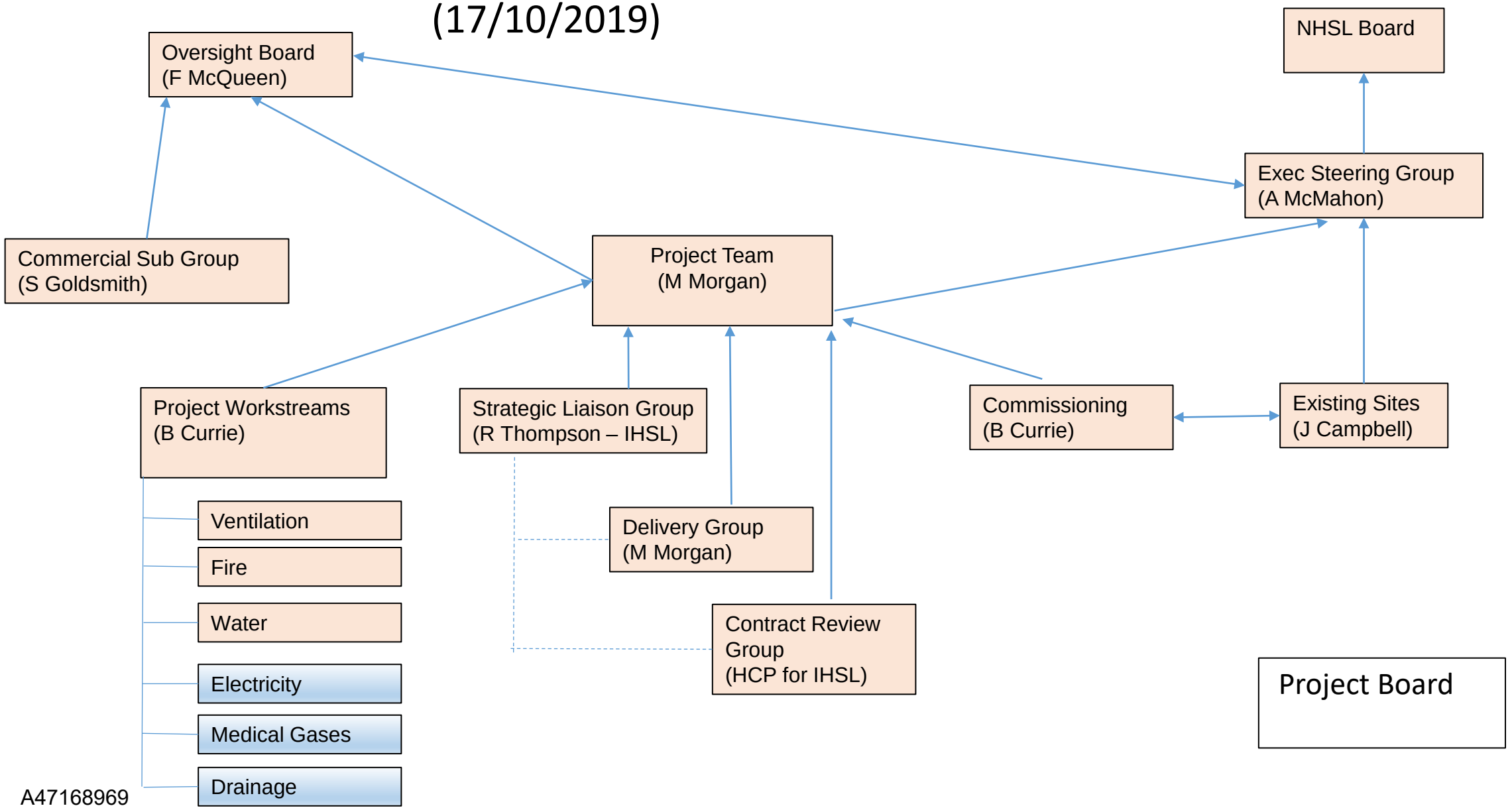
Please find attached a short briefing regarding an emerging issue with the new Edinburgh Children's Hospital. There is a phone call scheduled with NHS Lothian at 5.30pm and DG Health and Social Care may phone the Cabinet Secretary after that, depending on the outcome of that call.

Regards

Alan

Alan Morrison
Health Finance and Infrastructure
Scottish Government Health and Social Care Directorates
[redacted]

DCN/RCHYP Project Governance (17/10/2019)



Roles & Responsibilities

Executive Lead (The NHSL Senior Responsible Officer)

- Owns the overall service change which the project is supporting or enabling, for NHSL.
- Chairs the project board/Executive Steering Group
- Ensures that the project remains focussed on success, has the resources to deliver it and considers implications of project decisions on the wider service change and for NHSL (and vice versa).

Senior Programme Director

- Reports to the Oversight Board Chair
- Responsible for the actions required to ensure that the project facility is fit for occupation
- Provides the interface between programme oversight, ownership and delivery - Acts as a focal point between the Oversight Board, NHSL Board & Executive and the Project Director.

Project Director

- Leads, manages and co-ordinates the project activities and the project team on a day-to-day basis.
- Responsible to the Senior Programme Director to ensure that the facility is fit for occupation (Including commissioning) and to the NHSL Executive Lead for all other project actions relating to the existing sites and service migration
- Reports to the NHSL Executive Lead

Project Team (M Morgan)

	Chair	Record	Frequency	Membership
Strategic Liaison Group	IHSL: R Thompson	IHSL Note	Monthly	NHSL: SG, MM, BC, IG IHSL, BYES, MPX
Delivery Group (formerly Technical Review)	NHS: M Morgan	MML Notes and escalated action logs	Fortnightly 14.00-16.00 Wednesday	NHSL: MM, BC, RH IHSL, MPX, BYES
Contract Review Meeting	IHSL: tbc	IHSL Note	Monthly, 3 hours, next on 15/11/19	NHSL: SD, BW IHSL, BYES
Informal contract review and walkround	NHSL: S Davidson	None	Weekly 14.00-16.00 Friday	NHSL: SD, BW IHSL, BYES
Change Meeting	IHSL: tbc	IHSL Tracker	Weekly 11.00-12.00 Wednesday	NHSL: BC, SD, BW, R Shaw IHSL, BYES

BYES – Bouygues | HFS – Health Facilities Scotland | HPS – Health Protection Scotland | IHSL – IHS Lothian | IOM – IOM Consulting Limited | MML – Mott MacDonald Limited | MPX – Multiplex Construction Europe | NHSL - NHS Lothian | WC – Westfield Caledonian

Project Workstreams (B Currie)

	Chair	Record by	Frequency	Membership
Ventilation	NHSL: R Henderson	MML Action Log	Weekly 10.00-12.00 Friday	NHSL: BC, RH, LG, DI, MML, IOM, AE IHSL, MPX, BYES HFS, HPS
HVC095 + HVC 096 Design Workshop	NHSL: B Currie	MML, tbc	Weekly 10am Tuesday	NHSL: BC, RH, IPCT, H&S, Fire MML, IOM, AE IHSL, BYES HFS, HPS
Fire	NHSL: B Currie	MML Action Log	Initial workshops have taken place; weekly workstream to be set up	NHSL: BC, JG, RH, ED, FH, DH MML IHSL, BYES, HFS
Water Safety (to incorporate Drainage)	NHSL: R Henderson	MML Action Log	Fortnightly 9am Wednesday	NHSL: BC, RH, LG, DI, DH MML, WC IHSL, MPX, BYES, HFS, HPS
Electricity	Lead: R Henderson	MML Action Log	Through the Delivery Group	N/A
Medical Gases	Lead: R Henderson	MML Action Log	Through the Delivery Group	N/A

Operational Meetings (Not governance)

	Chair	Record	Frequency	Membership
Operations Meeting	NHS: B Currie	NHSL Note	Weekly 13.00-14.30 Monday	NHSL: BC, RH, SD, DH, FH, JC IHSL, MPX, BYES
Reactive and Defects	BYES tbc	BYES tbc	Weekly 10.00-12.00 Tuesday	NHSL: BC, RH, SD, DH, FH, JC IHSL, BYES, MPX
Daily Site Huddle	NHS: Various	NHSL Note	Daily 8.30am	NHSL: rotating attendance IHSL, MPX, BYES

Health Finance, Corporate Governance & Value Directorate
Richard McCallum, Director

Scottish Government
Riaghaltas na h-Alba
gov.scot

[redacted]

Mary Morgan
Programme Director for Royal Hospital for Children and Young People

via email

13th April, 2021

ROLE OF PROGRAMME DIRECTOR FOR ROYAL HOSPITAL FOR CHILDREN AND YOUNG PEOPLE

Dear Mary

As you will be aware, your appointment as Programme Director for the Royal Hospital for Children and Young People formed part of the tailored support to NHS Lothian, following the Board's escalation to Level 4 of the performance escalation framework. Escalation was specifically in relation to the Royal Hospital for Children and Young People programme, and the role was to strengthen the management and assurance arrangements for completing all of the outstanding works necessary to open the facility.

Following the successful completion in recent weeks of all works required to allow for the safe delivery of the hospital, and the closure of the Oversight Board on 8 April 2021, the Board will be de-escalated for this issue accordingly. This de-escalation will be confirmed publicly when we are able to notify parliament following the pre-election period. As a result of these factors, on behalf of the Scottish Government, I am content that you step down from the role as Programme Director.

I want to take the opportunity to thank you again for taking on the role of Programme Director and providing the leadership to help ensure the success of this project and delivering a safe hospital for the patients, families and staff of NHS Lothian.

Yours Sincerely

[redacted]

Richard McCallum
Director of Health Finance and Governance

cc Calum Campbell, Chief Executive, NHS Lothian
Amanda Croft, Chief Nursing Officer, Scottish Government

Director-General Health & Social Care and
Chief Executive NHSScotland
Malcolm Wright

Scottish Government
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gov.scot

[redacted]

Brian Houston, Chairman of NHS Lothian
Tim Davison, Chief Executive of NHS Lothian
Waverley Gate
2-4 Waterloo Place
Edinburgh
EH1 3EG

13 September 2019

Dear Brian and Tim

Royal Hospital for Children and Young People & Department of Clinical Neurosciences

Following the decision to halt the move to the new hospital, the Cabinet Secretary commissioned two independent reviews. The first by NHS National Services Scotland (NSS) to undertake a detailed assessment of all systems in the new hospital that could impact on safe operation for patients and staff. The second by KPMG to conduct an independent audit of the governance arrangements for RHCYP, ensuring a full understanding of the factors that led to the delay in the hospital's opening on 4 July 2019.

Having reviewed the contents of both reports that were published on Wednesday 11 September I have concluded, on the basis of scale of the challenge in delivering the Royal Hospital for Children and Young People, that NHS Lothian is escalated to Level 4 of our performance framework for this specific project. This level is defined as 'significant risks to delivery, quality, financial performance or safety; senior level external transformational support required.

In her statement to Parliament on Wednesday 11 September, the Cabinet Secretary set out the steps that will now be taken to strengthen the management and assurance arrangements for completing all of the outstanding works necessary to open the facility. We will retain the RHCYP Oversight Board which includes senior figures from Scottish Government Health and Social Care Directorates, NHS National Services Scotland, Scottish Futures Trust and NHS Lothian. The Oversight Board will continue to take overall responsibility for the completion of the works and opening of the hospital, reporting directly to the Cabinet Secretary. Underneath that Board a Senior Programme Director will be appointed, reporting directly to Scottish Government and this will be further supported by additional independent technical advice, to give the confidence that is required over the management and oversight of the actions identified to ensure the facility is fit for occupation.

I have appointed Mary Morgan to the role of Senior Programme Director, effective from Monday 16 September. Mary is currently Director of Strategy, Performance and Service Transformation in NHS National Services Scotland and most recently was Director for the Scottish National Blood Transfusion Service and led the successful completion of the new

SNBTS facility (Jack Copland Centre). In her role as Senior Programme Manager Mary will have responsibility for the actions to ensure that the facility is fit for occupation. All other actions relating to the existing site and to the service migration to the new facility, will remain the direct responsibility of NHS Lothian. I expect Mary to work as part of the NHS Lothian team and within your existing governance arrangements, whilst also formally reporting to the chair of the Oversight Board.

The Cabinet Secretary has also clearly set out in parliament her concerns about the issues that have led to the delay and the non-compliance with standards and guidance. It is my intention to hold further meetings with you over the coming weeks to discuss the response of the Board to the two reports, and to address the accountability questions that have been raised in relation to the current status of the project and findings of fact made by KPMG and NSS.

Yours sincerely

Malcolm Wright
Director General for Health & Social Care and Chief Executive of NHSScotland

Health Finance, Corporate Governance & Value Directorate
Christine McLaughlin, Director

Scottish Government
Riaghaltas na h-Alba
gov.scot

[redacted]

Personal
Ms Mary Morgan
Director: Strategy, Performance and Service Transformation
NHS National Services Scotland
Gyle Square
1 South Gyle Crescent
Edinburgh
EH12 9EB

23 September 2019

Dear Mary

Appointment to Senior Programme Director, Royal Hospital for Children and Young People & Department of Clinical Neurosciences

Thank you for agreeing to accept the role of Senior Programme Director, Royal Hospital for Children and Young People & Department of Clinical Neurosciences.

This appointment forms part of the tailored support to NHS Lothian as part of the escalation to Level 4 of the performance framework for this programme, to strengthen the management and assurance arrangements for completing all of the outstanding works necessary to open the facility. The appointment formally commenced on Monday 16 September and will be reviewed on a rolling quarterly basis. During the period of this appointment you will remain an employee of NHS National Services Scotland and retain your existing terms and conditions and will report to the Chair of the Oversight Board.

In your role as Senior Programme Director you will have responsibility for the actions to ensure that the facility is fit for occupation and I expect you to work as part of the NHS Lothian team. All other actions relating to the existing site and to the service migration to the new facility, will remain the direct responsibility of NHS Lothian.

We have discussed additional support to enable you to perform this role, including programme management support and additional technical advice. This additional support will be confirmed over the course of the next two weeks.

Yours sincerely

[redacted]

Christine McLaughlin

NHSScotland Assure Directorate Organisation Chart

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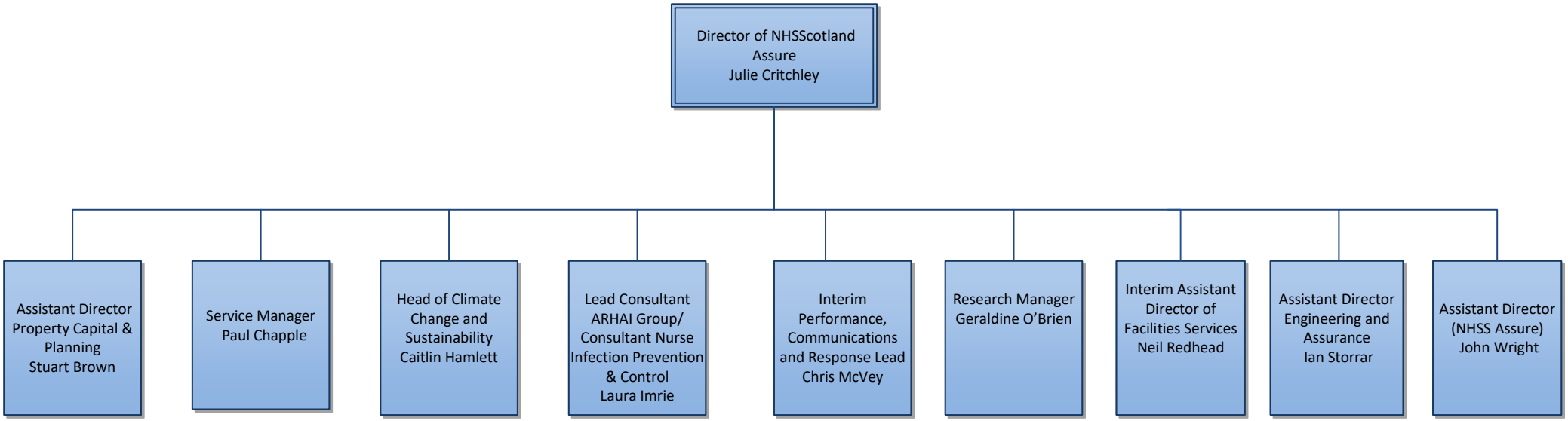
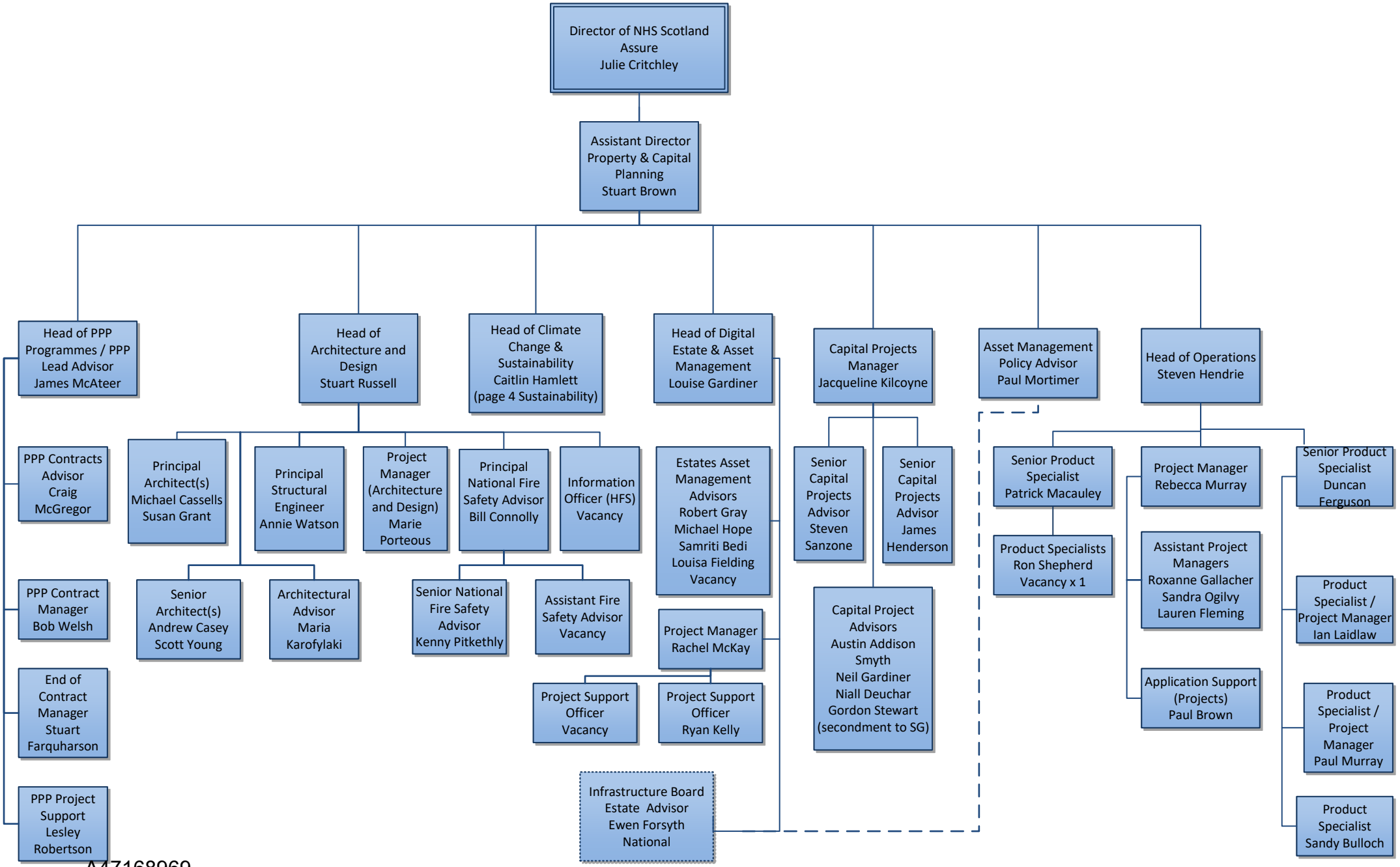
Page 8	Research and Engineering
Page 9	NHSScotland Assure Programme Team
Page 10 11 & 12	ARHAI
Page 13	Fleet

BDD307-008 Version 03

NHSScotland Assure Senior Management Team



Property and Capital Planning



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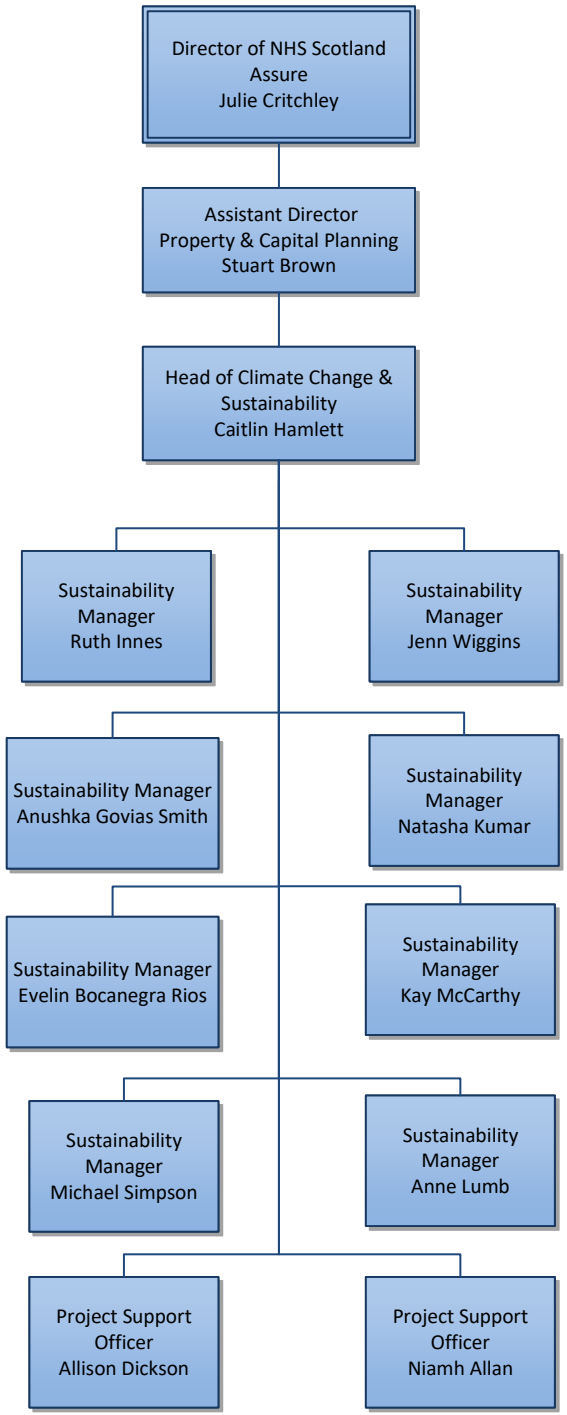
Sustainability



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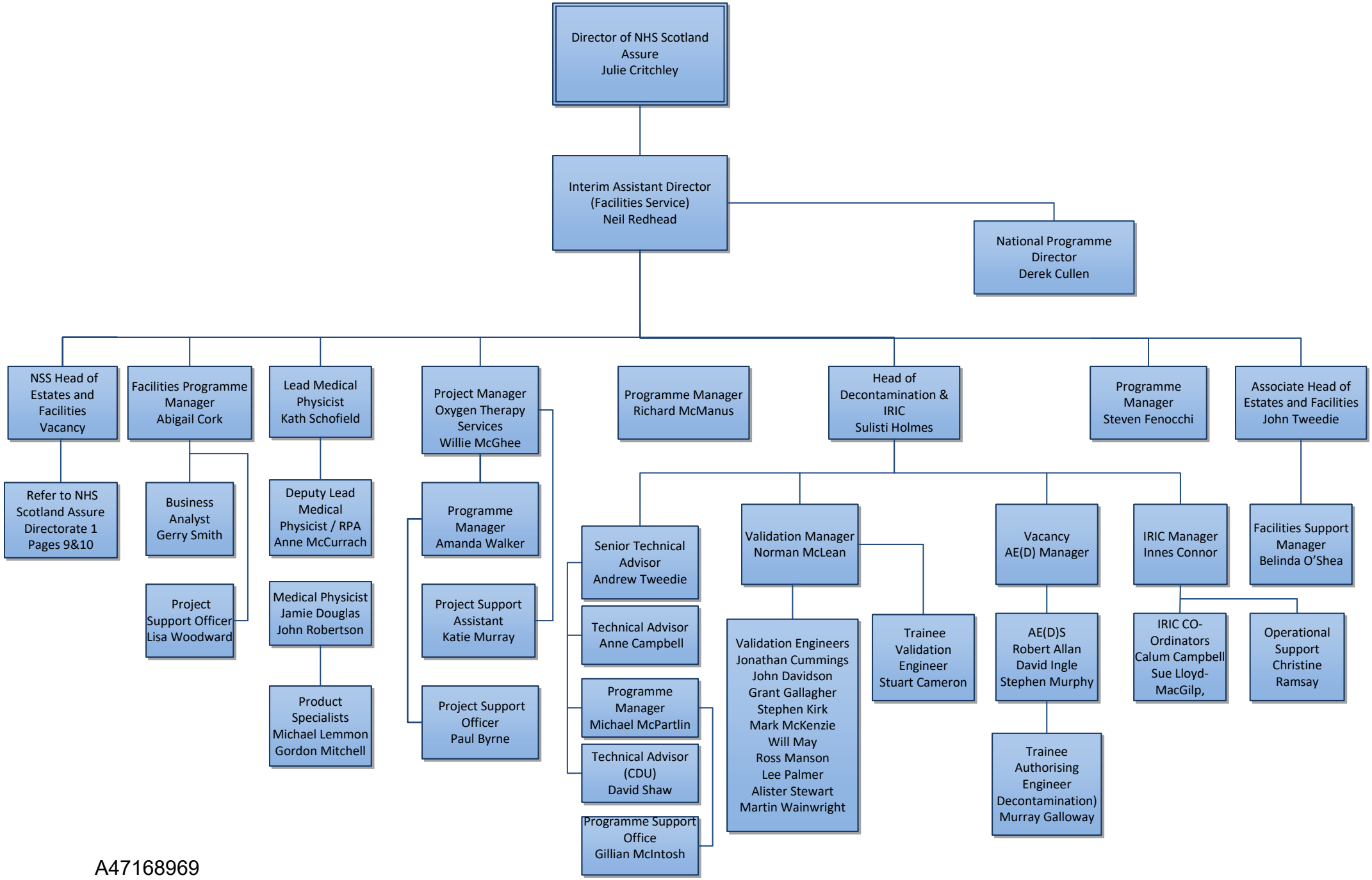

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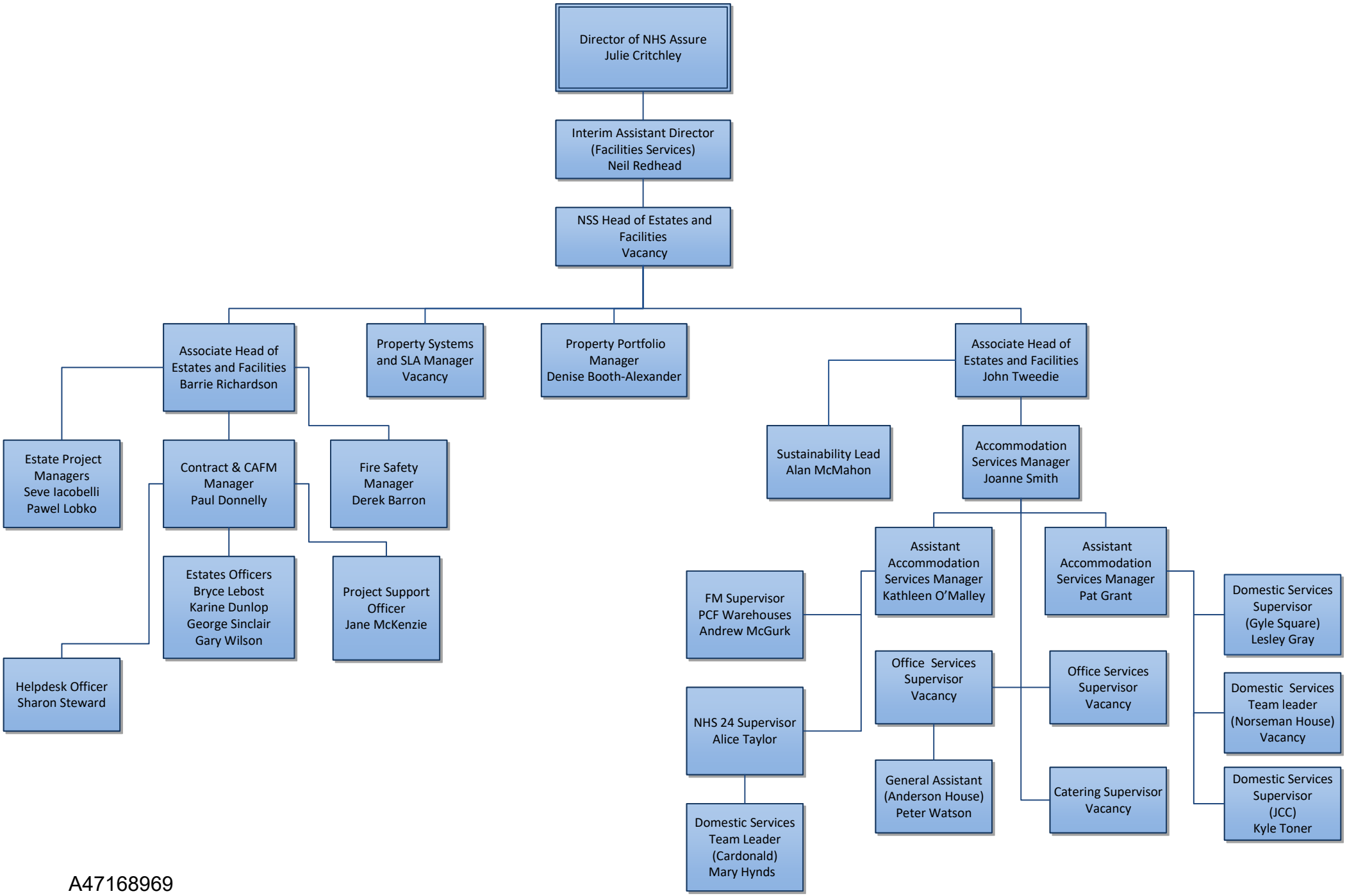
Facilities Services 2



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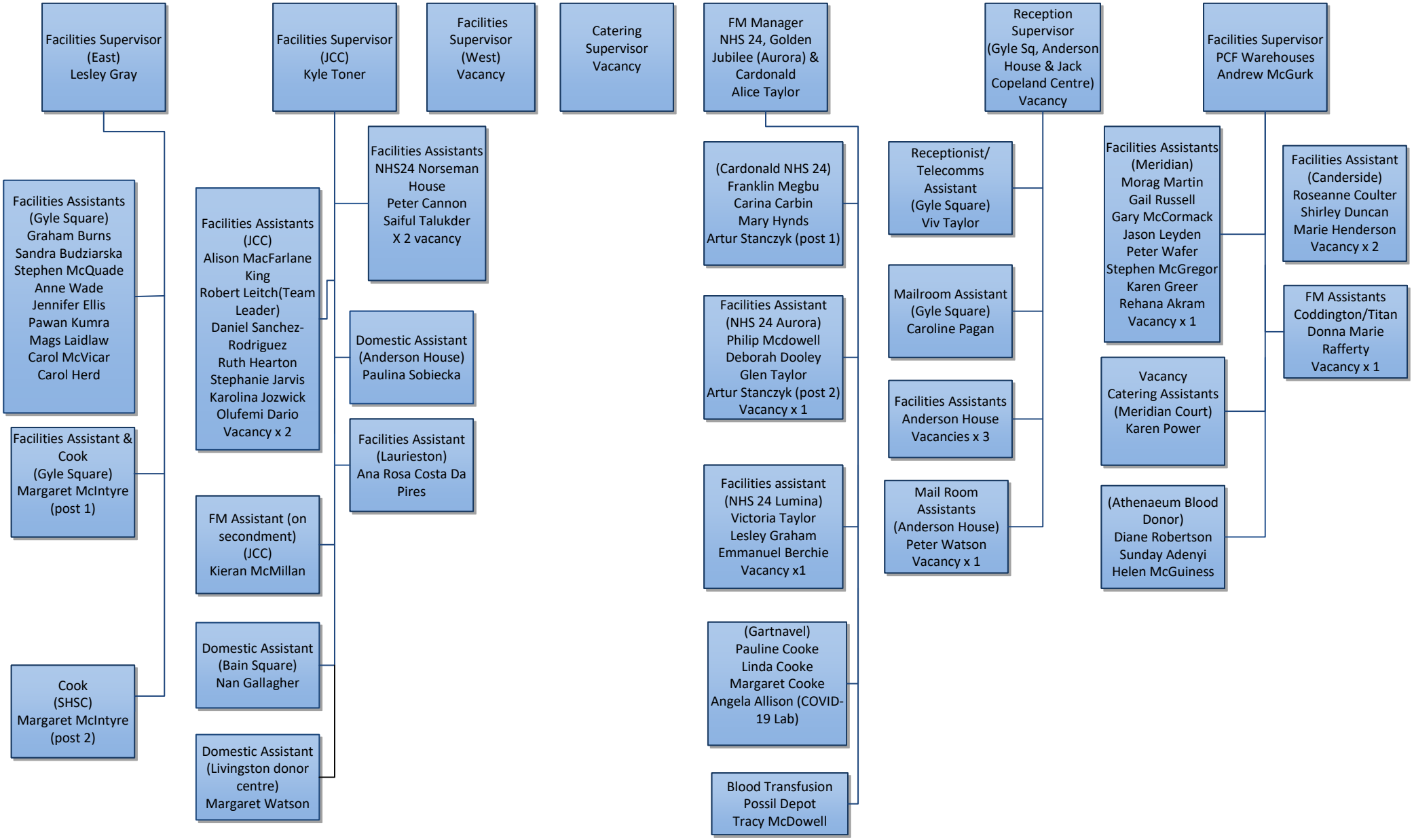
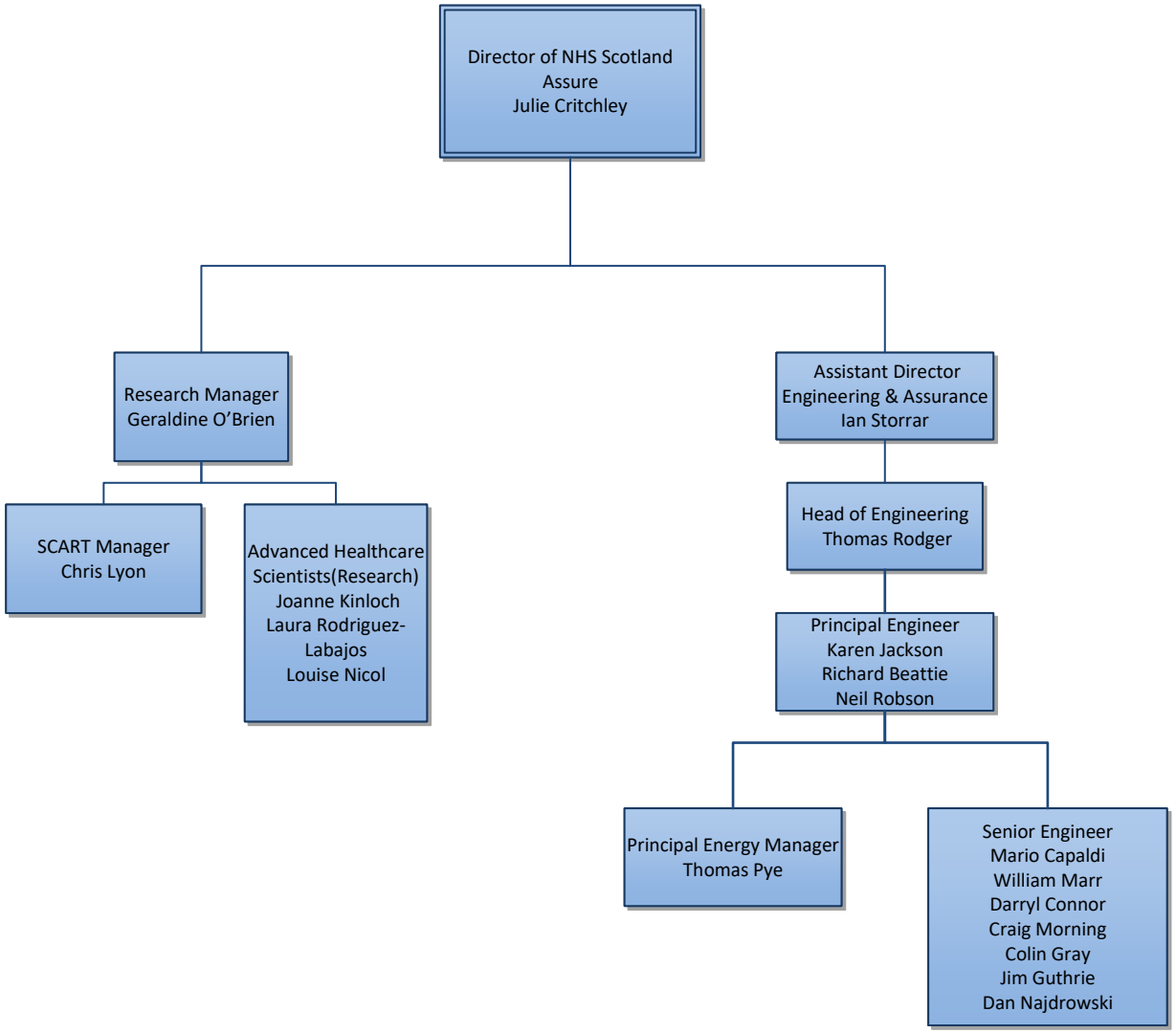
Facilities Services 3

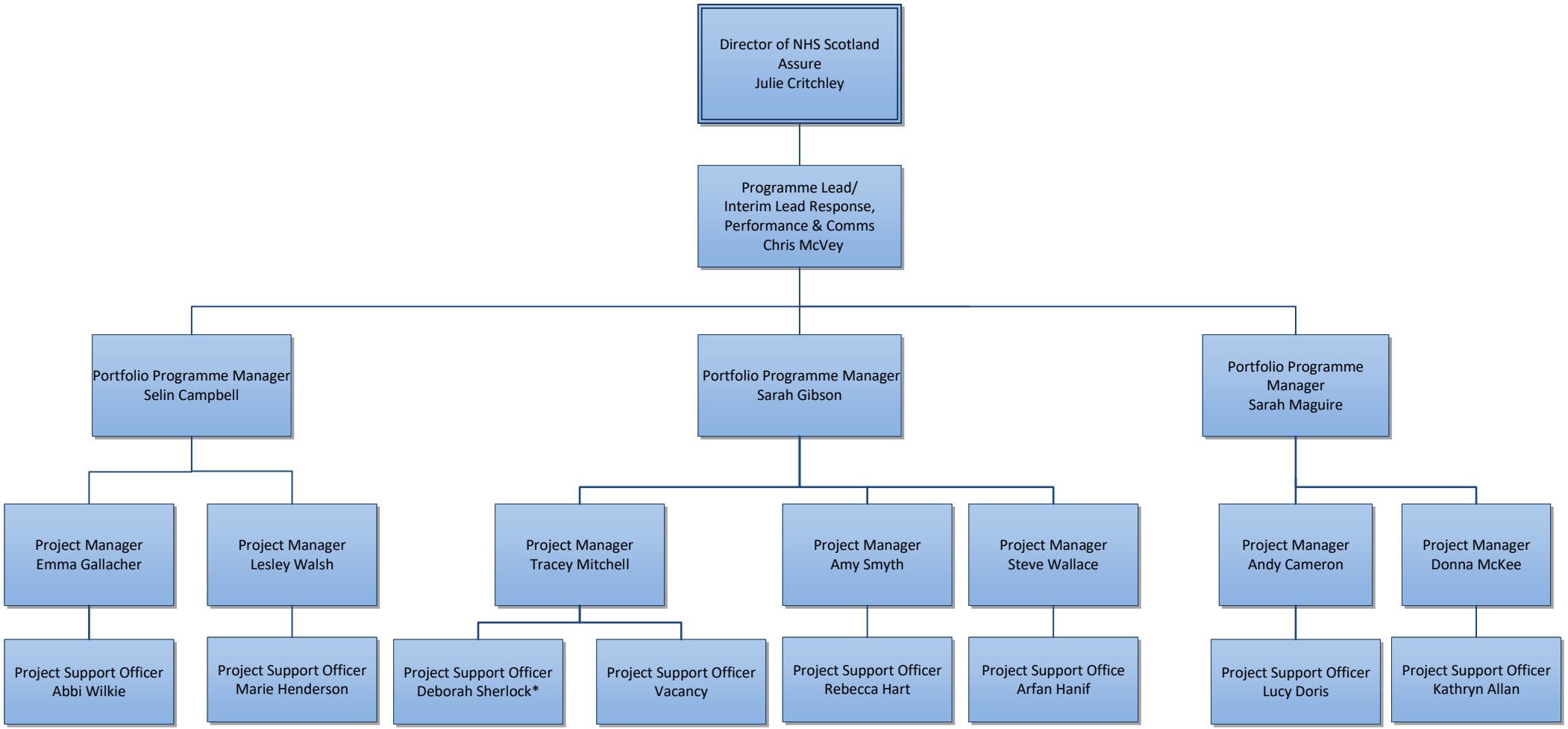


Research & Engineering

1= Secondment
2= Fixed Term
3= Mat Leave
4= Mat Leave Cover
5= Temp



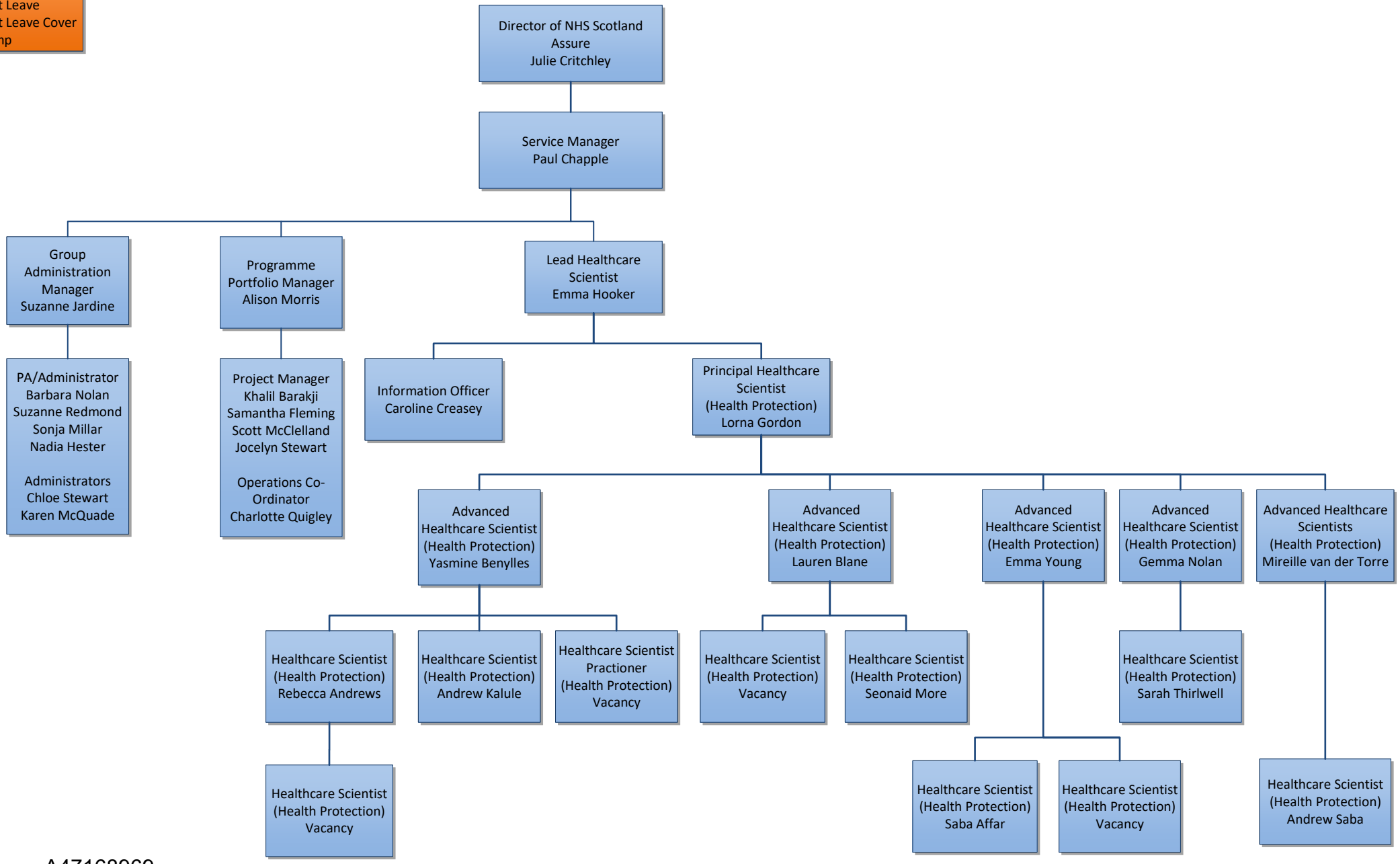
NHSScotland Assure Programme Team



* Temporary Contract

ARHAI - 1

1= Secondment
2= Fixed Term
3= Mat Leave
4= Mat Leave Cover
5= Temp



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ARHAI - 2

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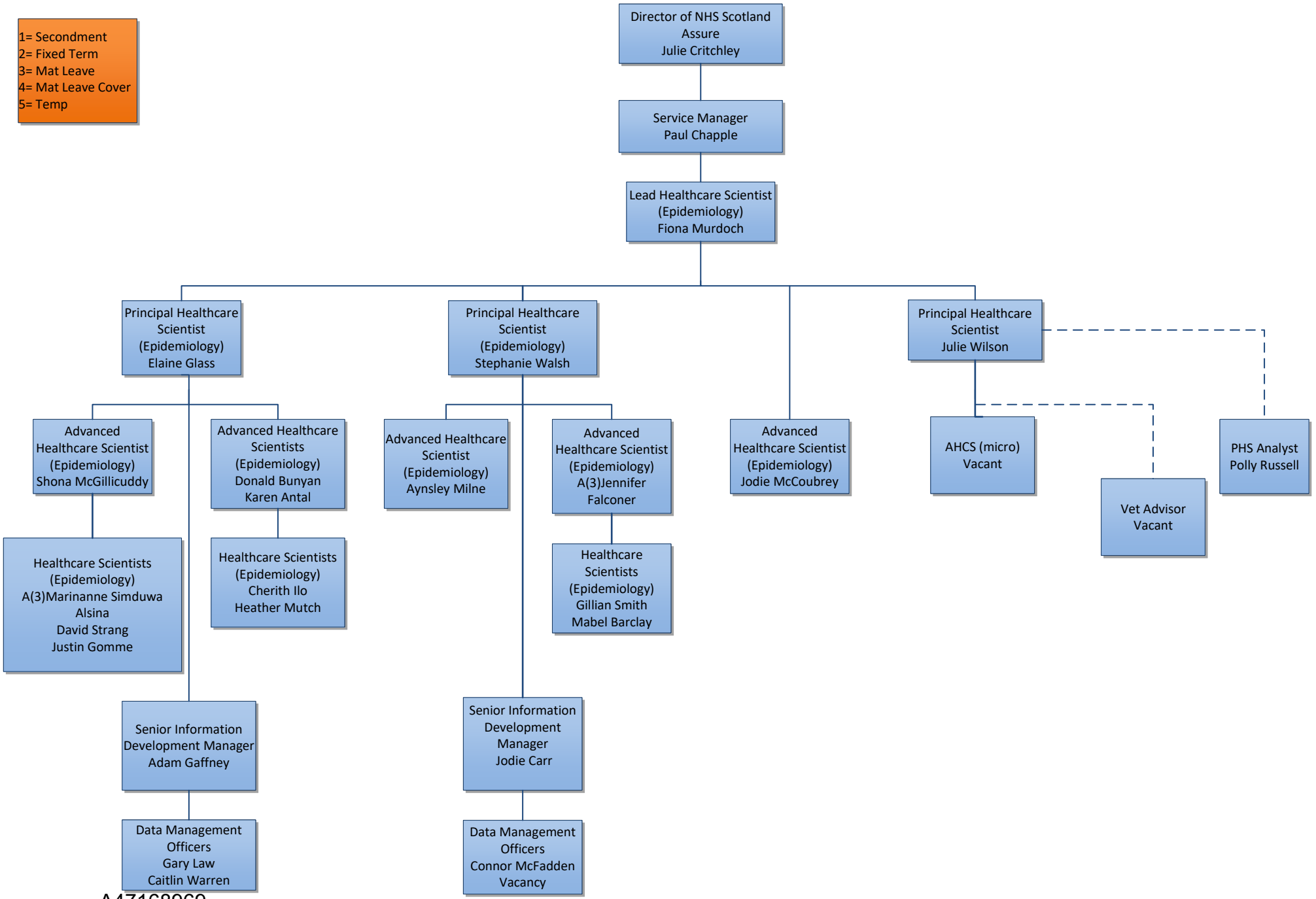
3= Mat Leave
4= Mat Leave Cover
5= Temp



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ARHAI - 3

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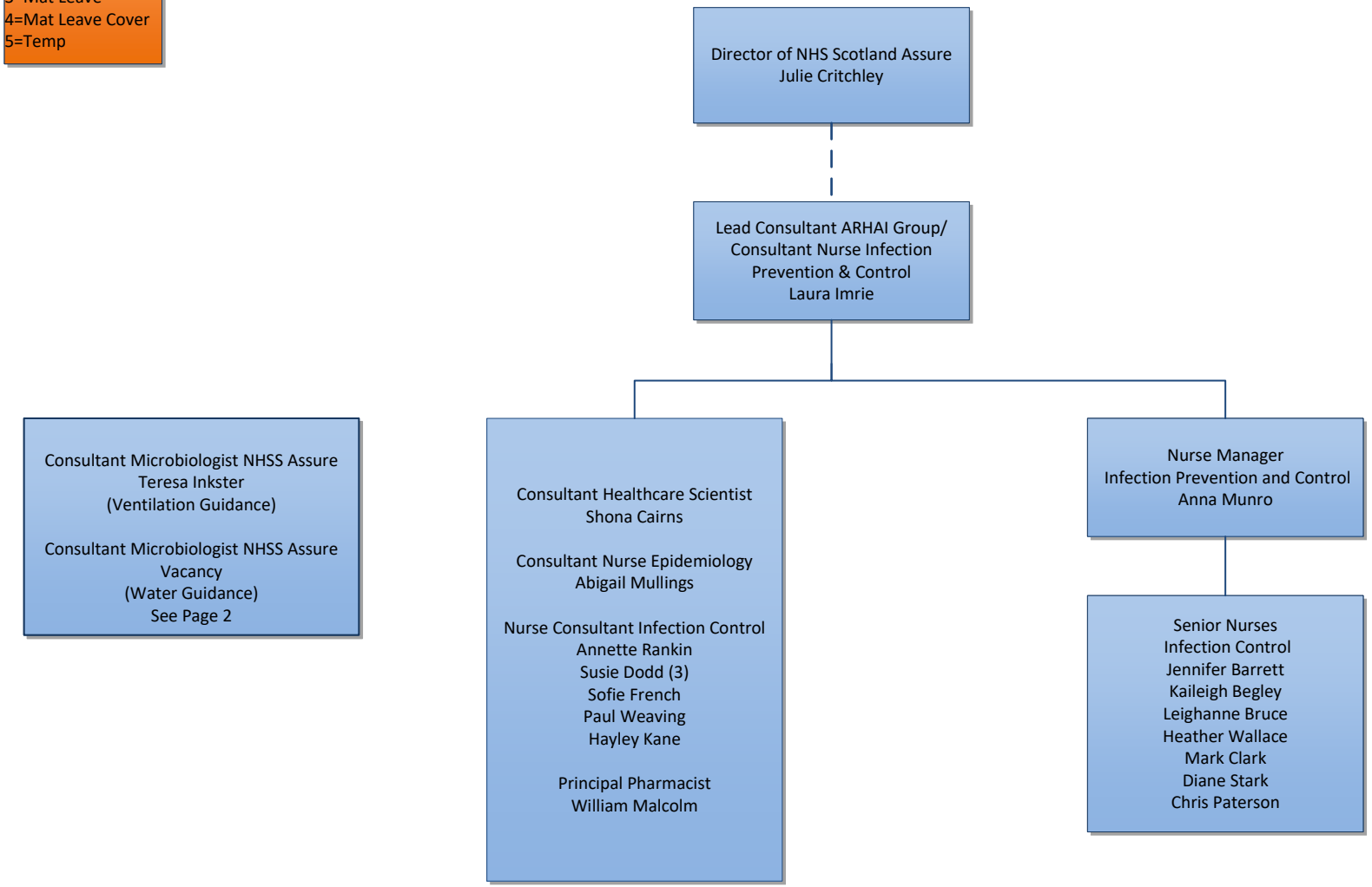
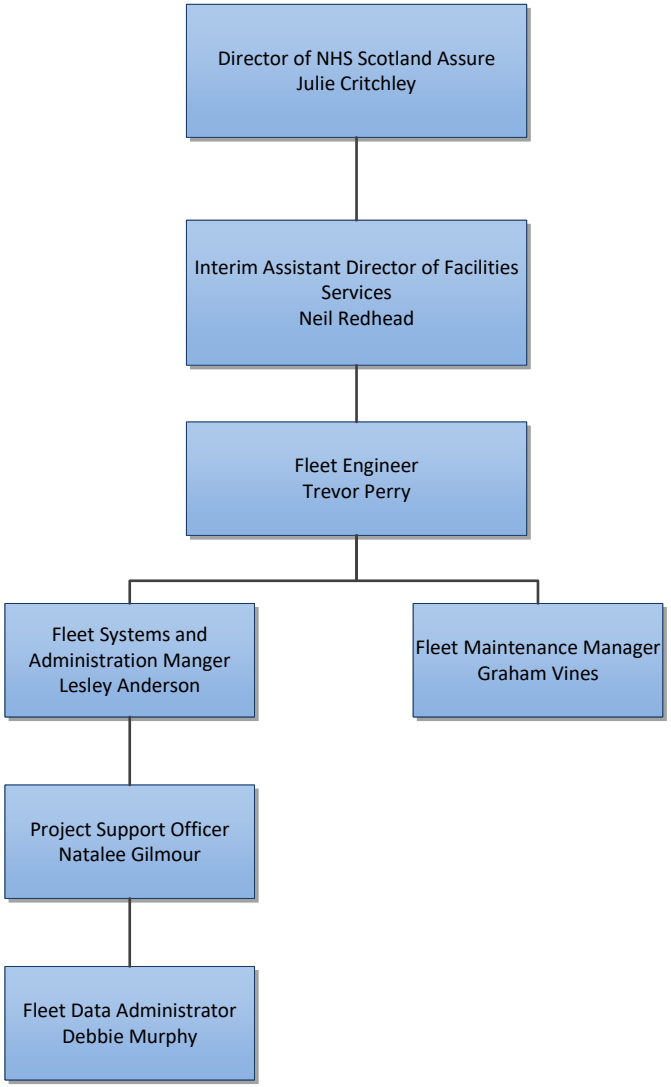
3=Mat Leave
4=Mat Leave Cover
5=Temp



Fleet


Director of NHS Scotland Assure
Julie Critchley
Interim Assistant Director of Facilities Services
Neil Redhead
Fleet Engineer
Trevor Perry
Fleet Systems and Administration Manger
Lesley Anderson
Fleet Maintenance Manager
Graham Vines
Project Support Officer
Natalee Gilmour
Fleet Data Administrator
Debbie Murphy

Regional Strategic Facilities Group

Paper No
RSFG/2023/02/03

Paper Title:	**RSFG Information paper**
Completed by:	**NHSS Assure and Advisory Group Chairs**
Purpose:	To clarify terms of reference in line with current governance and reporting deliverables and revisit the current Regional Strategic Facilities Group role and remit, moving to a more national, strategic and professionally credible group
Presented For:	**Approval/Decision** **Information** ☒ **Discussion**

1. Situation

This paper will outline changes to the existing RSFG setup in order to revise its current status to identify the best routes forward to increase the groups engagement, strategic decision making and communication routes.

2. Background

Previous discussions with the Regional Stategic Facuilities Group (RSFG) and SFG, agreement was reached to meet with the Advisory group chairs of Scottish Property Advisory Group (SPAG), Scottish Engineering Technology Advisory Group (SETAG), Scottish Facilities Management Advisory Group (SFMAG) and NHS Scotland Environmental Sustainability Group (NESG).

After ongoing discussion and feedback from nominated Advisory Group Chairs and further discussions at the January 2023 RSFG meeting the need for change was welcomed with additional clarity over membership.

Group consensus to proceed with a Naional model to repleace the current role and remit was reached at the 28th March 2023 RSFG meeting

3. Assessment

Proposed changes to move to a National Strategic Facilities Group (NSFG) first meeting 26th April 2023.

Virtual NSFG meetings monthly with a mix of formal and catch up engagement sessions (**Appendix 1)**

Two Face to Face (in person) Risk based Workshops per year to be included with invitation to the all NSFG members (**Appendix 1)**

The NSFG Chair will continue to be the Director of NHSS Assure with an additional Vice Chair agreed on a rolling 2 year basis from a nominated Chair from either the Scottish Property Advisory Group (SPAG), Scottish Engineering Technology Advisory Group (SETAG), Scottish Facilities Management Advisory Group (SFMAG) and NHS Scotland Environmental Sustainability Group (NESG) being considered

Topics for formal NSFG meeting agendas to be agreed by Chair and Vice Chair , facilitated through SPAG, SETAG, SFMAG & NESG Chairs which should be strategically focussed

Group re-naming … National Strategic Facilities Group

Revised membership

One Key Facilities Lead from each NHS Board

Existing NHS Scotland Leads to be contacted for board nominee confirmation and feedback to Ailsa Aitkinson , [redacted] by Friday 14th April * (Nominated deputy in absence only)

Director and Assistant Directors of NHSS Assure

Chairs of each of the Advisory Groups

Representation from Scottish Government

Agenda for formal NSFG meetings will comprise of;

Standing update from NHSS Assure to update any related national innovation , policy or development issues outwith the remit of the Advisory Group workplans

Standing update from Scottish Government to cover national directives , information and direction

Maximun of two and minimum of one topic from each of SPAG, SETAG, SFMAG & NESG

AOCB

Expodential NSFG meetings could be arranged by the NHSS Assure director / NSFG Vice Chair as required

NHSS Assure continued support and facilitation

Director and Assistant Directors to attend NSFG meetings

Continue to support Advisory Group Chairs through Assure Director , Assistant Directors and Assure Leads

Administration & Document facilitation overview / submission to meet required timelines

Additional Assure team members inclusion at all Expert Group meetings

Support on all guidance , systems , policy development and National SG direction

4. Summary
Strategic Group Chairs of SPAG, SETAG, SFMAG and NESG given equal accountability to provide content for the NSFG agendas and Risk Workshops which will provide a better sounding of key strategic discussions at future meetings NSFG to continue to be the direct governance and decision-making route for all advisory and expert groups New NSFG format to start in April 23 replacing both the current RSFG and SFG groups

Resource Implications	n/a
Financial Implications	n/a
Risks	Engagement and attendance at revised NSFG meetings to be measured over the next 6 months

Proposed meeting schedule 2023

Appendix 1

NSFG Formal Meeting (Teams) …. Full Agenda with topics supplied by Advisory Group Chairs

Catch up … 1 HR Teams meeting with Advisory Group Chairs, Director and Assistant Directors NHS Assure (NSFG Agenda confirmation)

Risked Based Workshops…. in person only and invitation to all NSFG members

	APRIL 26th	MAY 24th	JUNE 21st	JULY 26th	AUG 30th	SEPT 26th	OCT 18th	NOV 29th	JAN 31st	Feb 28th
NSFG	First Formal NSFG Meeting	Advisory Group Chairs Catch up	Risk Based Workshop In person (Meridian Court)	Advisory Group Chairs Catch up	NSFG Formal meeting	Advisory Group Chairs Catch up	Risk Based Workshop In person	Advisory Group Chairs Catch up	NSFG Formal meeting	Advisory Group Chairs Catch up

National Strategic Facilities Group

Terms of Reference

Date Published:
Version: Version 2.3
Document Type: Governance
Review Date: March 2024

DOCUMENT CONTROL SHEET:

Key Information:

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Date Effective From:	
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Document Type:	Governance
Document Status:	Draft
Author:	NHSS Assure
Owner:	Julie Critchley, Director of NHSS Assure
Approver:	National Strategic Facilities Group
Approved by and Date:	
Contact:	Julie Critchley, [redacted]
File Name:	

Revision History:

Version:	Date:	Summary of Changes:	Name:	Changes Marked:
Draft 2.3	26/04/23	National Strategic Facilities Group	NSFG	N

Approvals: This document requires the following signed approvals.

Name:	Title	Date:	Version:
Julie Critchley	Chair of NSFG		V2.3

Distribution: This document has been distributed to:

Name:	Title/SBU:	Date of Issue:	Version:

Linked Documentation:

Document Title:	Document File Path:

1. Official Name of Group
NHSScotland National Strategic Facilities Group (NSFG)
2. Purpose of Group
The purpose of the National Strategic Facilities Group will be to provide collaborative leadership, assurance, compliance and vision for Estates and Facilities Services across NHS Scotland Boards ensuring that these services remain fit for purpose, identify, and prioritise service risks through workplans and align with National Scottish Government Strategy, Health and Social Care Delivery Plans and Regional Delivery Plans.
3. Role and Remit of Group
The National Strategic Facilities Group is a key collaborative NHS Scotland stakeholder group, providing support, professional advice and leadership to NHS Boards, Health and Social Care and SGHSCD on Estates, Facilities and Capital Planning in order to develop a modern NHS estate and healthcare facilities and services of the highest quality for patients and staff. Specifically, the Group will: • Provide professional advice and guidance to NHS Boards and NHS Scotland on Estates, Facilities and Capital Planning Procurement matters. • To develop and sustain professionalism and foster a collaborative approach amongst SFG Board members to support the delivery of safe and effective Estates and Facilities services • Provide a body of influence and professional expertise to Chief Executives, SGHSCD and Health Boards, Health and Social Care Partnerships to ensure that Estates, Facilities and Capital Planning issues are fully considered as key enablers, in the development of healthcare services throughout Scotland. • Identify those Strategic Estates, Facilities and Capital Planning issues which are best addressed nationally on behalf of all Boards. • Oversee projects and programmes of work which will support NHS Boards in improving local service delivery and enable the implementation of National Clinical Strategy, Health and Social Care Delivery Plan and Regional Delivery Plans • Provide strategic direction for and determine, prioritise and endorse on an annual basis the Terms of Reference and work plans for the four main advisory groups, sub-groups and national programme groups. • Receive annual written performance monitoring reports from the groups to ensure performance against agreed plans and outcomes. • Approve via the attached organisational governance structure all relevant reports and recommendations going to national programme and governance groups, including the Chief Executives' Group. • Ensure a co-ordinated approach to share and spread knowledge and lessons learned relating to issues affecting all NHS Boards. • Seek to raise the standards and operational performance of all NHS Boards to that of the best performing Boards and recognised benchmarks. • Approve, endorse and publish national standards and best practice guidance. • Report and highlight compliance with agreed annual reporting on SCART, FMS, NCIS, EAMS, CPS, FMT and Corporate Green Code systems. • Support the development and maintenance of links with other Public and Private Sector organisations, where necessary requesting attendance and updates on strategic matters at the NSFG meeting • Identify and agree appropriate representatives for national groups.

- Lead on the professional development, training and education of staff employed in Estates, Facilities and Capital Planning.
- Provide leadership in terms of future service development and workforce planning.
- Work closely with other professional groups in NHS Scotland including the National Infrastructure Board, Sustainability & Value Board, National Planning Board and Executive Group, eHealth Leads Group and Directors of Finance Group.

4. Membership

Chair will be the Director of NHS Assure

Vice Chair will be a Strategic Advisory Group Chair

Members

The members of the Strategic Facilities Group Programme Board will be:

1. Nominated Directors / Heads of Facilities Representatives from each Health Boards
2. Director and Assistant Directors of NHSS Assure
3. Scottish Government representatives
4. 4 x Chairs of SETAG, SFMAG, SPAG and NESG Advisory groups
5. Programme and National Project Leads, Consultants, Health Board and SGHSCD representatives (by Invitation when required)

There will be a requirement for suitable deputy members to attend if a member of the group is unable to attend.

5. Reporting

There will be four substantive Advisory Groups. (NESG, SETAG, SFMAG, SPAG). All other Subgroups will be accountable to the Advisory Groups. The Chairs of the Advisory Groups and National Programmes will provide a written annual report on progress and outcomes of approved work plans, Workplans should be presented to NSFG in the first quarter of the new financial year.

The roles of the various Advisory Groups and Sub-Groups will be reviewed annually with the NSFG responsible for approving the Terms of Reference and annual workplans. This will ensure that their objectives remain relevant, and they continue to deliver evidence-based outcomes in support of NHS Boards' and NHS Scotland's strategic priorities.

NSFG Agenda and workplans should align with those of the subgroups to ensure a primary governance overview

Communication

Invites to meetings will be limited to agreed members of NSFG

A virtual catch-up meeting will be initiated with Advisory Group Chairs and Director / Assistant directors of NHSS Assure bi monthly before formal NSFG meetings to compile and agree agenda input

Actions and minutes of meetings will be copied in shared by e-mail to all NHS Scotland NSFG Members after each meeting

6. Relationship with other Organisations

The National Strategic Facilities Group will work closely with NHSS Assure, SGHSCD and other bodies as appropriate, to ensure effective stakeholder engagement and best practice, including the promotion of new service initiatives in the field of Estates, Facilities and Capital Planning.

The Group will also seek to develop and maintain links with other UK NHS Health Departments and various healthcare-related professional bodies and institutions, influencing decision-making to reflect Scottish interests. In particular, links will be maintained with the DoH in England, Northern Ireland Estates and Welsh Health Estates.

7. Meetings

The National Strategic Facilities Group will meet virtually on a scheduled monthly basis with inclusion of two in person risk-based workshops open to all NHS Scotland NSFG members

The agenda will be made up of topics supplied by the four strategic groups (maximum of two and minimum of one topic per meeting) on items requiring decision making or approval or highlighting risk, with progress reporting on projects and programmes. NHSS Assure will be responsible for providing admin support to the Group and for ensuring all papers for Group meetings are issued at least one week before SFG meetings.

NHSS Assure and Scottish Government will have standing updates on each agenda

All meeting papers and agenda topics will need to be supplied to the NHSS Assure secretariat at least seven days before the scheduled meetings. Agenda items for the formal NSFG meetings should be accompanied with a supporting paper.

Risk Based Workshop material will be organised and agreed through the four substantive Advisory Groups. (NESG, SETAG, SFMAG, SPAG)

Where strategically or operationally important special wider Strategic Facilities groups may be arranged at short notice.

8. Quorum and Voting

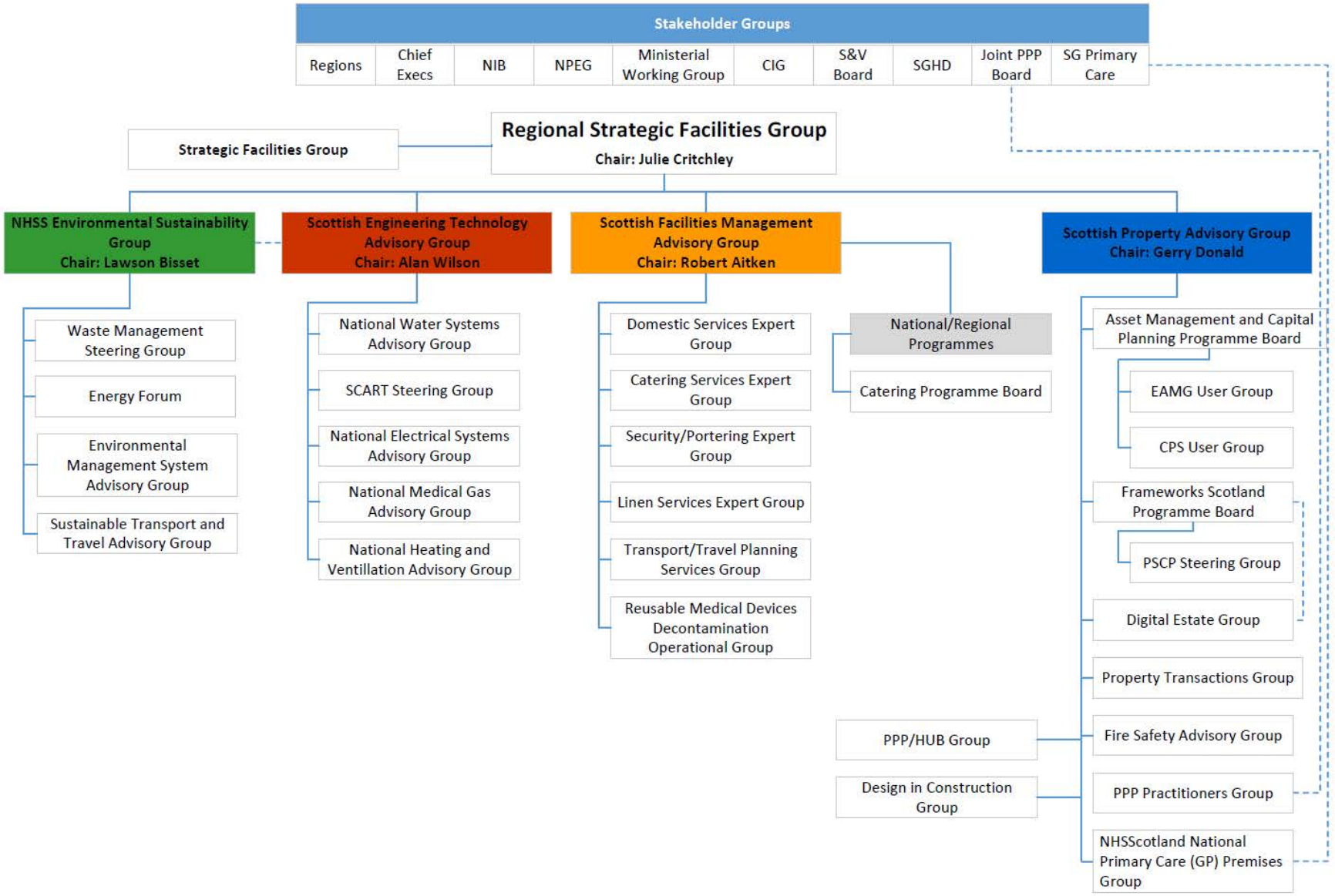
The Quorum will be set at 50% of the total membership of the RSFG. In the event of a vote on an item, there will be one vote per member.

9. Review Process

The terms of reference will be reviewed at least once on an annual basis to ensure that they remain fit for purpose and aligned with the strategic direction. The next review will be during the first quarter of 2024.

Appendix 1

Current RSFG Advisory Group Structure TO BE UPDATED WHEN NEW NAME AGREEMENT MET



NHS National Services Scotland

Scottish Health Technical Memorandum 06-01:
Electrical services supply and distribution
Part A: Design considerations

Health Facilities Scotland
Engineering and Environment

July 2015

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HTM 06-01 Part A has been updated by Health Facilities Scotland and amended for use in NHSScotland as SHTM 06-01 Part A. The contribution from the National Electrical Services Advisory Group has been gratefully received.

Preface

About Scottish Health Technical Memoranda

Scottish Engineering Health Technical Memoranda (SHTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

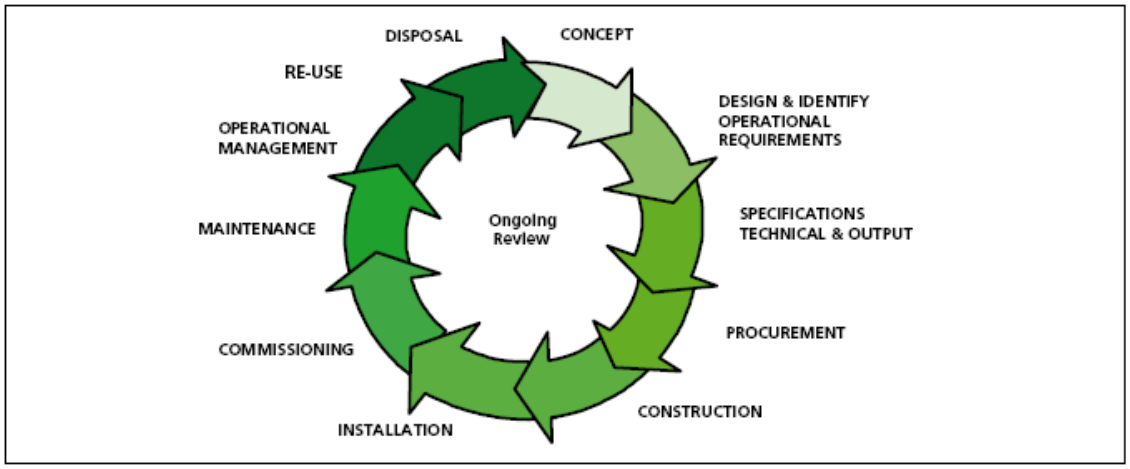
The focus of SHTM guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle. Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Scottish Engineering Health Technical Memoranda series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to repeat unnecessarily international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Scottish Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of eight subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.



Healthcare building life-cycle

Structure of the Scottish Health Technical Memorandum suite

The series of engineering-specific guidance contains a suite of eight core subjects pending a re-assessment of Firecode SHTMs 81-86.

Scottish Health Technical Memorandum 00: Policies and principles (applicable to all Scottish Health Technical Memoranda in this series)

Scottish Health Technical Memorandum 01: Decontamination

Scottish Health Technical Memorandum 02: Medical gases

Scottish Health Technical Memorandum 03: Heating and ventilation systems

Scottish Health Technical Memorandum 04: Water systems

Scottish Health Technical Memorandum 05: Reserved for future use

Scottish Health Technical Memorandum 06: Electrical services

Scottish Health Technical Memorandum 07: Environment and sustainability

Scottish Health Technical Memorandum 08: Specialist services

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Scottish Health Technical Memorandum 06-02 Part A will represent Electrical Services - Electrical safety guidance for low voltage systems.

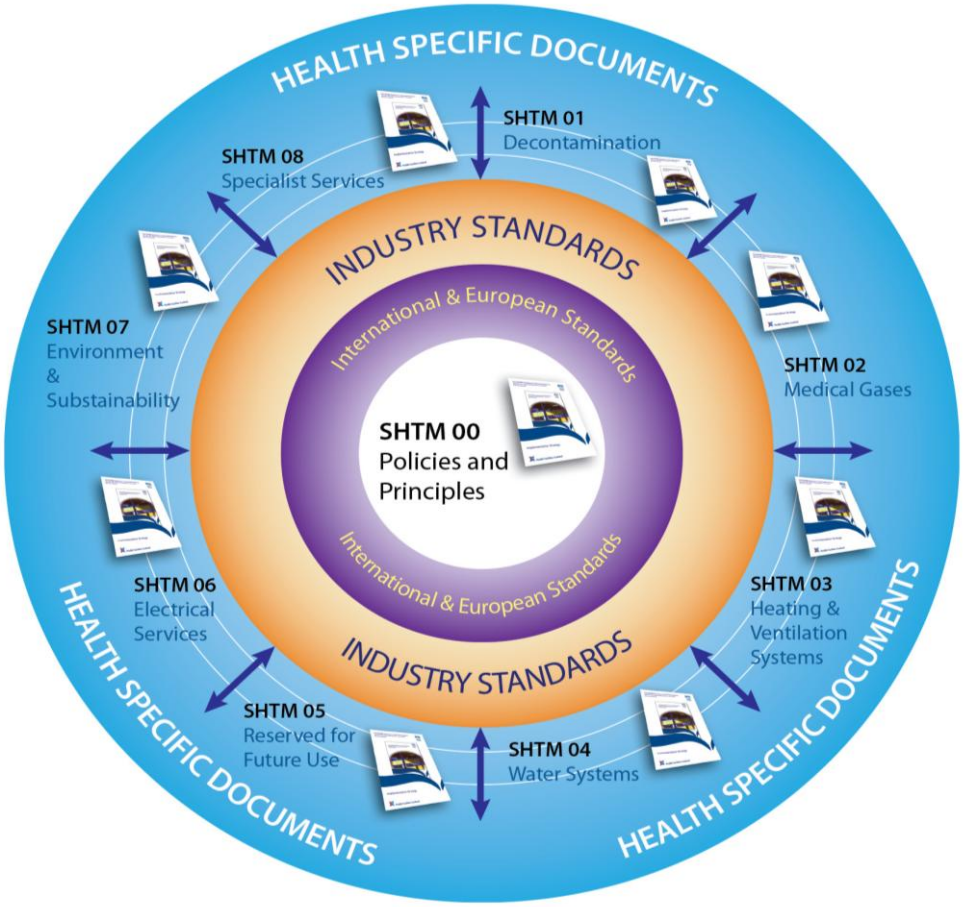
In a similar way Scottish Health Technical Memorandum 07-02 will simply represent Environment and Sustainability – EnCO_2de.

All Scottish Health Technical Memoranda are supported by the initial document Scottish Health Technical Memorandum 00 which embraces the management

and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.

Health Facilities Scotland wishes to acknowledge the contribution made by professional bodies, engineering consultants, healthcare specialists and NHS staff who have contributed to the review.



Engineering guidance structure

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Executive summary

Scottish Health Technical Memorandum 06-01: 'Electrical services supply and distribution' replaces Scottish Health Technical Memorandum 2007: 'Electrical services supply and distribution' and Scottish Health Technical Memorandum 2011: 'Emergency electrical services', and absorbs Scottish Health Technical Memorandum 2014: 'Abatement of electrical interference'.

This part (Part A) provides guidance for all works on the fixed wiring and integral electrical equipment used for electrical services within healthcare premises.

This document should be used for all forms of electrical design work ranging from a new green field site to modifying an existing final sub--circuit. The relevance of each section will depend on the extent of the design works.

It provides guidance to managers of healthcare premises on how European and British Standards relating to electrical safety such as the IEE Wiring Regulations BS7671, the Building (Scotland) Regulations 2004 with subsequent amendments and the Electricity at Work Regulations 1989 can be used to fulfil their duty of care in relation to the Health and Safety at Work etc Act 1974.

1. Scope of Scottish Health Technical Memorandum 06-01

1.1 Scottish Health Technical Memorandum 06-01: 'Electrical services supply and distribution' replaces Scottish Health Technical Memorandum 2007: 'Electrical services supply and distribution' and Scottish Health Technical Memorandum 2011: 'Emergency electrical services', and absorbs Scottish Health Technical Memorandum 2014: 'Abatement of electrical interference'.

1.2 This part (Part A) provides guidance for all works on the fixed wiring and integral electrical equipment used for electrical services within healthcare premises. The document should be used for all forms of electrical design work ranging from a new green field site to modifying an existing final sub-circuit.

1.3 This document provides guidance to managers of healthcare premises on how European and British Standards relating to electrical safety such as the IEE Wiring Regulations BS7671, the Building Regulations 2008 and the Electricity at Work Regulations 1989 can be used to fulfil their duty of care in relation to the Health and Safety at Work etc Act 1974.

1.4 The policies and principles of all engineering services are described in Scottish Health Technical Memorandum 00: 'Policies and principles', which should be read in conjunction with this document.

Abbreviations and definitions

24 / 7: 24 hours a day, 7 days a week

ac: alternating current

ACB: air circuit breaker

AMD: assumed maximum demand

AVR: automatic voltage regulator

BASEC: British Approvals Services for Electrical Cables

BEMS: building energy management system

BMS: building management system

BS: British Standards

BSRIA: Building Services Research and Information Association

CCM: CIBSE commissioning manual

CCTV: closed-circuit television

CDM: Construction Design and Management Regulations

CE: European Conformity

CENELEC: The European Committee for Electrotechnical Standardization

CHP: combined heat and power

CIBSE: Chartered Institution of Building Services Engineers

CPC: circuit protective conductor

CT: current transformer

DB: distribution board

DBU: distribution unit

dc: direct current

DNO: distribution network operator

DRUPS: diesel rotary uninterruptible power supplies

DTC: diagnostic and treatment centres

EC: European Community

ECG: electrocardiogram

EEA: European Economic Area

EEC: European Economic Community

EI: extreme inverse

EMC: electromagnetic compatibility

EMCD: electromagnetic compatibility directives

EMI: electromagnetic interference

EPR: electronic patient records

ERB: earth reference bar

ERIC: Estates Return Information Collection

ESD: electrostatic discharge

ETSI: European Telecommunications Standards Institute

EU: European Union

FL: full load

GRP: glass-reinforced plastic

GSM: global system for mobile communication

HBC: high breaking capacity

HBN: Health Building Note

HDU: high dependency unit

HFN: Health Facilities Note

HGN: Health Guidance Note

HRC: high rupturing capacity

HV: high voltage (11 kV)

HVAC: heating ventilation and air-conditioning

ICU: intensive care unit

IDMT: inverse definite minimum time

IEC: International Electrotechnical Commission

IEE: Institution of Electrical Engineers

IET: Institution of Engineering & Technology

IGBT: Insulated-gate bipolar transistor

IM&T: information management and technology

IMD: insulation monitoring device

IP: ingress protection (rating)

IPS: isolated power supplies (also known as medical IT)

ISO: International Standards Organisation

ISS: intake substation

IT: impedance terra earthed (derived from an isolated power supply)

ITU: intensive therapy unit

IV: intravenous

LBTC: logbook template customisable

LBTS: logbook template standard

LDRP: labour delivery recovery and post partum

LPS: lightning protection system

LV: low voltage

M&E: mechanical and electrical

MCB: miniature circuit breaker

MCC: motor control centre

MCCB: moulded-case circuit breaker

MD: maximum demand

Medical IT: medical impedance terra (earthed) also known as IPS

MEIGaN: Medical Electrical Installation Guidance Notes

MET: main earth terminal

MRI: magnetic resonance imaging

NEAT: NHS Environmental Assessment Tool

NHS: National Health Service

OCB: oil circuit breaker

OJEC/OJEU: Official Journal of the European Community/Union

ONAN: oil natural circulation, air natural flow

PEC: protective earth conductor

PEI: primary electrical infrastructure

PELV: protected extra LV

PES: public electrical supply

PET: protective earth terminal

PF: power factor

PFC: power factor correction

PFI: Private Finance Initiative

PPE: personal protective equipment

PPP: Public Private Partnership

PPS: primary power source

PSCC: prospective short-circuit current

PV: photovoltaic cell

PVC: polyvinyl chloride

RCBO: residual current breaker with overcurrent

RCD: residual current device

REF: restricted earth fault

RMU: ring main unit

SCADA: supervisory control and data acquisition

SCBU: special care babies unit

SELV: separated extra LV

SF_6: sulphur hexafluoride

SI: Système Internationale

SHFN: Scottish Health Facilities Note

SHPN: Scottish Health Planning Note

SP & N: single phase and neutral

SPS: secondary power source

TETRA: trans-European trunked radio access

TFL: time fuses links (may also be referred to as tlf time-lag fuses)

THD: total harmonic distortion

TN-C: combined neutral and earth throughout the electrical distribution system

TN-C-S: neutral and earth is combined at point of supply and separate throughout the electrical installation

TN-S: separate neutral and earth throughout the electrical system

TP & N: three-phase and neutral

TPS: tertiary power supply

UMTS: universal mobile telecommunications service

UPS: uninterruptible power supply

VRLA: valve regulated lead acid (battery)

VT: voltage transformer

XLPE: cross-linked polyethylene

Applied part: part of a medical electrical device which in normal use necessarily comes into physical contact with the patient for the device to perform its function

or

can be brought into contact with the patient

or

needs to be touched by the patient.

Authorised Person (HV): a person appointed to take responsibility for the effective management of the safety guidance given in Scottish Health Technical Memorandum 06-03: 'Electrical safety guidance for high voltage systems'.

Authorised Person (LV): a person appointed to take responsibility for the effective management of the safety guidance given in Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems'.

Dual-unified distribution: separate primary and secondary circuits collectively forming the electrical distribution of the healthcare facility. The secondary supply is equal to the primary supply; that is, both primary and secondary circuits are fully rated and provide a resilient distribution.

Designer: a person (or organisation) with the responsibility to design the electrical services technically correctly and in a safe manner. The designer need not be a direct employee of the healthcare organisation.

Essential: any part of the electrical distribution and/or final circuits that can be automatically transferred between either the primary or secondary supply circuits.

Medical electrical equipment: electrical equipment intended to diagnose, treat or monitor a patient under medical supervision which will make physical or electrical contact with the patient, transfer energy to and from the patient, or detect such energy flows.

Note 1: equipment is not covered by this Scottish Health Technical Memorandum. The Medicines and Healthcare products Regulatory Agency (MHRA) is the government agency which is responsible for ensuring that medical equipment works and is acceptably safe.

Medical IT (IPS): IT electrical system having specific requirements for medical installations. The system will include a monitoring device to provide an alarm on loss of IMD connections, insulation failure, overload and high temperature.

Medical location: location intended for the purpose of diagnosic treatment (including cosmetic) or monitoring a patient under medical supervision.

- *Group 0* Medical location where no applied parts are intended to be used.
- *Group 1* Medical location where discontinuity of the electrical supply is not a risk to human life (unless the location is part of a Group 2 location).
- *Group 2* Medical location where discontinuity of the electrical supply can cause danger to life.

Note 2: “discontinuity” means any unplanned loss of the power supply (see MEIGaN).

MEIGaN: Medical Electrical Installations Guidance Note published by MHRA.

Normal (non-essential): any part of the electrical distribution and/or final circuits connected only to the primary distribution and with no means of being connected to the essential (secondary) distribution. Note: in some distributions, manual reconfiguration may allow the normal circuits to be connected temporarily to the essential (secondary) distribution.

Patient: living person undergoing healthcare, therapy or diagnostic investigation (including dental and cosmetic).

Patient environment: any area in which intentional or unintentional contact can occur between the patient and parts of the electrical system or between the patient and other persons in contact with parts of the system (see Figure 46).

Point of use: Electrical distribution points where electrical equipment may be connected. This may be an accessory or isolator etc.

Protected extra LV: a PELV system that is earthed at one point only. Additional protection against direct contact is achieved by barriers and/or enclosures. Alternatively the insulation will have a “withstand” test voltage of 500 V dc for 60 seconds.

Residual risk: a risk that has not been fully mitigated by the design process.

Segregated distribution: an electrical distribution that includes separated primary and secondary circuits not of equal size or capacity. The secondary circuits are the only circuits that are supported by the standby power system.

Separated extra LV: an electrical system which is electrically separated from earth (normally not exceeding 50 V ac or 120 V ripple-free dc) derived from a safety source such as an isolating transformer to BS EN 61558-1:1998 and BS EN 61558-2.

Single point of failure: a connection point (other than a point of use) where

any upstream single fault will cause the loss of supply to the downstream parts of the distribution.

Site engineer: a designated person from the healthcare organisation's estates staff either at Authorised Person level or a Competent Person appointed by the Authorised Person, qualified, experienced and with knowledge of the installation.

Stakeholder: a person (or organisation) with vested interest (not necessary pecuniary) in the electrical services quality and provision at healthcare premises. The stakeholders will normally be employees of the healthcare organisation.

Tertiary power supply: a third supply that supplements the primary and secondary supplies, usually in the form of a UPS or battery system.

Unified distribution: primary (normal) and secondary (essential) circuits combined as one circuit to form a common electrical distribution of the healthcare site. Where the secondary power source does not provide 100% capacity of the primary power source, local automatic devices will be required to isolate the non- essential circuits whenever the primary power source is not available.

2. Introduction

Overview

2.1 Scottish Health Technical Memoranda 2007, 2011 and 2014 have been superseded and combined into one document: Scottish Health Technical Memorandum 06-01.

2.2 Scottish Health Technical Memorandum 06-01 Part A addresses design considerations for the electrical services supply and distribution within any healthcare facility. Part B addresses the operational management and maintenance of the electrical services supply and distribution within any healthcare facility. Both parts provide best practice guidance on the design and operational management of electrical services within healthcare premises.

2.3 Throughout this document, the following voltages are used (see BS7671:2008 for the defined voltage bands):

Extra low voltage	50 V ac or 120 V ripple-free dc
Separated extra low voltage (SELV)	50 V ac or 120 V ripple-free dc
Protected extra low voltage (PELV)	50 V ac or 120 V ripple-free dc
Low voltage	230V phase to neutral, phase to earth or line-to-line (medical IT) 400 V phase to phase
High voltage	11,000 V phase to phase 6350 V phase to neutral

2.4 This document has been divided into 18 sections:

- Sections 1 and 2 set out the structure of the Scottish Health Technical Memorandum;
- sections 3 to 11 deal with design issues. Although this Scottish Health Technical Memorandum is written for new works and developments on a green-field site, it should be used for all works and adaptations to the fixed wiring of any healthcare facility;
- sections 12 to 17 describe how the electrical services should be installed and put together from the various distribution centres to the final circuits and point of use locations.

Section 3 provides guidance on what needs to be considered when planning a new development in terms of the electrical services.

Section 4 explains how the design options should be assessed to minimise the risk of system failure and the consequential impact on patients and users of the healthcare premises. The section introduces the concept of clinical risk in terms

of the clinical function of a department within the healthcare facility. The chapter also considers the business continuity risks in a similar manner. The chapter provides a risk matrix that may be used in the evaluation of the distribution strategy.

Section 5 defines the required standard of the electrical supply.

Section 6 describes the techniques to be used that will provide an appropriate resilient electrical system for any healthcare facility (or part within a healthcare facility).

Section 7 describes the physical electrical switchrooms, their construction, location, and environmental requirements.

Section 8 continues the descriptions of switchrooms that may be used for alternative, including emergency, power supplies.

Section 9 provides the details of the electrical equipment that will be found in the primary and secondary distribution centres. The section provides information on the protection and isolation methods of the electrical services and distribution.

Section 10 provides details of battery units that may be used to start standby generator plant or provide more local power to items such as uninterruptible power supplies (UPS) or inverter units.

Section 11 provides details on how the electrical distribution system may radiate or absorb electromagnetic interference and how these problems may be mitigated.

Section 12 describes the general wiring formats in relation to earthing and insulation.

Section 13 describes the full earth systems to be used. The section is subdivided into HV, LV, and switchroom earths. In addition, the specific requirements for isolated power supplies, earthing radiographic rooms and circuits with high leakage currents are discussed. The method of providing earth monitoring systems to BS4444:1989 for mobile trailer units is also considered in the guidance. The section concludes with the requirements for lightning protection systems.

Sections 14 and 15 describe the various cable types and the respective methods of installing them in healthcare premises.

Section 16 describes the various final circuits, including uninterruptible power supplies, isolated power supplies, fixed equipment temporary supplies and alarm circuits.

Section 17 provides designers and stakeholders with an insight into the validation and commissioning tests required before a new installation may be signed off and formally accepted.

Appendices and References can be found at the end.

How to read this Scottish Health Technical Memorandum

2.5 This document has been written in a top-down format. The design process for new builds is likely to follow a similar planning, design and construction order to that of this document.

2.6 It is recommended that designers and stakeholders review Section 4 as well as Section 6 for all projects.

2.7 Designers and stakeholders should review any other section in relation to the nature of the particular project.

3. Initial considerations

3.1 This section introduces the design element of the document. The intent is to assist designers and stakeholders to develop the design of electrical networks for new builds, but equally it applies to modifications to existing installations. Some parts of this section can be addressed prior to or during the outline design stage, but all can be addressed before the detailed electrical design stage.

Sources of supply

3.2 All healthcare premises require an electrical connection to the public electrical supply (PES), which will be provided and operated by the distribution network operator (DNO). Electrical supplies to large healthcare premises are mainly at 11kV (high voltage), while smaller healthcare premises may be supplied at 400V (low voltage). The supply frequency at both voltage levels will be 50Hz (see the Electricity Safety, Quality and Continuity Regulations 2002 for further details). Within this Scottish Health Technical Memorandum, the connection to the PES will be referred to as the "primary source of supply". Any embedded generating plant and/or combined heat and power (CHP) plant can be used as the primary source of supply, provided appropriate measures for resilience; maintenance and safety have been included.

3.3 Many healthcare premises will require resilience of the internally distributed electrical installation, which should be provided according to the clinical risk assessments (see Section 4). The resilience may be provided by embedded sources of electrical power from plant such as:

- secondary source of supply;
  - standby generators;
  - CHP systems;
  - wind turbines;
  - photovoltaic systems.
- tertiary source of supply;
  - uninterruptible power supplies (UPS), rotary or silent;
  - UPS static;
  - battery packs.

3.4 Adequate stocks of the fuel used by standby generators and/or CHP will need to be maintained. The fuel for wind turbines (wind) and/or photovoltaic systems (solar) may not always be readily available at the optimum volumes, and therefore these sources of power should not be considered as essential power sources. UPSs use batteries as a power source, which have a definitive autonomy dependent on the connected load. UPS and battery supplies should

only be considered as a short-term measure. The PES connection may be used as the secondary source of supply where appropriate measures for capacity, resilience, maintenance and safety have been included with the embedded sources of electrical power. However, it may be less viable to provide a dual PES connection than it is to provide additional on-site secondary power supplies, for example standby generators.

Resilience

3.5 Large healthcare premises should generally be supplied by a dual PES (ideally both at 100% fully rated) arranged with either an automatic or a manual change-over system. In order to maximise the resilience of dual supply arrangements and minimise the actual single point of failure, the supplies should be diverse. Where possible, they should originate from separate DNO substations, in turn ideally fed from separate parts of the National Grid, with independent cable routes to and across the healthcare site to the substations.

3.6 Having two separate HV supply feeders is an additional safeguard for larger premises; whether this is practicable largely depends on the local distribution system and the DNO.

Essential/non-essential supplies

3.7 When planning for new installations, the option of segregated non-essential and essential electrical systems or a unified electrical system (that is, duplex or simplex) should be evaluated.

3.8 The need for more essential supplies increases the demand on the standby system. Electrical supplies in the healthcare sector are growing at a rate of between 3% and 6% year on year. A suitable philosophy should be agreed with estates staff to reflect this growth before sizing the standby plant and distribution strategy.

3.9 A risk-orientated approach should be adopted, and different categories of the essential and non-essential load identified to assign appropriate standby provision (historically, it has been customary to have a discrete segregated essential/ non-essential service combination). For clinical areas, there should be 100% essential load provision. A segregated duplicated essential system could be used to overcome the inherent single-fault breakdown potential. This would also facilitate the operational opportunity to test and periodically validate electrical installations.

3.10 The provision of two segregated systems, each of smaller power capacity, should be balanced against having one larger unified power system in terms of economics and reliability in emergencies. The availability of the distribution and final sub-circuits for testing, validation and upgrading of systems should also be taken into consideration.

3.11 In systems that employ a segregated duplicated essential service, thought should given to the space needed for separate feeders, independent risers and

stand-alone distribution board (DB) cupboards so as to reinforce the system resilience. This will help to ensure that a local failure will not compromise the entire system.

3.12 Even when two segregated systems are provided (essential/non-essential), an emergency coupling should be normally locked open between them. This allows the standby generator to be connected to both systems if necessary; for example, during a prolonged outage, some normally non-essential services may become essential, such as catering and laundry. In addition, with the coupling it is possible to provide a larger test load.

3.13 Where essential, non-essential and duplex essential circuits are installed, diverse cable routes should be provided, and the possibility of a single cable fault damaging both circuit cables should be minimised as much as possible.

3.14 In areas where there are many essential sub-circuits, separate cable trays should be used for the routing of duplex essential and non-essential circuit cables.

3.15 Consideration should be given to the requirements of BS 5588 and fire-protected cables or cable routes.

Primary sources of supply

3.16 This section deals with the primary supply, distribution and sub-distribution of the primary electrical infrastructure (PEI), and presents best practice configurations for both HV and LV DNO supplies (see Figure 1). The configurations are presented generally in order of resilience, from low to high. The selection of a particular configuration will be dependent on the specific factors of each individual design in terms of available DNO supply, type of healthcare facility, category of patient etc. Whichever configuration is selected, it should be based on a risk analysis to determine the appropriate level of resilience (see Section 7).

3.17 The configurations presented in this section should not be taken as being definitive, prescriptive or restrictive. They are intended as a guide to best practice and not intended to restrict innovation in any design.

Secondary main sources of supply – generation

3.18 This section deals with secondary supplies of the PEI and presents best practice configurations for both HV and LV standby supplies (see Figure 2). The configurations are presented generally in order of resilience, from low to high. The selection of a particular configuration will be dependent on the specific factors of each individual design. Whichever configuration is selected, it should be based on a risk analysis to determine the appropriate level of resilience (see Section 8).

Tariff negotiations and private generation

3.19 At an early stage of the design process, designers and stakeholders should assess the capacity of the new electrical load. Negotiations with an electrical energy supplier should be initiated at this early stage. Where the building services operator is responsible for the purchase of electrical energy, they will also be responsible for the negotiations. However, in the more usual case where the electrical energy is a pass-through cost, or where the building services operator is the healthcare organisation, the healthcare organisation will be responsible for the above negotiations.

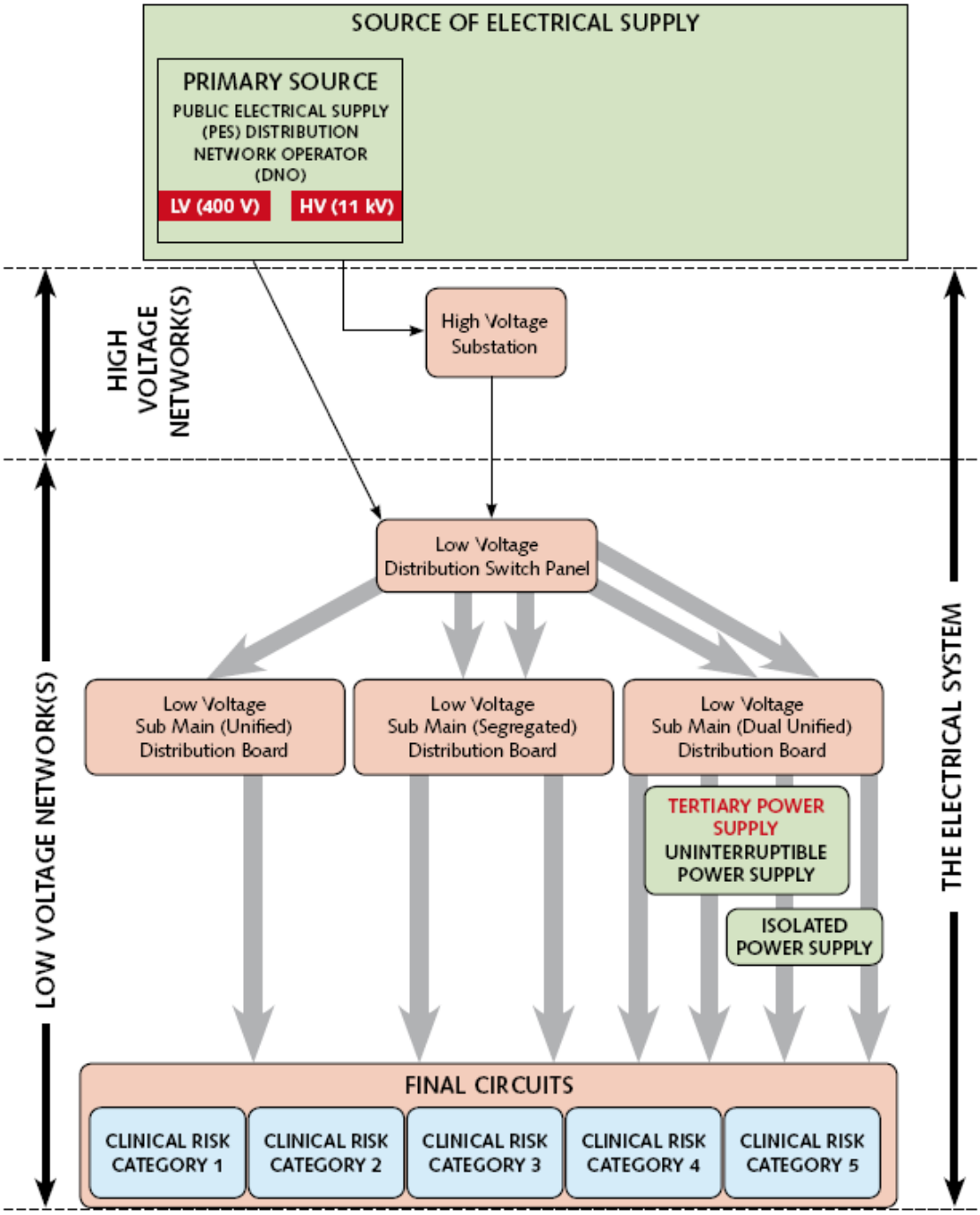

Figure 1: Primary electrical infrastructure for healthcare premises.

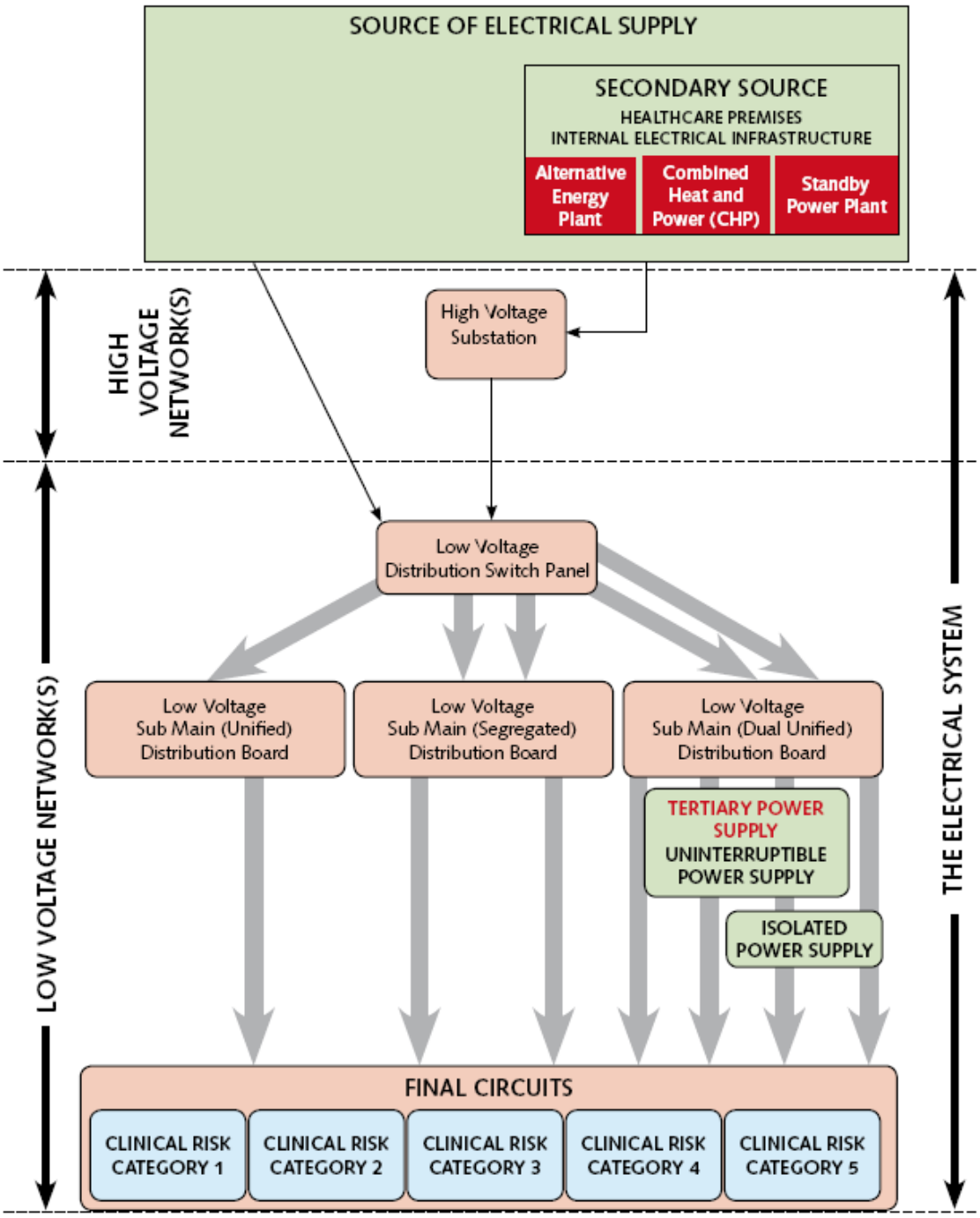

Figure 2: Secondary electrical infrastructures for healthcare premises.

3.20 The opportunities for alternative energy sources should be explored wherever practical. For example, sources such as CHP or wind power will reduce the net carbon emissions and potentially provide an improved economic solution. Where alternative energy sources are used, the resilience of such plant should be considered. This may be in the form of “N+1” CHP plant or suitable alternative supply from the DNO.

3.21 Healthcare organisations should use BREEAM Healthcare 2008 which supersedes the NHS Environmental Assessment Tool (NEAT) to help find out

how their facilities and services impact on the environment and to estimate the level of environmental impact taking place (http:// www.dh.gov.uk).

3.22 Where the proposed alterations are for modification and/or adaptations to the internal electrical infrastructure, tariff negotiations may not be required. Nevertheless, the use of alternative power sources should still be considered to offset the increased electrical demand.

3.23 Guidance on the environmental benefits of alternative energy sources can be obtained from:

- Building Services Research and Information Association (BSRIA) (http://www.bsria.co.uk);
- Chartered Institution of Building Services Engineers (CIBSE) (http://www.cibse.org);
- Combined Heat and Power Association (CHPA) (http://www.chpa.co.uk);
- Department for Environment Food and Rural Affairs (http://www.defra.gov.uk);
- The Carbon Trust (http://www.carbontrust.co.uk).

See also Scottish Health Technical Memorandum 07-02: 'EnCO_2de'.

Supply voltages

3.24 The DNO will deliver the PES at the customer's intake terminals at a declared voltage in accordance with the requirements of the Electrical Safety, Continuity and Quality Regulations 2002. Each healthcare facility will have an electrical supply at one of the following voltages:

11kV	Large acute hospital, typical floor area greater than 8,500m^2
11kV/400 V	Medium-sized acute hospital, typical floor area 5,500m^2 to 8,500m^2
400V TP & N	General/community hospitals, health centres, large off-site clinics, off-site administrative buildings, stores and decontamination facilities
230V SP & N	GP and dental practices, small off-site clinics

The types of healthcare facility in the above list are for illustration and are not definitive. For voltage tolerances in the above list, see the latest issue of the IEE Regulations (BS7671: 2008), and the Electricity Safety, Quality and Continuity Regulations 2002.

3.25 Some larger sites may have multiple feeds (at the intake point) with an internal distribution network (see Sections 6–8). In such cases, the declared voltage will be either 11kV or 400V. Such connection arrangements provide an improved resilience of supply.

3.26 Some healthcare sites, particularly older sites that have expanded over a number of years, may have multiple intake points (which may not all be at the same supply voltage). The various intake points should be consolidated to a single or multiple feeds at a common point. Such arrangements will provide economies with tariff and standing charges.

3.27 The DNO may arrange with the healthcare facility (under a wayleave agreement) to have their own electrical equipment, including transformer, on-site. This arrangement is frequently used in rural areas where the healthcare facility is some distance from the nearest DNO substation. In such cases, the DNO's electrical equipment will be at a higher voltage (11kV) to that supplied at the healthcare site's intake terminals (400V).

Design of installations for growth and change

3.28 Changes in medical technology and healthcare practice have had an effect on the requirements for electrical power in healthcare. Examples include:

- cook-chill: the introduction of cook-chill has meant more meals are cooked electrically and ward-based "regeneration ovens" have been introduced;
- electronic patient records (EPR) and patient entertainment systems: although these have a very low electrical power requirement, such systems require a significant increase in containment and space.

3.29 Alterations to existing installations, unless planned and allowed for during the original construction, can be costly, particularly when structural changes are involved.

3.30 Healthcare premises are frequently remodelled within the economic life of an electrical installation. Designers and stakeholders should identify means of remodelling the electrical distribution and determine to what extent any flexibility for remodelling should be incorporated with the initial design.

3.31 Each electrical distribution centre should include an element of equipped and unequipped enclosures for retrofitting of switches, protective devices and so on.

3.32 The designers should evaluate, by risk assessment, the degree of remodelling and natural expansion that will be incorporated into the initial installation. The risk assessment should reflect both clinical and commercial risks.

3.33 This allowance for growth and remodelling should be incorporated into the adopted distribution strategy (see Section 6).

Assessment of existing electrical systems

3.34 Designers will need to make a reasonable assessment of any existing electrical services that are to be modified or connected to as part of the proposed works. For existing sites, the building logbook (see Section 17) will provide details of the existing electrical systems, periodic test results (including fault levels),

applied diversity, load profile and schematic drawings of the electrical system and/or network. Examination of the settings on all adjustable protection devices will identify the extent of any tolerance within the grading and discrimination of such protective devices.

Greenfield site

3.35 Where the proposed works is a new building site and not part of an existing hospital complex, the assessment of existing electrical systems may be limited to an understanding of the DNO's infrastructure in the area. This knowledge will help in determining the cost associated with any reinforcements.

New-build on existing site

3.36 Where the proposed works are a new building site within part of an existing complex, the assessment of existing electrical systems will determine the extent of any spare capacity at the proposed connection point. The connection point may be at the site intake or embedded in the internal distribution network. This knowledge will help to determine the practicalities and cost associated with any reinforcements of switchgear, protection devices and cables.

New equipment on existing site

3.37 Where the proposed work is limited to the installation of new equipment or the modifications of sub-distribution and final circuits, the power requirements and an understanding of the existing distribution (including final sub-circuits) will determine the most appropriate connection point and any reinforcements of switchgear, protection devices and cables.

Load profile

3.38 Designers and stakeholders should understand the electrical profile of the healthcare facility at an early stage. This will prove invaluable in assessing the viability of any secondary and/or tertiary energy sources (for example CHP plant). Where the healthcare facility is an existing site, electrical demand data records should be available. The data may be available from the building energy management system (BEMS), the utility supplier (in the form of digital pulse metering) or from the Estates Return Information Collection (ERIC).

3.39 Table 1 indicates a typical range of power densities found in healthcare premises over a five-year period. The actual figures will reflect the technology used and the particular department. Power densities at the lower end of the range reflect average power densities of large healthcare premises. Power densities at the upper end of the range reflect power densities for smaller healthcare premises such as GP surgeries. The figures do not take account of any growth. Power densities at the lower end do not necessarily imply any improved efficiency over power densities at the higher end. However, power densities outside the range may give cause for further investigation.

Power	W/m^2	GJ/100m^2
General power	9-25	3.7-10.3
IM&T power	3-6	1.2-2.5
Medical power	5-15	2.0-6.2
Lighting		
General	9-15	3.7-6.2
Special	0.9-1.5	0.4-0.6
Task	1.35-2	0.5-0.8
Medical	0-1	0.0-4

Table 1: Typical range of power densities for a healthcare facility over a five-year period

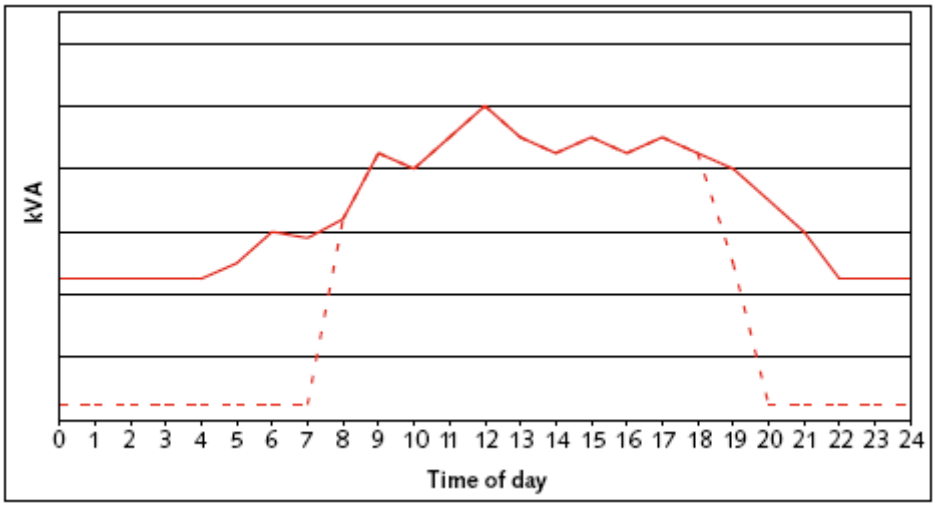

Figure 3: Typical diurnal electrical profiles for a hospital

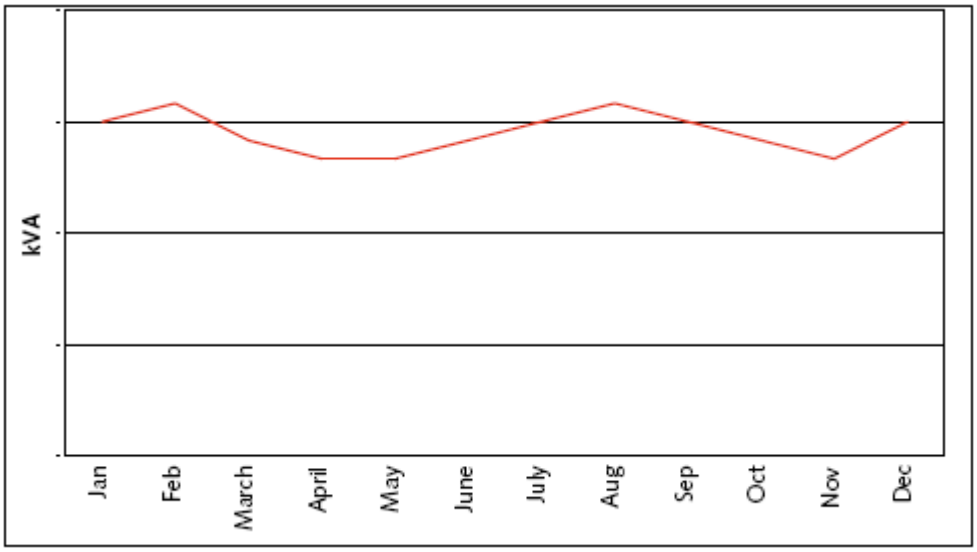

Figure 4: Typical annual electrical profiles for a hospital

3.40 Figure 3 shows a typical daily electrical profile for a hospital. The annual profile is shown in Figure 4. The actual shape and kVA values are unique to the site and a function of the size and clinical facilities provided.

3.41 The various options of providing the electrical energy required to satisfy the load

profile should be evaluated. Where the profile indicates a relatively short peak maximum demand, which is high in relation to the average demand, the cost of the DNO connection will be disproportionately expensive, as the cost of the connection is only optimised at the maximum demand period. In such cases, the healthcare organisation should consider developing some of the electrical energy from on-site alternative energy sources such as CHP or wind power. Where alternative energy sources are used, the resilience of such plant should be considered.

Diversity factors

3.42 The electrical diversity factor is the ratio of instantaneous power to the total installed power. Diversity factors can be applied to each element of the electrical service (for example the lighting load or small-power load) or to a whole department. Where the healthcare site is large and has multiple substations, the diversity factors can be calculated for each individual substation. It should be clear that the diversity factor for a particular service (for example lighting) may differ during the day and year, while the diversity of, say, the chiller plant may have a different cycle. Similarly, the diversity variation for one department (for example radiography) may be higher on weekday mornings than in the afternoon, while the accident and emergency department may peak in the early evenings.

3.43 The above variations in actual diversity will reflect the true load profile as identified in paragraphs 3.38–3.41.

3.44 Designers should assess the actual diversity factors for each service and department to make a value judgement of the site-wide normalised diversity. This figure can then be applied to the total installed power and the allowance for growth to determine the electrical capacity of the DNO connection. Table 2, shows some typical figures.

	Power density (W/m2)	PF	Building diversity	Substation diversity	Connected load diversity	Off-peak diversity	Growth factor
AHU fans	15-25	0.95	0.7-0.90	1.00	0.7-0.90	0.68	0.10
Building services pump	1-3	0.95	0.7-0.90	1.00	0.7-0.90	0.68	0.10
Lifts	5-8	0.95	1.35-0.23	0.50	0.3-0.5	0.6	0.05
Chiller	25-35	0.95	0.9-0.95	1.00	0.9-0.95	0.8	0.05
General low power	9-25	0.95	049-060	0.70	0.7-0.85	0.65	0.20
Information systems	3-6	0.95	0.80	0.80	1	0.65	0.20
Medical equipment	6-16	0.95	035-0.49	0.70	0.5-0.7	0.2	0.20
General lighting	9-15	1.00	049-0.63	0.70	0.7-0.9	0.8	0.15
Specialist lighting	0.9-1.5	1.00	0.35-0.63	0.70	0.8-0.9	0.5	0.15
Task lighting	1-2	1.00	0.45-0.54	0.60	0.75-0.9	0.4	0.15
Medical lighting	0-1	1.00	0.42-0.54	0.60	0.7-0.9	0.7	0.15

Table 2: Typical electrical diversity factors for healthcare premises.

Notes referring to Table 2:

Power density: The power density relates to the relevant internal floor area of the healthcare premises.

Power factor (PF): Power factor is assumed to be the corrected power factor at each substation.

Building diversity: The building diversity reflects that not all substations within the healthcare premises will have the same operating profile. The building diversity is the product of the connected load and substation diversity. The building diversity is the actual demand seen at the point of common coupling with the PES.

Substation diversity: Substation diversity reflects that not all areas, of any one substation, will have the same operating profile, for example clinics and 24-hour areas. The substation diversity is multiplied by the connected load diversity to produce the building diversity.

Connected load diversity: Connected load diversity reflects that any electrical system (fixed medical equipment etc) will not be operating at full demand or used to maximum capacity at all times of the day.

Off-peak diversity: Off-peak diversity reflects that not all equipment will be used (to the same profile) at night as in the day (for example 12-hour clinics etc). The off-peak diversity is not used in these calculations, but will be an element used in the energy calculations.

Growth factor: Growth factor is an allowance for the natural expansion in electrical equipment used, and potential remodelling of the hospital. Growth factor is applied to switchgear, cable sizes, and transformer sizes etc. The function of the growth factor is to ensure that the electrical network will not need premature replacement.

Consideration for EMC requirements

3.45 Electrical installations must be compliant with the requirements of the Electromagnetic Compatibility Regulations 2005. The regulations describe the electrical installation as a manufactured item, and therefore require the installation to be tested for electromagnetic radiation and absorption. Procurement contracts for electrical equipment associated with the distribution of the electrical installation should stipulate that the equipment must be compliant with the Electromagnetic Compatibility Regulations 2005.

Roles and responsibilities

3.46 The Electromagnetic Compatibility Directive (EMCD) and the Electromagnetic Compatibility Regulations 2005 describe who is responsible for meeting compliance. There are only two parties involved – the manufacturer and the

operator.

In a healthcare building project:

- the designer and installer of an integrated heating, ventilation and air-conditioning (HVAC) or power distribution control system are the “manufacturer”;
- the manager of the healthcare premises and the building services maintenance organisation are the “operators”.

It will not always be possible to design-in equipment that is CE-marked to show compliance with the EMCD. An installation may comprise CE-marked and non-CE-marked equipment. Supply of non-CE-marked equipment is acceptable providing the installer who is integrating them into the system can be sure that they will not cause undue interference to the installation or be overly sensitive to the electromagnetic environment where the equipment will be used.

3.47 The designer should obtain a technical file from the installer demonstrating that good engineering practice has been applied, and should show details of any concessions granted to items that are not compliant with the installation specification, but which may be used without detrimental effects.

3.48 Designers and stakeholders may assume that any equipment which is supplied for operation in the medical environment will have sufficient immunity to operate successfully in that environment, and it should not emit excessive radiation. The above statement assumes that the healthcare organisation has an approved policy for the procurement of medical equipment which does not involve the designers or stakeholders of the electrical installation.

Building owner/ designer	Ensures system legally complies with EMC legislation	Requires documentary proof of compliance
Designer	Designs using compliant systems. Defines EMC specifications and good EMC practices to be used	Specifies documents to be provided
Integrator	Provides compliant integrated installation	Specifies documents to be provided
Contractor	Purchases and installs systems that meet the design specification. Installs using good EMC practices	Supplies evidence of compliance to the operator

Figure 5: Roles and responsibilities

Access for maintenance

3.49 In order to comply with the Construction, Design and Management Regulations (CDM) 2007, designers need to give due account for access and maintenance at a very early stage of the design, irrespective of the size, complexity and extent of the proposed installation.

3.50 Electrical services should not compromise the space and access routes for other services such as mechanical and public health. Maintenance tasks should be carried out with the minimum disruption to continuity of supply and business.

3.51 The following documents provide additional information:

- Scottish Health Technical Memorandum 06-01 Part B: 'Operational management';
- Scottish Health Technical Memorandum 00: 'Policies and principles';
- Defence Works Functional Standard DMG 08: 'Access and accommodation for engineering services: space requirements for plant access, operation and maintenance';
- manufacturers' operational and maintenance manuals.

Commissioning procedures

3.52 Designers should consider how the installation will be commissioned and how the required test measurements will be made. This will include the inspection of services that may be hidden at the time of handover. It will also include the implications of any phased occupation (see Section 17 for more information).

3.53 The design team should make an application to connect the new works to the DNO or healthcare site prior to doing so. At this point, the installation should be suitably safe and ready to be energised.

Connection to the DNO

3.54 Where the new installation will be connected directly to the DNO's network (PES), the application to connect will take the form of a "completion certificate" as identified in BS7671: 2008. The DNO will be entitled to conduct a range of tests to be satisfied that the installation is safe for energising and that any fault currents which may arise are cleared before injecting into the DNO's network.

3.55 In cases where the new installation includes embedded generator plant (including CHP or PV cells), the DNO will need to understand the methods used to clear any faults from the internal energy sources in order that they are not reflected onto the DNO's network.

3.56 For green field sites, it may be necessary to coordinate the activities of the DNO, meter operator and energy supplier before a connection can be completed (see paragraphs 8.29–8.47).

3.57 The DNO will reserve the right not to connect a new installation where the installation fails to comply with its criteria.

Connection to the healthcare site network

3.58 Where the new installation will be connected into part of the healthcare site's existing network, the application to connect will take the form of a "completion certificate" as identified in BS7671: 2008. The healthcare facility will be entitled to conduct a range of tests to be satisfied that the installation is safe for energising and that any fault currents which may arise are cleared before reflecting onto the remaining part of the healthcare site's network.

3.59 The site engineer should reserve the right not to connect a new installation where the installation does not comply with the guidance given in this Scottish Health Technical Memorandum and local electrical safety guidance. The site engineer may also reserve the right not to connect a new installation where the installation compromises the distribution strategy of any other part of the electrical network.

3.60 At a very early stage of the design (or if appropriate, procurement planning), the designer should assess the power requirement and subsequently make a request for a suitable supply.

Supply from the DNO

3.61 Where the new supply will be direct from the DNO, the designer should contact the DNO for the appropriate forms. The cost of the supply will reflect the level of infrastructure reinforcement.

Supply from internal connection point

3.62 Where the new supply will be connected to part of the healthcare facility's existing internal distribution, the designer should liaise with the site engineer to determine the most appropriate connection point, and the required method and degree of reinforcement of the internal distribution.

4. Understanding risk and ownership

4.1 This chapter deals with the assessment of risk and the need to ensure that the design of the primary electrical infrastructure (PEI) adequately protects the end-user, and in particular patients, from electrical failures. It promotes multidisciplinary design-team and stakeholder involvement throughout the design process to ensure an appropriate distribution strategy (see Section 6), incorporating resilience, redundancy and duplication as necessary. This should identify any “residual risks” from the design. The identification of the residual risks will enable the healthcare organisation to manage their collective ownership of risk management and hence make appropriate non-electrical and/or fixed wiring operational and emergency contingency plans in accordance with DH Emergency Planning Guidance.

Introduction

4.2 A failure can occur at any point or at any time in any electrical system, regardless of the design standards employed. The design and installation of PEI systems inherently allows failure (by operation of a protective device) to minimise the risk of danger and/or risk of injury. This is true of internal PEI systems as well as the wider PES network delivered by the DNO. The effects of accidental damage and the need for maintenance and training should not be overlooked. It is essential that an appropriate level of risk management is considered and practical emergency contingency plans are always available and ready to implement.

Need for risk assessment

4.3 Appropriate controls should be put in place to reduce any risk to an acceptable manageable level. It is essential that, at the very least, legislative requirements be met and risk be managed proactively.

4.4 A complete risk assessment for a sustainable electrical supply is a key duty of care owed to patients, staff and visitors.

4.5 The design process should ensure that single points of failure are minimised by providing the appropriate level of resilience at the point of use. Risk management carefully balances the approach to a design strategy with the cost/benefit relationships, where cost represents investment, business continuity and operational risk.

4.6 Failures of the PEI system are commonly considered as a consequential effect of the failure of the incoming DNO supply, main transformer, main switchboard etc. In these cases, it is assumed that the emergency power system (secondary and/ or tertiary power supply) is available. However, failure of the PEI itself is also possible. All potential points of failure should therefore be considered during the design process. The emergency supply system design may be

different for each type of failure.

Note 3: An inappropriate level of resilience or response to a failure may compromise patient safety.

Ownership and design

4.7 The duties of the stakeholders involved in the design, or assessment and operation, of an existing infrastructure should ensure (as far as reasonably practicable) that all risk levels and the likelihood of an electrical failure are balanced against the consequences of such failures. All stakeholders and designers should understand and accept the intended operation, limitations and inherent possible failure scenarios of the electrical system and, where necessary, implement contingency arrangements where risks of electrical failures cannot be, or are not, mitigated within or by the electrical system itself. These risks will include those inherent and residual from the design strategy (see Section 6). For example, the stakeholders and designers may agree that it is an acceptable risk that clinical risk Category 1 and 2 areas (see paragraphs 4.12–4.24) need not have any embedded secondary power source (SPS) to cover an outage of the electrical system. The management of such residual risks may therefore be to reorganise any postponed elective consultations.

Risk profile

4.8 This Scottish Health Technical Memorandum divides risk into two core elements: clinical risk (subdivided into patient and non-patient areas) and non-clinical business continuity risks (subdivided into medical services and engineering services). Designers and stakeholders should consult with medical and technical staff to evaluate the overall risk and the measures proposed to address the perceived outcomes. Most critical within this assessment is the mobility and degree of healthcare support provided to the patient, including medical procedures, critical care and continuity of treatment.

4.9 Small healthcare premises such as GP practices and health clinics/centres may have areas that fall into Category 1 and possibly Category 2. Community hospitals may have departments in Categories 1, 2 and 3, but unlikely in Category 4 or 5. Large acute healthcare premises and above may well have departments in all categories. There is no rule that definitively places healthcare premises in any one category, or defines one category for a particular healthcare site.

4.10 Each healthcare facility will have a mixture of categories (clinical risks and non-clinical business continuity risks) in varying ratios. The assessed higher clinical or non-clinical and business continuity risk for any particular area will determine the adopted electrical infrastructure strategy for that area. Designers and stakeholders should evaluate the economics of providing different distribution strategies (see Section 6) for each risk category area, or of applying an appropriate distribution strategy for the highest-order risk category to many or all areas.

Clinical risk

4.11 Within any healthcare environment, there are wide ranges of departments with complex requirements and potential risks. The risk management process will categorise each department in terms of susceptibility to risk from total (or partial) loss of electrical supply.

4.12 The consequence of a power failure is assessed and categorised against some broad clinical patient groups and patient care plans. This is on a scale from ambulant through to critical care. Consequence is also related to the organisation in terms of contingency arrangements, emergency preparedness and business continuity, all of which have a financial implication. There is also the operational consequence of the electrical system in terms of the operation and maintenance of the infrastructure from the point of view of both its physical construction and installation, and the managerial and technical staff structure in place to operate the electrical infrastructure.

4.13 The level of consequence of a power failure may be evaluated as increasing with patients' clinical category, for instance, and the level of consequence per category will equally be dependent on the duration and extent of the failure.

4.14 Medical Electrical Installations Guidance (MEIGaN) published by MHRA addresses "special locations" and deals with specific in-patient areas, and classifies the dependence certain healthcare departments have on a sustainable electrical supply. The guidance relates in part to the reliability of electrical supplies and their subsequent safety requirements. These classifications are ranked in time performance (seconds) to re-establishing a supply following an interruption, whether controlled or otherwise.

4.15 Within a GP practice or health centre, it may be assessed as acceptable to have single points of failure in a system, given that patients are likely to be more mobile than patients in critical care areas, and staff will be able to move away from the affected area in the event of a power failure. At the other end of the scale, for example in critical care areas, the consequence of a prolonged, or even a very short, power failure could be serious involving health disabilities or, in the worst cases, fatality. In this instance, a more resilient infrastructure with additional levels of secondary and/or tertiary power supplies would be appropriate.

4.16 While it is not intended to be absolute, this section should be sufficient to prompt the necessary discussion at all stages of the design process. The categories given are intended to demonstrate a range of patient risk from an electrical fault or loss of electrical supply.

4.17 Consideration of the categories in Figure 6 should establish a minimum acceptable risk option at the point of treatment or care. For the purpose of this guidance, the patient levels described are not intended to be exhaustive, but rather an aid to consider the issues.

Category 1 – Support service circulation

4.18 These areas do not directly relate to the patient environment of any group under MEIGaN. The areas include circulation spaces, waiting areas, offices and non-patient care areas such as laboratories or finance departments. Consequently, engineering services do not have an immediate effect on the clinical treatment or safety of patients (notwithstanding the requirements of the escape lighting and so on that may be provided from a local tertiary power source).

Category 2 – Ambulant care and diagnostics

4.19 These areas do not directly relate to the patient environment of any group under MEIGaN. The areas may include patients in consultation (excluding examination) or general out-patient areas. Loss of supply may give rise to disruption, inconvenience and a reduced environmental quality but would not directly compromise patient clinical treatment and safety. The loss of electrical power to other engineering services (for example ventilation or medical gases) equally will not cause concern for the safety of the patient or staff. There may be a business continuity risk if these areas are not connected to the SPS for supply failures that last greater than three hours (notwithstanding the requirements of the escape lighting etc that may be provided from a local tertiary power source).

Category 3 – Emergency care and diagnostics

4.20 These areas relate to the patient environment of group 0 under MEIGaN. The areas will include mental health wards and some maternity areas. Patients are not generally connected to any electro-medical equipment. However, medical monitoring or medical test equipment may occasionally be used and connected externally to the patient's body for a short or intermittent time (for example patient monitors or ultrasound machines). Clinical treatment and patient safety will not be compromised by an interruption of electrical power. However, the interruption of electrical power should not exceed those set out in Appendix 1.

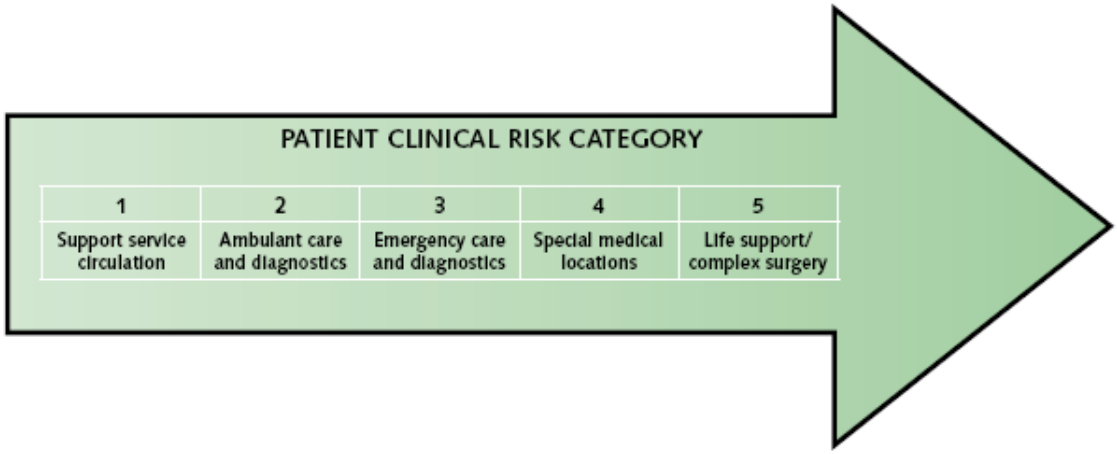

Figure 6: patient clinical risk categories

Category 4 – Patients in special medical locations

4.21 These areas will relate to the patient environment of group 1 under MEIGaN. The areas may include LDRP (labour, delivery, recovery, and post-partum) areas (maternity), endoscopy rooms, accident and emergency general/minors, haemodialysis areas, ECG areas, nuclear medicine, radiography diagnostic, magnetic resonance imaging (MRI), endoscopic examination rooms, urology treatment areas, or therapy rooms and ultrasound. Patients may have electro-medical equipment, medical monitoring or medical test equipment connected externally to their body for a prolonged period. Clinical treatment and patient safety may be compromised (but not endangered) by any interruption of electrical supply. Electrical protective devices should include an RCD, but may not require an IPS circuit. Supplementary equipotential bonding will be required in the patient environment. Any interruption of the electrical supply to medical equipment should not exceed those set out in Appendix 1. Consideration may be given to providing an alternative electrical supply (tertiary power supplies) within 0.5 seconds, subject to the range of patient treatment. Other engineering services used in support of clinical treatment should be connected to the SPS on any interruption of the electrical supply as set out in Appendix 1, (notwithstanding the requirements of the escape lighting and so on that may be provided from a local tertiary power source).

Category 5 – Life support or complex surgery

4.22 These areas will relate to the patient environment of group 2 under Chapter 10 in 'IEE Guidance Note 7'. The areas are defined as operating theatre suites, critical care areas, cardiac wards, catheterising rooms, accident & emergency resuscitation units, MRI, angiographic rooms, PET and CT scanner rooms. Patients may have electro-medical equipment, medical monitoring or medical test equipment (for example intracardiac procedures) connected externally or internally to their bodies for a prolonged period. Clinical treatment and patient safety may be compromised by any interruption of electrical supply. A patient's natural electrical resistance is significantly reduced when electro-medical conductive parts are placed in the body. Supplementary equipotential bonding (within the patient environment) should be provided for patient safety. Best practice provision should include, but not be limited to, IPS systems and the provision of an alternative electrical supply (tertiary power supplies) within 0.5 seconds of any interruption of the electrical supply if required by the medical equipment. Other engineering services used in support of the patient clinical treatment should be connected to the secondary power source (SPS) within 15 seconds of any interruption of the electrical supply (notwithstanding the requirements of the escape lighting etc that may be provided from a local tertiary power source).

4.23 Tertiary power supplies such as a UPS (see paragraphs 16.3–16.19) or a battery, within the equipment, may be considered as a method to limit the interruption of electrical supply to less than 0.5 seconds. Standby generator(s) (see Section 8) may be considered as a method of limiting the interruption of electrical supply as set out in Appendix 1. In Category 4 or Category 5 areas, a patient may be at risk from both a general loss of supply and a local final sub-

circuit fault. In Category 5 areas, enhanced levels of resilience for the provision of patient therapies may be required. This may be provided by interleaved circuits at the bed-head or pendant. Such arrangements will assist in the ability to perform maintenance with minimal disruption.

Non-clinical and business continuity risk

4.24 While clinical risk is the important factor in the design of PEI in healthcare premises, it does not just relate to the criticality of patients. There are numerous supporting elements and departments essential to continuity of care and business continuity.

4.25 The failure of these services should be assessed on the same basis as the clinical risk. The increasing reliance on information technology and electronic medical records is an obvious example of this, where the loss of electrical power could affect essential diagnosis of a patient or the ability to operate a clinic. Essential items of building services and plant may also necessitate the closure of departments in the event of a power failure where these services are not adequately protected by a resilient electrical system.

4.26 Consideration of the categories in Figure 7 should establish a minimum acceptable risk option at the point of treatment or care. For the purpose of this guidance, the non-clinical and business continuity described is not intended to be exhaustive, but an aid to consider the issues.

Category 1 – Business support services

4.27 The business support areas are departments such as finance, stores, laundries and workshop areas. In general, an interruption of the electrical supply may not compromise the treatment or welfare of patients. It may be appropriate to provide a single-conversion UPS (see paragraphs 16.3–16.19) to allow certain systems such as computer applications to shut down safely. Electrical load management systems may prove useful where the interruption to the electrical supply (for these areas) is for more than four hours (see paragraphs 8.17–8.19; notwithstanding non-patient safety measures with the provision of a tertiary power source).

Category 2 – Building services safety and security

4.28 The requirements for these facilities are covered by various British and European legislative documents, for example BS5839-1: 2002. Typically, battery packs or single-conversion UPS systems will support such requirements. An interruption of the electrical supply could compromise the safety and welfare of patients. These facilities may be included on the SPS, where the sum of their respective loads would only represent a very small percentage of the SPS. An understanding of the need for maintenance and the capacities of any such battery packs employed on these facilities will be required (notwithstanding the requirements of the escape lighting etc that may be provided from a local tertiary power source).

Category 3 – Building services environmental control

4.29 The building services environmental control systems will include HVAC systems, hot water services, energy centres and building energy management systems. In general, an interruption of the electrical supply could represent a compromise to the treatment or welfare of patients. A single-conversion UPS should be provided to allow certain systems such as computer applications to be shut down safely. Electrical load management systems should be considered where the interruption to the electrical supply (to, say, chilled water systems) gives an unacceptable rise in the internal space temperature by internal heat gains (see paragraphs 8.17–8.19; notwithstanding the requirements of the escape lighting etc that may be provided from a local tertiary power source).

Category 4 – Medical support services

4.30 The medical support areas are departments such as disinfection units, laboratories, medical records, and physiotherapy. An interruption of the electrical supply may represent a slight disruption to the treatment or welfare of patients. A single-conversion UPS (see paragraphs 16.3–16.19) should be provided to allow certain systems such as computer applications to be shut down safely. Electrical load management systems may prove useful where the interruption to the electrical supply (for these areas) is for long periods, say more than two hours (see paragraphs 8.17–8.20; notwithstanding the requirements of the escape lighting etc that may be provided from a local tertiary power source).

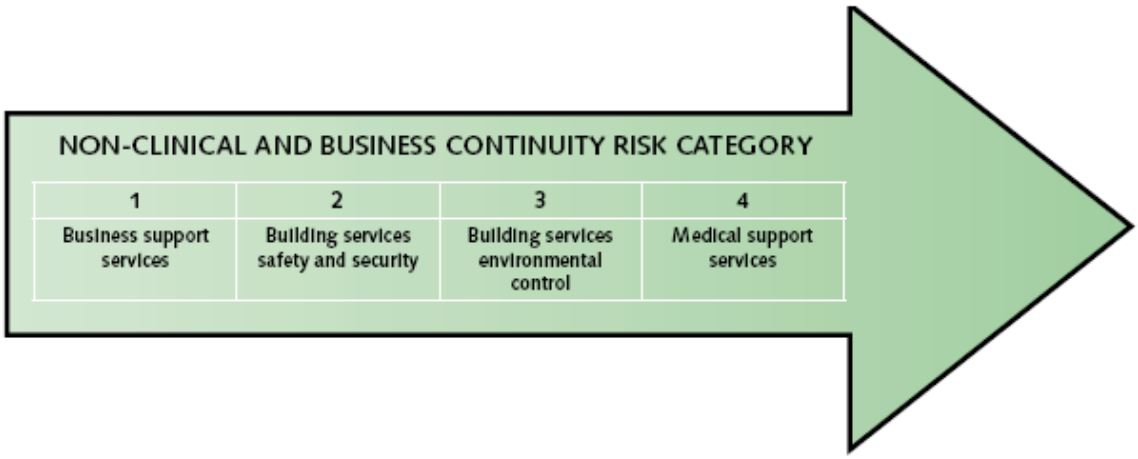

Figure 7: Non-clinical and business continuity risks

Electrical infrastructure

4.31 This Scottish Health Technical Memorandum divides electrical infrastructure into two core sections: primary and secondary (see Section 6):

- the two types of distribution may share the same cables, which defines a unified electrical infrastructure;

- where there are two sets of cables common to the primary and secondary distribution, the network is said to be a dual-unified distribution;
- where the primary and secondary distribution has entirely separate cables, the distribution strategy is said to be a segregated distribution.

The most resilient distribution strategy will have both dual-unified distribution and primary and secondary power sources.

4.32 Business continuity risk assessments evaluated by “cause-and-effect” models may be used to analyse the impact of electrical failures on departments which are reliant on the services provided. Within the integrated departmental model, consideration should be given to the cause and effect of electrical failures which escalate exponentially with time.

4.33 Cause-and-effect risk models are used to analyse the global electrical infrastructure from intake to point-of-use equipment. The risk evaluation should consider single electrical faults that cascade into multiple electrical faults and unrelated simultaneous multiple faults (see Sections 6 and 9).

4.34 A distribution strategy should be developed that drives the risk of failure of an electrical supply (at the point of use) to a low or residual risk (Figure 8). A lower distribution strategy with increased redundancy of primary and/or secondary power supply plant – which still achieves the same risk level indicated above – should be adopted. Further consideration may be given to accepting a slightly higher risk factor than the indicated lowest possible for a particular clinical area.

Resilience

4.35 Overall, the PEI can be considered in three main sections:

- supply;
- distribution;
- point of use.

4.36 The essential elements of a resilient infrastructure are:

- redundancy;
- moving the first “single points of failure” as near to the point of use as possible;
- appropriate access for practical maintenance and testing procedures.

RISK OF ELECTRICAL FAILURE BY INFRASTRUCTURE

Risk by clinical category (refer to Chapter 4 under 'Clinical risk')	Distribution strategy (refer to Chapter 6)				
	Unified distribution	Unified and segregated distribution	Dual supply unified and dual unified distribution	Dual supply unified and dual unified distribution	Dual primary and secondary supply unified and dual unified distribution
Life support complex surgery	HIGH	HIGH	SIGNIFICANT	MODERATE	LOW
Special medical locations	SIGNIFICANT	SIGNIFICANT	MODERATE	MODERATE	LOW
Emergency care and diagnostic	MODERATE	MODERATE	MODERATE	LOW	RESIDUAL
Ambulant care and diagnostic	MODERATE	MODERATE	LOW	LOW	RESIDUAL
Support services and circulation	LOW	LOW	RESIDUAL	RESIDUAL	RESIDUAL

Figure 8: Electrical failure risks evaluation to clinical categories

4.37 The resilience required to maintain essential supply in the event of not only primary failures but also secondary failures should be considered. A suitable assessment of the likelihood of concurrent failures occurring within a foreseeable period should be made, and therefore the operation and inter-relationship of the system and its component parts should be fully understood. With regard to the consequence and risk, any reasonably foreseeable secondary failures should be appropriately protected against. An example here may be a standby generator failing to start (second-line fault) on a supply blackout (first-line fault).

4.38 Incoming electrical supplies may be constrained by what the DNO is able to provide, or what has been assessed as cost-effective for the type of healthcare facility. The distribution strategy should maintain the minimum acceptable resilience level throughout the internal electrical system.

4.39 An iterative design process will help stakeholders to assess the distribution strategy. The process may be used to determine the location of the first single point of failure in addition to the method used to mitigate the risks on the distribution downstream of that point. The provision of tertiary supplies (UPS) on final distribution boards or the ability to reconfigure manually the distribution may be suitable risk mitigation.

4.40 The effects of electrical power failures due to faults at any level within the infrastructure can be designed out by the robustness of the network resilience. The distribution strategy should include adequate resilience and access space so that routine testing and maintenance can be carried out safely, without placing patients, staff and users at unnecessary risk. Such strategies may call for a redundancy in certain electrical equipment, for example generators, UPSs and IPSs. The provision of resilience for maintenance is considered best practice.

Electrical infrastructure system selection

4.41 A number of different elements link together to form the primary and secondary infrastructure system (see Figure 9). Some of the elements will be optional

dependent on design strategy (see Section 6) and required resilience issues based on assessed risk from power failures. All possible configurations of the electrical infrastructure elements will have risk-mitigation strategies associated with the possibility of power failures occurring. Similarly, each element will link to other elements, and the links and interactions between them will present additional risk minimisation. The overall risk of a power failure occurring can be mitigated by the correct selection of element configurations and interconnections. Standard system and component configurations at appropriate infrastructure sections can be broadly categorised in terms of their resilience and therefore residual risks. Evaluating the cause and effect can make selection of the appropriate configurations apparent at the point of use (deepest part) of the infrastructure.

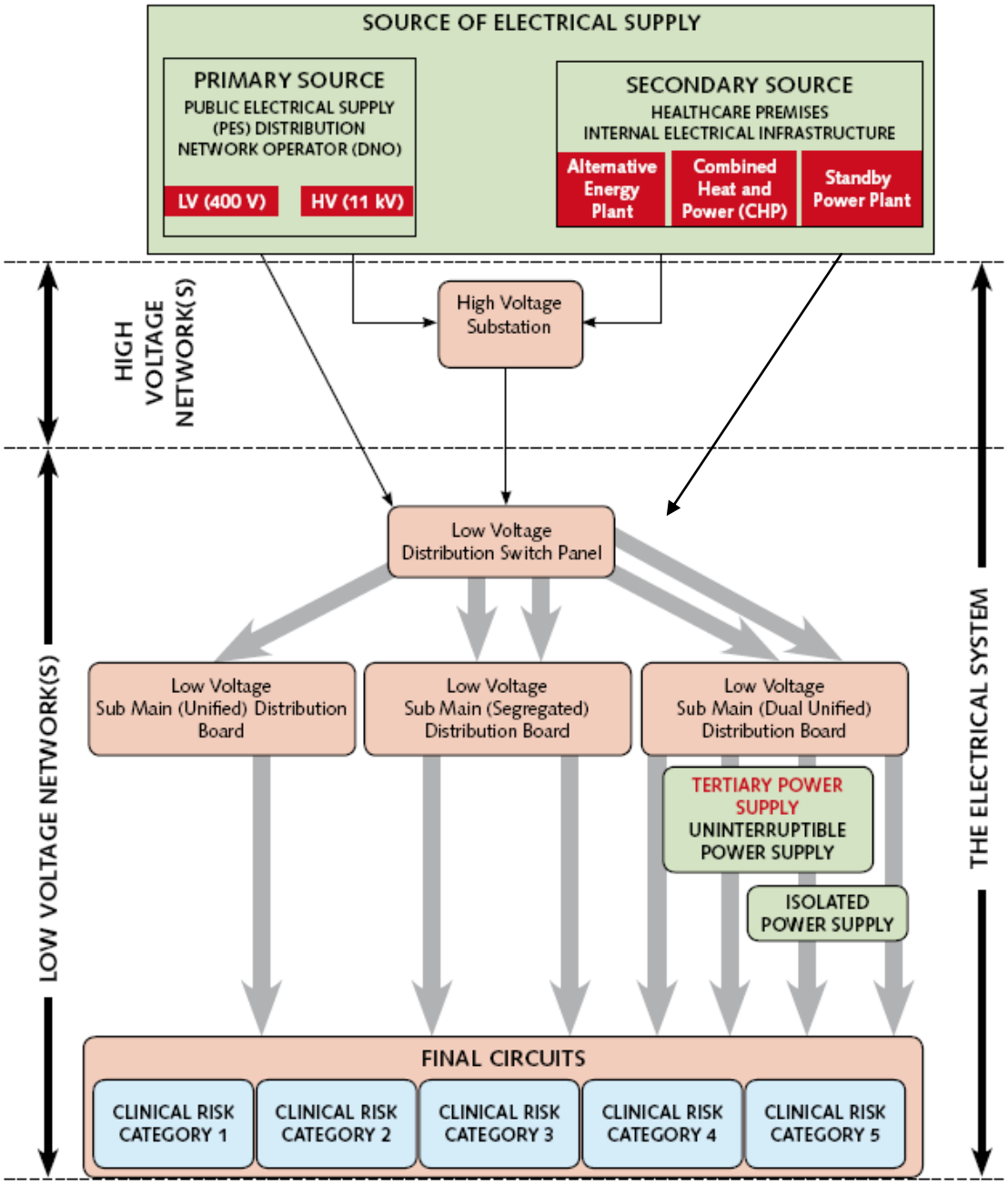

Figure 9: Electrical infrastructure generic flow diagram

5. Power quality

5.1 The quality of the electrical supply is the responsibility of the DNO, which will comply with the requirements of the Electrical Safety, Quality and Continuity Regulations. However, the use of the electrical energy within healthcare premises can affect the quality of the internal distribution in terms of power factor and harmonics.

5.2 Healthcare premises have numerous switch mode power supplies and inherently high inductive electrical loads and unless corrected, the power factor will be poor, requiring large transformers, cables and high-energy cost. Improving a typical poor power factor from say 0.75 lagging to an appropriate power factor of say 0.95 lagging will reduce the kVA demand by 20% and will be reflected as a utility cost saving. The actual inductive load will vary throughout the day and year. The inductive load will also vary across the site according to the location of mechanical plant, lifts and to some extent the clinical departments.

5.3 The normal supply frequency is 50Hz with a tolerance of ±1%. The nature of the electrical equipment used throughout the site can inject secondary frequencies that cause significant disturbances to the internal distribution and the supply. The majority of secondary frequencies, known as harmonics, are generated from switch-mode power supplies found in a wide range of electrical and electronic equipment.

Power factor correction

5.4 The usual method of correcting a low power factor uses capacitive reactance to oppose the inductive reactance. Using capacitor banks with automatic step changes will ensure that the net reactance does not produce a leading power factor. There are three basic locations for power factor correction equipment.

Located at the intake point

5.5 Power factor correction can be installed at the main distribution intake point, in which case the entire electrical system will be corrected. The power factor correction equipment should be automatically disconnected if the primary supply is interrupted, and if used in conjunction with the standby generator plant (or CHP plant) adjusted to suit the generator (or CHP plant) manufacturer's recommendations. Where the only power factor correction equipment is located at the intake, the appropriate cable sizes for the higher currents should be used.

Located at sub-main distribution boards

5.6 Power factor correction can be installed at the sub-main distribution board, in which case only the outgoing circuits will be corrected. The advantage of power factor correction units installed at sub-main distribution boards is that several

inductive loads can be corrected with one common unit. This will save on the capital cost and space required. Where the power factor correction equipment is located at the intake and sub-main distribution boards, the appropriate sub-circuit cable sizes for the higher currents should be used. Similarly, the rating of the sub-main distribution board and protective equipment may need oversizing.

Located on the electrical equipment

5.7 Where individual pieces of equipment generate a high inductive reactance such as large motors, it is advisable to install the power factor correction direct to the motor. This arrangement has the advantage of reducing the voltage drop on the motor supply cable(s) and hence smaller distribution cables can be used.

5.8 Power factor correction equipment may generate harmonic currents as well as allowing the downstream harmonics to pass through. Therefore consideration should be given to the use of detuning inductors within the power factor correction equipment.

5.9 Power factor correction equipment can be installed as an integral part of a switchboard, or as a freestanding unit. Where a cubicle of the switchboard is used to house the power factor correction equipment, consideration should be given to the effect this will have on future flexibility and remodelling of the power factor correction equipment and/or the switchboard circuits.

5.10 Power factor correction equipment requires natural ventilation to remove the small amount of heat it generates. Further information on the amount of natural ventilation should be available from the manufacturer.

Harmonics

5.11 The normal supply frequency is 50Hz with a tolerance of ±1%. The nature of the electrical equipment used throughout the site can create secondary frequencies that cause significant disturbances to the internal distribution and the supply. The majority of the secondary frequencies, known as harmonics, are generated from short surge currents and transient currents arising from non-linear electrical loads such as switch-mode power supplies and rotating machinery, variable speed drives and so on found in a wide range of electrical and electronic equipment.

5.12 Surge transient currents are also caused by lightning strikes. Further details on the lightning strikes and surge arrestors can be found in paragraphs 13.39 to 13.49.

5.13 Even-order harmonic frequencies are self-negating and do not cause a real disturbance to the electrical distribution. Odd-order harmonics with zero rotation effect, known as “Triplen” harmonic frequencies (3rd-, 9th- and 15th-order), and odd-order harmonics (5th, 7th and 11th) can cause significant disturbances leading to high currents and voltages, and overheating of cables and equipment, particularly transformers.

5.14 Electrical systems must comply with the Energy Networks Association's Engineering Recommendations G.5/4, which limits the reflected total harmonic distortion (THD) at point of common coupling. For voltages up to 0.4kV, the THD is 5%, whereas at 11 kV the THD is 4%. Designers should evaluate the sources of harmonic disturbances within the healthcare site's electrical network and the methods to mitigate the effects. Harmonics can be controlled by the use of harmonic filters (active or passive). The use of oversized neutral conductors (200% to 300%) will carry the harmonic current back to the transformer, which then should be sized for such currents and heat. Consideration should also be given to the use of clean-earth conductors for power supplies to items such as IM&T computer server and hub rooms. A single-phase third-harmonic current on a balanced three-phase circuit can produce currents at 70% of the fundamental current and flow within the neutral conductor. If the harmonic currents reach the distribution transformer they will be reflected into the primary delta winding and circulate. The unchecked harmonic current in the primary winding of a distribution transformer will be dissipated as unwanted heat and noise.

5.15 The network analysis of harmonic currents propagated within the electrical systems should be made and communicated to the supplier of any standby generator. The generator design will need to reflect the anticipated harmonic currents. Harmonic currents not allowed for within the generator design may cause excessive heating, high torque loads and consequently vibration within the generator while running. Only active harmonic filters or isolating passive harmonic filters should be used while the generator is online (see paragraph 5.18).

5.16 The electrical load of a typical healthcare facility with many modern medical facilities and support services may have non-linear loads (propagating harmonic disturbances) at 40% of the overall load. Unless the harmonics are controlled and eliminated downstream from the transformer primary winding, the transformer may need to be de-rated by the "factor-K method" (as defined in BS7821), which may typically be 70% of the transformer nameplate kVA rating to avoid transformer damage.

5.17 Alternative methods may include using oversized neutral conductors, using separate transformers for linear circuits and using inductive loads or preferably harmonic filters. Active or passive harmonic filters should be used, which can be located in one of three locations depending on the source and severity of the disturbance.

(1) Located at the intake point

5.18 Harmonic filters can be installed at the main distribution intake point, in which case the entire electrical system will be corrected. Any passive harmonic filters should be automatically disconnected when any standby generator plant is supplying the load. Harmonic filters should not be located here, as large harmonic currents may require neutrals oversized by as much as 300%.

5.19 It should be noted that for the purpose of this section of the guidelines, the intake point means the HV/LV substation, LV switchboard. Alternatively, where

the site has an internal HV network, the intake point means each such substation LV distribution board.

(2) Located at sub-main distribution boards

5.20 Harmonic filters may be installed at the sub-main distribution board, in which case only the outgoing circuits will be corrected. The advantage of harmonic filters installed at sub-main distribution boards is that several sources of harmonic inductive loads can be corrected with one common unit. This will minimise the harmonic disturbance reflected on the sub-main and main distribution cables and save on the capital cost and space required.

(3) Located on the electrical equipment

5.21 Where an individual piece of equipment generates a high transient current or voltage from a switch-mode power supply, it is advisable to install active harmonic filters direct to the equipment. This arrangement has the advantage of reducing the harmonic disturbances on the final sub-circuit cables.

Voltage surge protection

5.22 Consideration should be given to the provision of voltage surge protection at the LV intake point, where equipment which may be sensitive to such voltage surges is connected to the distributed installation from the intake.

6. Distribution strategy

6.1 For the purpose of this Scottish Health Technical Memorandum, it is assumed that the highest distributed voltage in any healthcare facility will be 11kV. DNO connections to healthcare facilities may be at elevated voltages such as 33kV, but it is considered that such voltages are not distributed within the healthcare site. Where healthcare facilities do have a DNO connection at voltages above 11kV, the strategy for such connections (and if appropriate, distribution) should follow the distribution philosophy described in this chapter. This Scottish Health Technical Memorandum only considers any electrical energy used at low voltage as a three-phase or single-phase connection. This Scottish Health Technical Memorandum does recognise that some electrical energy used in healthcare premises will be at SELV or PELV, but is only concerned with the fixed wiring at low voltage. In a similar way, electrical energy used at high voltage, for some large vapour compression chillers for example, is acknowledged, but again this Scottish Health Technical Memorandum only addresses the fixed wiring at HV.

6.2 When designing the strategy for the electrical network(s), it is essential to take a holistic approach. The electrical system may include HV and LV distribution networks, or just LV distribution networks, depending on the size of the site.

6.3 The topology of the LV network(s) can provide the most resilient service at the point of use. The cost of such security of supply may be compromised if the HV system is not equally resilient. Best practice is achieved when the distribution strategy places the first single point of failure as close to the final sub-circuits as practical to satisfy the critical nature of the healthcare facility while remaining financially viable.

6.4 The required system resilience can be achieved in two basic ways, first by having dual circuits and secondly by having an alternative power supply. Standby generators can be connected at the intake point or may be connected at specific LV switchboards. While this chapter describes the resilience provided by generators, it does not describe the starting or control methods, which can be found in Section 8.

6.5 The resilience can be enhanced at the final distribution board with the use of tertiary power supplies such as UPS (see paragraphs 16.3–16.19). Alternatively, the resilience can be enhanced with battery packs fitted to medical equipment such as intravenous (IV) pumps. Further guidance on alternative supplies can be found in Section 8. This section deals with the strategy and design of the fixed wiring network to achieve the desired resilience.

6.6 To achieve this resilience, all stakeholders and designers should contribute to the risk assessment debate (see Section 4).

6.7 The available electrical supply rating should be verified with the DNO. Most DNOs will provide between 500kVA and 800kVA as a single LV (0.4kV) connection. Supply ratings between 750kVA and 12MVA should be supplied at

high voltage (11kV). Where a healthcare facility has an assumed maximum demand (AMD) greater than 12MVA, the DNO connection should be at 33kV or above. Clearly, where the healthcare facility has an AMD no more than 500kVA, the internal electrical infrastructure will only be at low voltage; other AMDs will require an HV and LV internal infrastructure.

Design for resilience

6.8 Throughout this Scottish Health Technical Memorandum (and in common parlance) resilience is expressed in terms of “N+1”. This Scottish Health Technical Memorandum considers N+1 to mean the normal total requirement plus one resilient unit. For example, where the electrical demand is 1,000kVA, two transformers at 1,000kVA would satisfy the N+1 definition. However, three 500kVA transformers would also be defined as N+1, as the normal element comprises two units. When calculating the resilience of a system it is important to consider elements that are mutually inclusive and not mutually exclusive. For example, the standby generator complement (with a common point of coupling) would be a mutually inclusive system. The standby generator complement and primary electrical infrastructure at a common point of coupling are mutually exclusive. Best-practice electrical distribution strategy solutions provide resilience to the first-fault conditions at a common point of coupling. Distribution strategies that provide resilience above the first-fault condition (at a common point of coupling) are unlikely to be economically viable. Distribution strategies that provide N+1 resilience at several different points of common coupling are more robust and economically viable.

Supply connections

6.9 In electrical supplies to large healthcare premises (in electrical terms this means greater than 2MVA), a general arrangement with a dual-PES connection should be adopted, arranged with either an auto-changeover or a manual-selection switch. Dual supplies with diverse routes may be considered an economic strategy to maximise the resilience and minimise the actual single point of failure. They should originate, if possible, from separate DNO substations, ideally fed from separate parts of the National Grid, with independent cable routes to the healthcare site’s substations. However, the origin and nature of the PES supply routes will largely be beyond the control of the designer or stakeholders.

6.10 Two separate HV supply feeders (or LV if appropriate) may provide an additional safeguard (for the healthcare site) against a PES connection failure. Whether this is practicable largely depends on the local distribution system and the DNO. The healthcare organisation will not be in control of the PES network and therefore cannot influence the value of a second diverse routed connection. The healthcare organisation has more control over any embedded resilience and internal backup power sources, which may provide more robust security of electrical power.

Risk of transformer failures

6.11 The only moving part of a transformer is the tap-changing mechanism, which may be discounted when considering transformer reliability. As a result, transformer reliability can be as high as 99.999% (or 0.001% unreliable), which could mean 5.25 minutes unavailability per year. However, the issue is the time to repair or replace a faulty transformer, which may be at least one week. Distribution strategies that have two transformers with a common primary supply but have their secondary linked by a normally open bus coupler would provide a transformer system resilience of N+1. While both transformers are on duty, they would share the instantaneous load at 50% each. Opportunities for transformer and busbar maintenance are improved, as well as improved continuity of supply following a transformer outage. Such arrangements are shown for the intake substation (ISS) in Figure 13. Transformers connected in parallel or operating transformers on no load are not recommended.

Risk of generator failures

6.12 Generators have many moving parts requiring lubrication, cooling and control. The standby generator controls are electronic and electromechanical devices are used to modulate the output in response to the demand inputs. Standby generators should be maintained in an operational readiness state in order to provide their principal function of standby supply. Generator reliability may be of the order of 99.95% (or 0.05% unreliable), which equates to 4.5 hours unavailability per year. The majority of generator failures are a result of the generator not starting or occur during the first five minutes after starting.

6.13 Distribution strategies that have two standby generators (each rated at full load) with a common point of coupling with the distribution network would provide generator system resilience of N+1. Three standby generators, similarly connected, all rated at 50% of the connected design load, would also provide a generator system resilience of N+1. Three generators each rated at 100% of the connected design load would provide N+2, but may be difficult to justify economically. Opportunities for standby generator and busbar maintenance are improved, as well as improved continuity of supply following a generator outage (while the sets are on line). Such arrangements are shown in Figure 17.

Other reasons for failure of electricity supply

6.14 The following list provides further reasons for failure of the main internal electrical distribution systems, all of which are minimised by adopting the guidance within this Scottish Health Technical Memorandum (Parts A and B) and the guidance given in Scottish Health Technical Memorandum 06-02: 'Electrical safety systems':

- cable faults within the private network;
- inappropriate grading of protection devices;
- poorly designed network with common points of failure;
- reliance on one form of standby protection;

- accidental isolation.

Distribution system – high voltage

6.15 Healthcare premises with an AMD greater than 800kVA will require an internal HV network. There are two basic forms, radial networks (for AMDs up to say 3.5MVA) and ring networks (for AMDs above 3.5MVA).

6.16 The following simplified schematics are provided to show the main HV supply arrangements. They are arranged generally in order of resilience from low to high, but their selection as a design solution will be dependent on the supply arrangement available from the DNO, the type of healthcare facility, and the level of assessed risk with regard to end-users. Where typical HV distribution arrangements are shown connected to the LV distribution, these are included only to assist in the understanding of the LV arrangements. LV distribution arrangements are considered more fully in paragraphs 6.31–6.59. This section does not describe the control of any standby generator system (see Section 8 for details).

HV Network – one radial circuit with one substation only

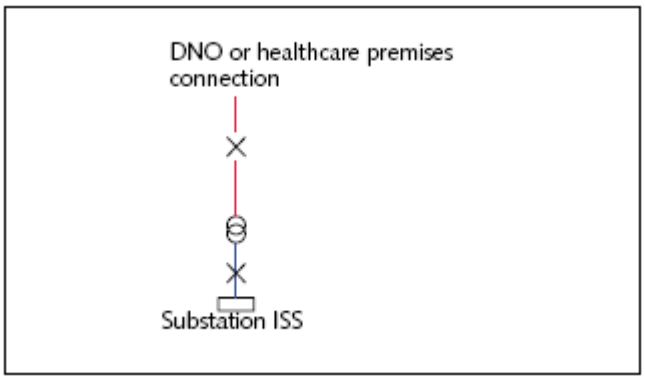

Figure 10: HV network – one radial circuit, one substation

6.17 A single HV supply from the DNO feeds onto the healthcare site's HV-switchboard part of the substation. This would typically be up to, say, 1,500kVA.

6.18 This type of distribution strategy is appropriate for a small to medium-sized acute hospital. As there is only a primary source of supply, this system creates a single point of failure right through to the LV distribution switchboard(s). Designers and stakeholders should consider the benefits afforded by the additional resilience that may be required, dependent on the clinical risks (see Section 4).

6.19 The resilience of the HV supply of Figure 10 may be enhanced by including a secondary source of supply at the intake, as a second DNO connection, or an LV standby generator at the LV switchpanel. Clearly, generators at the LV switchpanels would add resilience to the internal distribution. Having multiple LV standby generators is unlikely to provide any economic benefit.

HV network – one radial circuit with three substations

6.20 In Figure 11, a single HV supply from the DNO feeds onto the healthcare site's HV-switchboard part of the substation. From the intake substation, a single HV radial circuit connects up to two more HV substations. Each of the substations would typically be up to say 1,500kVA. However, the AMD for the healthcare site would be between 800kVA and 3.5MVA.

6.21 This type of distribution strategy may be appropriate for a healthcare site with many detached buildings. The areas served by any single substation do not exceed a clinical risk assessment of Category 2. As there is only a primary source of supply, this system creates a single point of failure right through to the LV distribution switchboard(s). The benefits afforded by additional resilience that may be required are dependent on the clinical risks (see paragraphs 4.11 to 4.23).

6.22 The resilience of the HV supply may be enhanced by including a secondary source of supply at the intake as a second DNO connection. Additional transformers at each substation (all 100% rated and not connected in parallel), or LV generator(s) connected at the LV switchpanels, may also enhance the infrastructure resilience. The second transformers at each substation will provide additional resilience and reduce the impact of transformer failure and maintenance. Standby generators could be local to each substation or in a common central facility, depending on the spread of the site. Clearly, the generator at LV switchpanels would add resilience to the internal distribution. Having multiple LV generators at a common central facility may provide economic benefit to the healthcare facility during maintenance periods.

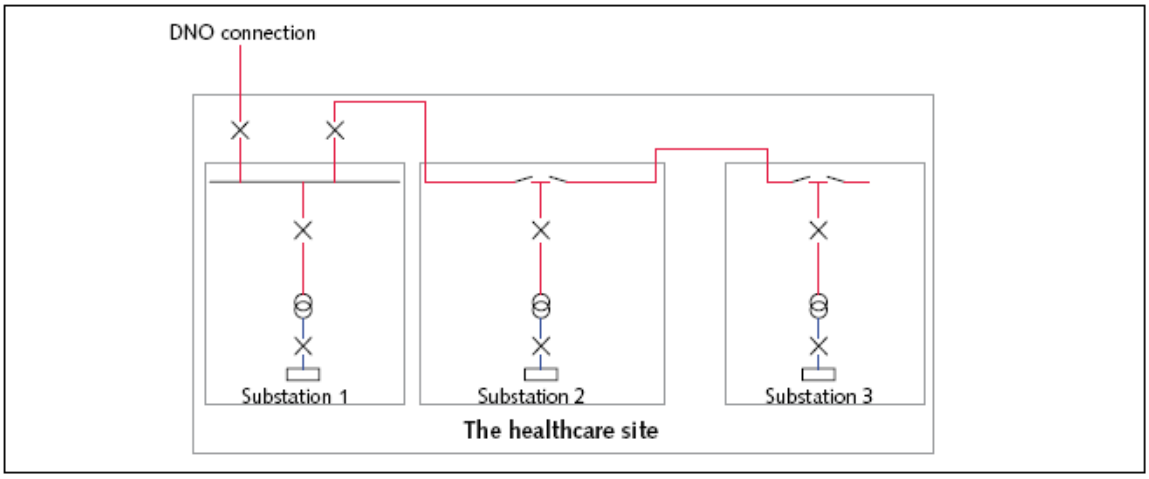

Figure 11: HV network – one radial circuit, three substations

6.23 In Figure 14, below, a single HV supply from the DNO feeds onto the healthcare site's HV-switchboard part of the substation. From the intake substation, three HV radial circuits, each with one substation, are connected. Each of the substations would typically be up to 1,500kVA. However, the AMD for the healthcare site would be between 800kVA and 3.5MVA. This distribution network is an enhancement of that in Figure 11 above, as failure of any part of the internal HV electrical infrastructure will affect a smaller area. The dual 100%-rated transformers (not operated in parallel) of substation 2 will provide

improved transformer and switchgear maintenance opportunities for that area.

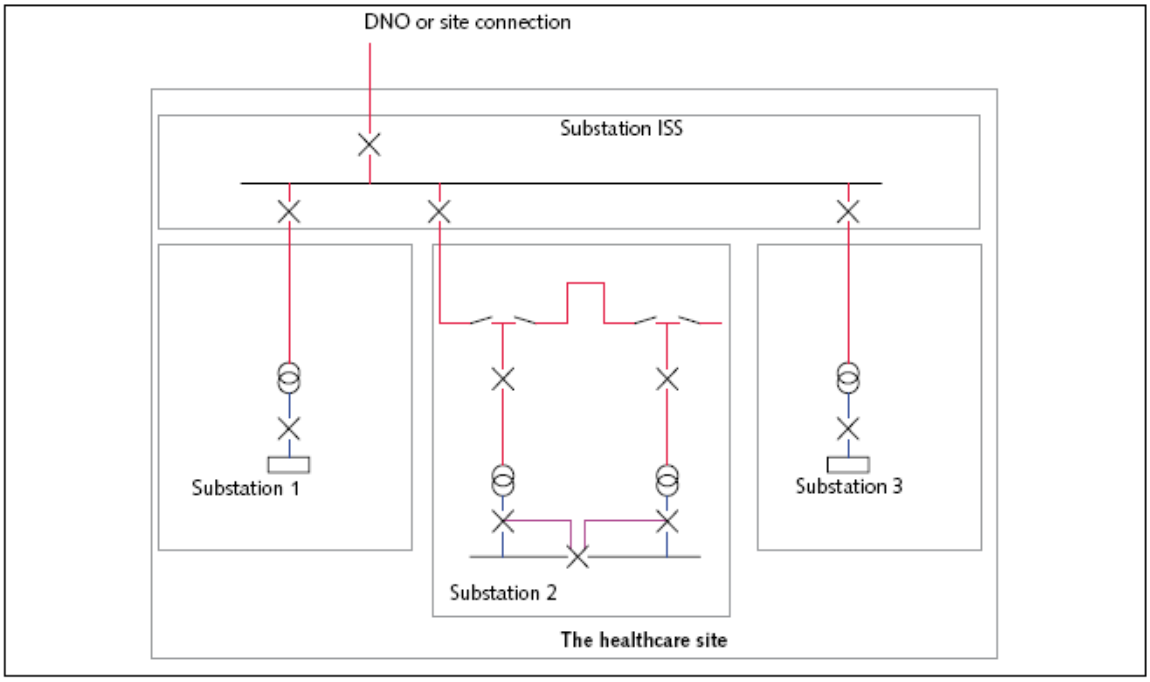

Figure 12: HV network – three radial circuits each with one substation

6.24 This type of distribution strategy may be appropriate for healthcare premises with many detached buildings. The areas served by any one substation do not exceed a clinical risk assessment of Category 3. As there is only a primary source of supply, this system creates a single point of failure right through to the LV distribution switchboard(s).

6.25 The resilience of the HV supply of Figure 12 may be enhanced by including a secondary source of supply at the intake as a second DNO connection. Standby LV generator(s) connected at the LV switchpanels will enhance the infrastructure resilience and facilitate improved transformer maintenance opportunities. Standby generators could be local to each substation or in a common central facility, depending on the spread of the site. Clearly, the standby generator at LV switchpanels would add resilience to the internal distribution. Having multiple LV generators at a common central facility may provide economic benefit to the healthcare facility during maintenance periods.

HV ring network – ring with four substations

6.26 In Figure 13, a single HV supply from the DNO feeds onto the healthcare site's HV-switchboard part of the substation. From the intake substation one HV ring-circuit connects to all other internal HV substations (which may be more than the four shown here). Each of the substations would typically be up to say 1,500kVA. However, the AMD for the healthcare site would be greater than, say, 3.5MVA. This distribution network is an enhancement of that in paragraphs 6.23–6.25, as failure of any part of the internal HV ring electrical infrastructure will affect a smaller area. Following a ring distribution fault, the manual or automatic operation (where the switchgear has suitable controls) of network ring switch positions will restore the inherent resilience.

6.27 The HV ring network of Figure 13 indicates the four basic types of HV substation: single and dual ring main units, single or dual circuit breakers. The intake substation should consist of circuit breakers, and all field substations should have a common switch type. See Section 9 for additional details of HV protection and switchgear details.

6.28 This type of distribution strategy may be appropriate for a large acute hospital with several other support facilities on the same site. The areas served by the ISS substation and substation 3 may include clinical risk assessments of Category 4 or Category 5. The areas served by substation 2 and substation 4 may include clinical risk assessments of Category 3. As there is only a primary source of supply, this system creates a single point of failure right through to the LV distribution switchboard(s).

6.29 The resilience of the HV supply of Figure 13 may be enhanced by including a secondary source of supply at the intake, as a second DNO connection. Additional transformers at each substation (all 100% rated and not connected in parallel), or standby LV generator(s) connected at the LV switchpanels, may also enhance the infrastructure resilience. The transformers at each substation may provide resilience and assist in transformer failure and/or maintenance. Standby generators could be local to each substation or in a common central facility, depending on the spread of the site. Clearly, the generator at LV switchpanels would add resilience to the internal distribution. Having multiple LV standby generators at a common central facility may provide economic benefit to the healthcare facility during maintenance periods.

6.30 The resilience of the HV ring network can also be enhanced if the ring normally operates in a “closed ring” control. Electrical faults may then be isolated to a discrete section of the ring (typically one substation leg or between two substations) and hence not affect the supply to any part of the healthcare site. An alternative level of resilience may be available by the introduction of a switch control monitoring and management system to the HV ring switch. Such a system can automatically reconfigure the HV network open position of the closed ring, and hence restore power to all areas, well within in a few minutes (see Section 9).

Primary and secondary distribution systems

6.31 All LV distributions should be configured as TN-S systems as defined by the IEE Regulations BS7671: 2008. Within special areas, medical risk Categories 4 and 5 and wet areas such as post-mortem rooms, the wiring system would be configured as a medical IT system with non-tripping earth fault for patient areas and tripping for wet areas by insulation monitors to IEC 61557-8 (see paragraphs 13.6–13.14 for more details). Consideration may be given to the use of a protected extra LV (PELV) system or a separated extra LV (SELV) system.

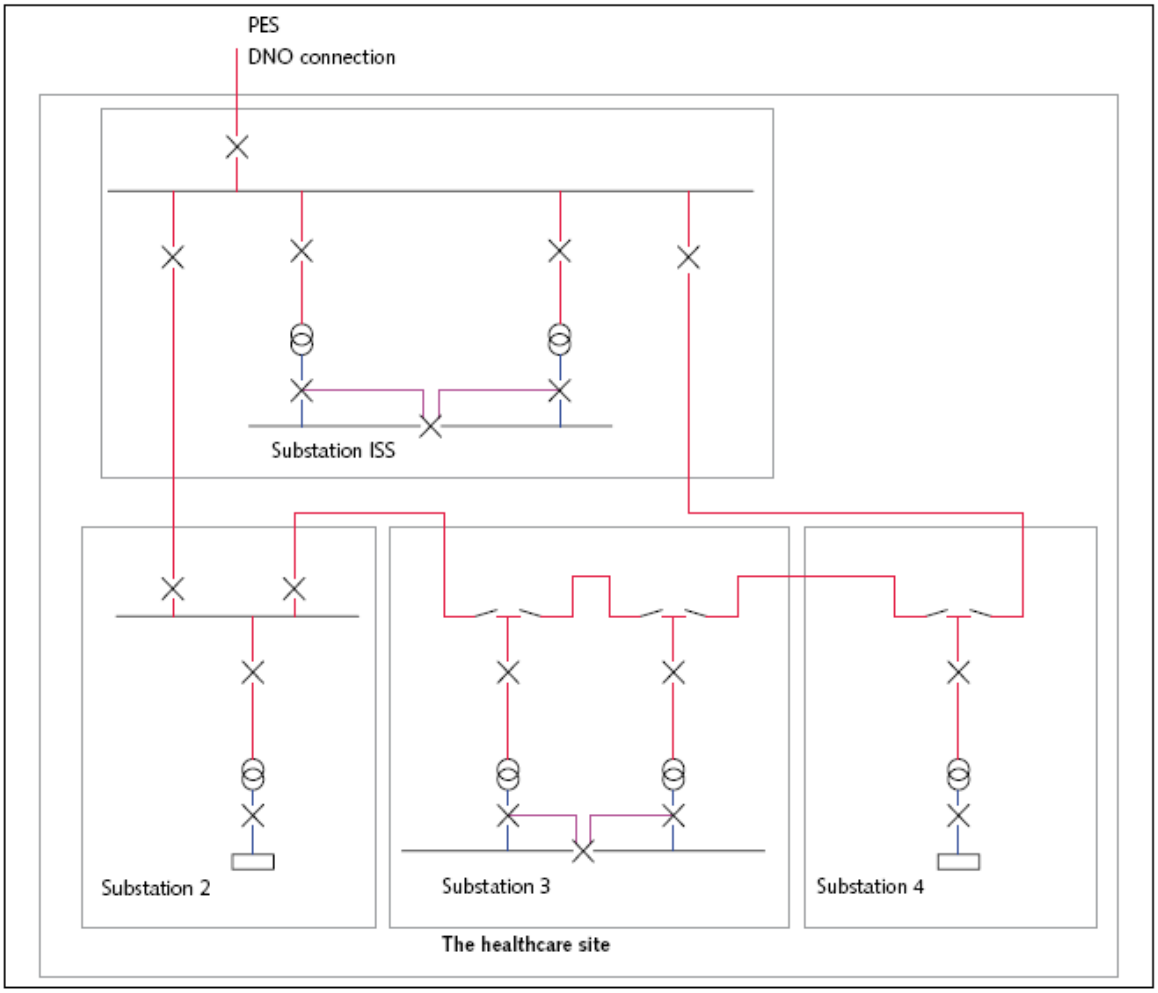

Figure 13: HV ring network – ring with four substations

6.32 The following simplified schematics are provided to show the main LV supply arrangements. They are arranged in order of resilience from low to high, but their selection as a design solution will be dependent on the supply arrangement available from the DNO, the type of healthcare facility, and the level of assessed risk with regard to end-users.

6.33 The method of fire protection should be considered for essential distribution circuits, and the opportunities for flexible remodelling. For compliance with BS5588, essential circuits associated with life-support services should be either fire-rated or fire-protected.

6.34 Single line representation is used in the diagrams for single-and three-phase distribution. Where typical HV distribution arrangements are shown connected to the LV distribution, these are included only to assist in the understanding of the LV arrangements. HV distribution arrangements are considered more fully in paragraphs 6.15–6.30.

Primary supply – unified infrastructure

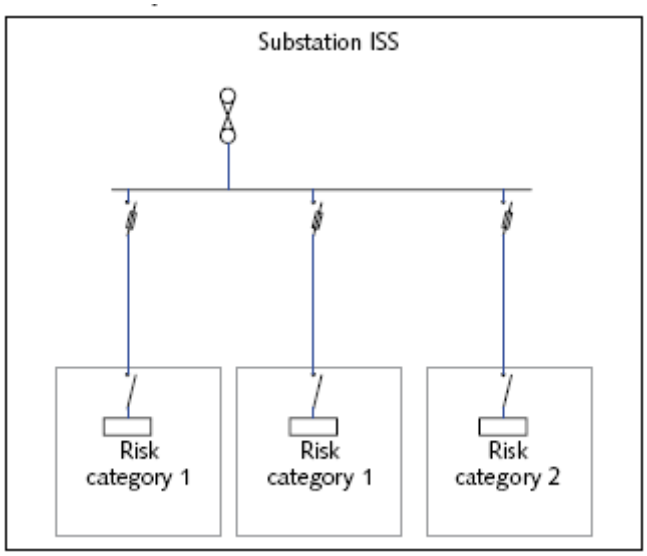

Figure 14: Primary supply – unified distribution system

6.35 This is the simplest form of LV infrastructure with a primary supply only, direct either from the DNO or from a single HV transformer arrangement, feeding a unified LV distribution network. The transformer switchgear and main cables should be rated to take the AMD and an allowance for growth (see paragraphs 3.28–3.33).

6.36 The first single point of failure will be the connection point (to the DNO healthcare site's transformer). A LV infrastructure of this kind is appropriate for clinical risk Categories 1 or 2 (see paragraphs 4.11–4.23). This infrastructure does not provide for inconvenience-free maintenance opportunities. Therefore, the infrastructure lends itself to healthcare premises that do not operate 24 hours a day/7 days a week (24/7) facilities, and hence give rise to operational windows in business continuity.

6.37 Enhancing the infrastructure resilience and adding a facility to connect a mobile generator plant at the intake may improve the maintenance opportunities and business continuity. Alternatively, a tertiary power source, single-conversion UPS (see paragraphs 6.3–6.19) may be connected to dedicated equipment such as computer systems.

6.38 An assessment of the potential for expansion and/or remodelling of the healthcare premises should be made, to understand how the LV distribution of Figure 14 could accommodate such adaptations.

6.39 This simple arrangement may be appropriate for GP practices, health centres and office accommodation, dependent on the assessed level of risk posed by a failure.

Primary and secondary supply – unified and segregated infrastructure

6.40 This form of LV infrastructure has a primary supply, connected directly to either

the DNO or the healthcare site's transformer, and a non-distributed secondary supply connected at an internal LV switchboard. The transformer, switchgear and main cables should be rated to take the AMD and an allowance for growth (see paragraphs 3.28–3.33). However, the standby generator is rated only for the segregated essential part of the healthcare site's electrical demand.

6.41 The first single point of failure will be the connection point (to the DNO healthcare site's transformer) for the unified non-essential circuits. However, the segregated essential circuits have a single point of failure much nearer the point of use. This infrastructure does not fully provide for inconvenience-free maintenance opportunities to all areas. Therefore, the infrastructure lends itself to healthcare premises that have part 24/7 facilities and part non-24/7 facilities. Enhancing the infrastructure resilience and adding additional standby generator units to the essential circuits may improve the maintenance opportunities and business continuity. Alternatively, a manual load management system coupled with the facility to interconnect the essential and non-essential circuit (via cables or a manual bus coupler) may offer a similar increased resilience. (Section 9 refers).

6.42 An assessment of the potential for expansion and/or remodelling the healthcare premises should be made, to understand how the LV distribution of Figure 15 could accommodate such adaptations.

Primary and secondary supply – unified and dual-unified infrastructure

6.43 This form of LV infrastructure (see Figure 16) has a primary supply connected directly to either the DNO or the healthcare site's transformer, and a distributed SPS also connected at the intake LV switchboard. The transformer, standby generator, switchgear, and main cables should all be rated to take the full assumed maximum demand and an allowance for growth (see paragraphs 3.28–3.33).

6.44 The first single point of failure will be at the main LV switchboard for the unified circuits, and at the point of use for the dual-unified circuits. An LV infrastructure of this kind is appropriate for clinical risk categories 2, 3 or 4, where the dual-unified circuits are used in Category 3 or 4 risk areas (see paragraphs 4.11 to 4.23). This infrastructure may provide for inconvenience-free maintenance opportunities in the Category 3 or 4 risk areas. However, the same opportunities do not exist in the Category 1 and Category 2 risk areas, where the infrastructure resilience is only achieved by the standby generator subject to the operating demand. There is no resilience with the distribution cables and/or switchgear for the Category 1 and Category 2 risk areas. The unified circuit infrastructure lends itself to that part of the healthcare premises that do not operate 24/7, and the dual-unified circuit infrastructure (Category 4) lends itself to those which do operate 24/7.

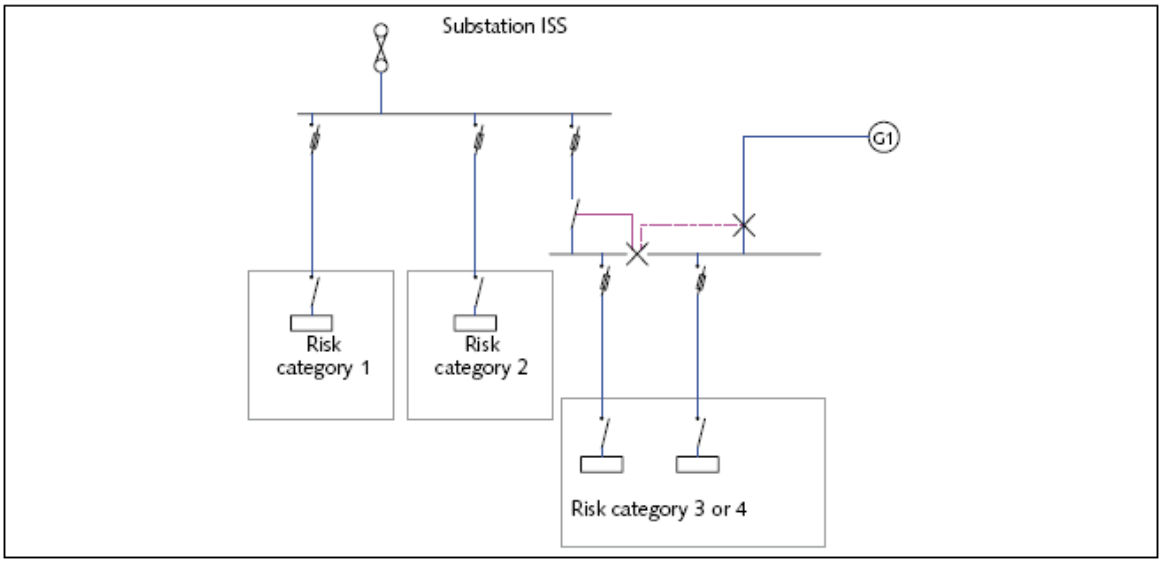

Figure 15: Primary and secondary supply – unified and segregated infrastructure

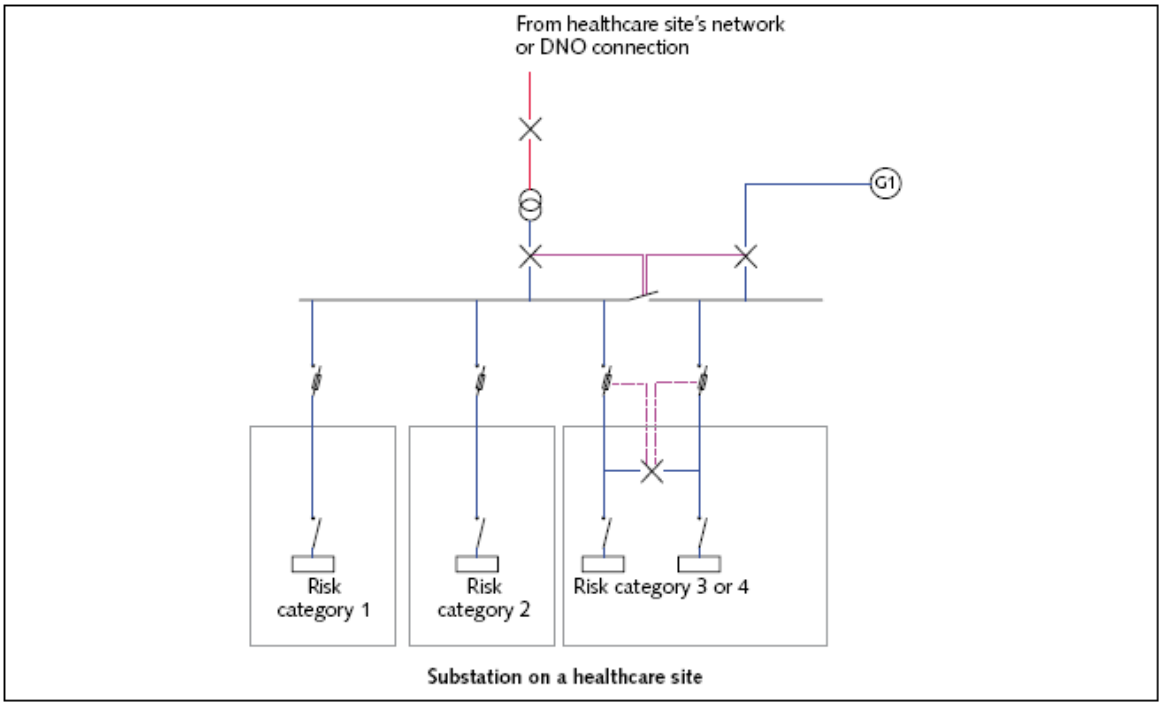

Figure 16: Primary and secondary supply – unified and dual – unified infrastructure

6.45 Enhancing the infrastructure resilience may be achieved by adding a tertiary power source. A single-conversion UPS may be connected to dedicated final circuits of the unified distribution. Enhancing the dual-unified infrastructure resilience and adding additional standby generator units may improve the maintenance opportunities and business continuity for the Category 3 or 4 risk areas.

6.46 An assessment of the potential for expansion and/or remodelling the healthcare premises should be made, to understand how the LV distribution could accommodate such adaptations. This arrangement may be appropriate for a general acute or large acute hospital with additional support services,

dependent on the assessed level of risk posed by a failure.

Dual primary and dual secondary supply – unified and dual-unified infrastructure

6.47 The LV infrastructure shown in Figure 17 has a dual-primary supply, connected directly to either the DNO or the healthcare site's transformer, and a dual-distributed secondary power supply also connected at the intake LV switchboard. The transformer, standby generator, switchgear and main cables should all be rated to take the AMD and an allowance for growth.

6.48 The first single point of failure will be at the main LV switchboard for the unified circuits, or at the point of use for the dual-unified circuits. An LV infrastructure of this kind is appropriate for clinical risk categories 2, 3 or 4, where the dual-unified circuits are more appropriate for Category 4 or 5 risk areas (see paragraphs 3.28–3.33). This infrastructure may provide for inconvenience-free maintenance opportunities in the Category 3 or 4 risk areas. However, the same opportunities do not exist in the Category 2 risk areas, where there is no resilience with the distribution cables and/or switchgear. Therefore, the unified circuit infrastructure lends itself to that part of the healthcare premises that does not operate 24/7.

6.49 Enhancing the infrastructure resilience may be achieved by adding a tertiary power source. A single-conversion UPS (see paragraphs 16.3–16.19) may be connected to dedicated final circuits of the unified distribution. Enhancing the dual-unified infrastructure resilience and adding additional standby generator units may improve the maintenance opportunities and business continuity for the Category 3 or 4 risk areas.

6.50 An assessment should be made of the potential for expansion and/or remodelling of the healthcare premises and how the LV distribution of Figures 16 and 17 could accommodate such adaptations. This arrangement may be appropriate for general acute or large acute hospitals with additional support services, dependent on the assessed level of risk posed by failures.

6.51 Figure 17 shows a potential connection point for a CHP plant. The schematic only provides one of many potential electrical connections for the CHP plant. Designers and stakeholders should assess the ideal CHP connection based on the opportunity to "black start" the CHP sets, and to synchronise the CHP with the PES supply and/or standby generator supply.

6.52 In reality, the CHP location may be driven by the thermal and environmental requirements rather than the electrical connection. For example, locating the CHP plant close to the boiler plant may provide a more beneficial connection for the reclaimed heat energy into the boiler return pipework. In addition, the CHP engine exhaust can be ducted alongside the boiler flues.

Dual primary and dual HV secondary supply – dual-unified infrastructure

6.53 The LV infrastructure illustrated in Figure 18 has a dual primary supply, connected to the healthcare site's transformer, and a dual distributed SPS

connected directly to the internal HV network. The transformer, standby generator, switchgear, and main cables should all be rated to take the full assumed maximum demand and an allowance for growth (see paragraphs 3.28–3.33).

6.54 The first single point of failure will be at the point of use for all circuits. An LV infrastructure of this kind is appropriate for clinical risk categories 4 or 5 where the dual-unified circuits are Category 5 (see paragraphs 4.11–4.23). The Category 5 risk areas have the added installed resilience of tertiary power supplies, double-conversion UPSs and IPSs. This infrastructure may provide for inconvenience-free maintenance opportunities in all areas, particularly when the final sub-circuits are interleaved (see paragraphs 6.60–6.63).

6.55 The potential for expansion and/or remodelling of the healthcare premises should be assessed in terms of how the LV distribution could accommodate such adaptations. The arrangement may be appropriate for a large acute hospital with additional support services, dependent on the assessed level of risk posed by a failure.

Dual primary and dual LV secondary supply – dual-unified infrastructure

6.56 This form of LV infrastructure is illustrated in Figure 19 and has a dual primary supply connected to the healthcare site's transformer, and a dual distributed secondary power supply connected directly to the internal HV network, via step-up transformers. The transformer, standby generator, switchgear and main cables should all be rated to take the AMD and an allowance for growth (see Section 3).

6.57 This form of LV infrastructure is the same as that in paragraphs 6.53–6.55 except that the standby generators are low voltage with step-up transformers.

6.58 The IPS connection arrangement in Figures 18 and 19 is only one such possible arrangement. Designers may wish to consider not supporting the IPS with a UPS as per Figure 41.

6.59 Many large healthcare premises will have a mixture of clinical risk areas (see paragraphs 4.11–4.23) and consequently may require an overall distribution strategy based on a mixture of the above examples. Designs with a single distribution strategy, best suited to the highest category of clinical risk across the whole healthcare site, are less complex and easier to control. The design strategy principles promoted by this Scottish Health Technical Memorandum achieve the best opportunities for flexibility and remodelling.

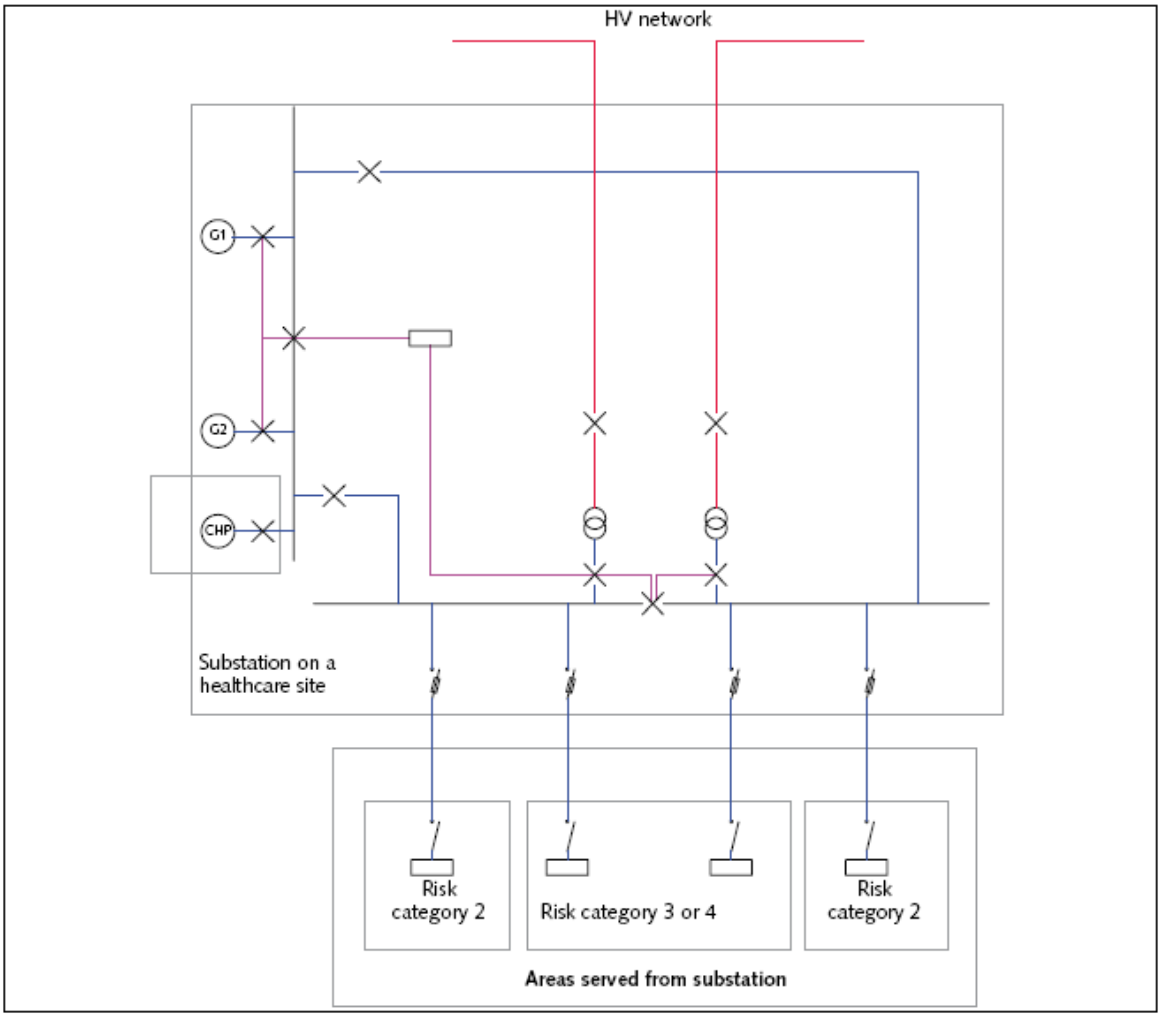

Figure 17: Dual-primary and dual-secondary supply – unified and dual-unified infrastructure

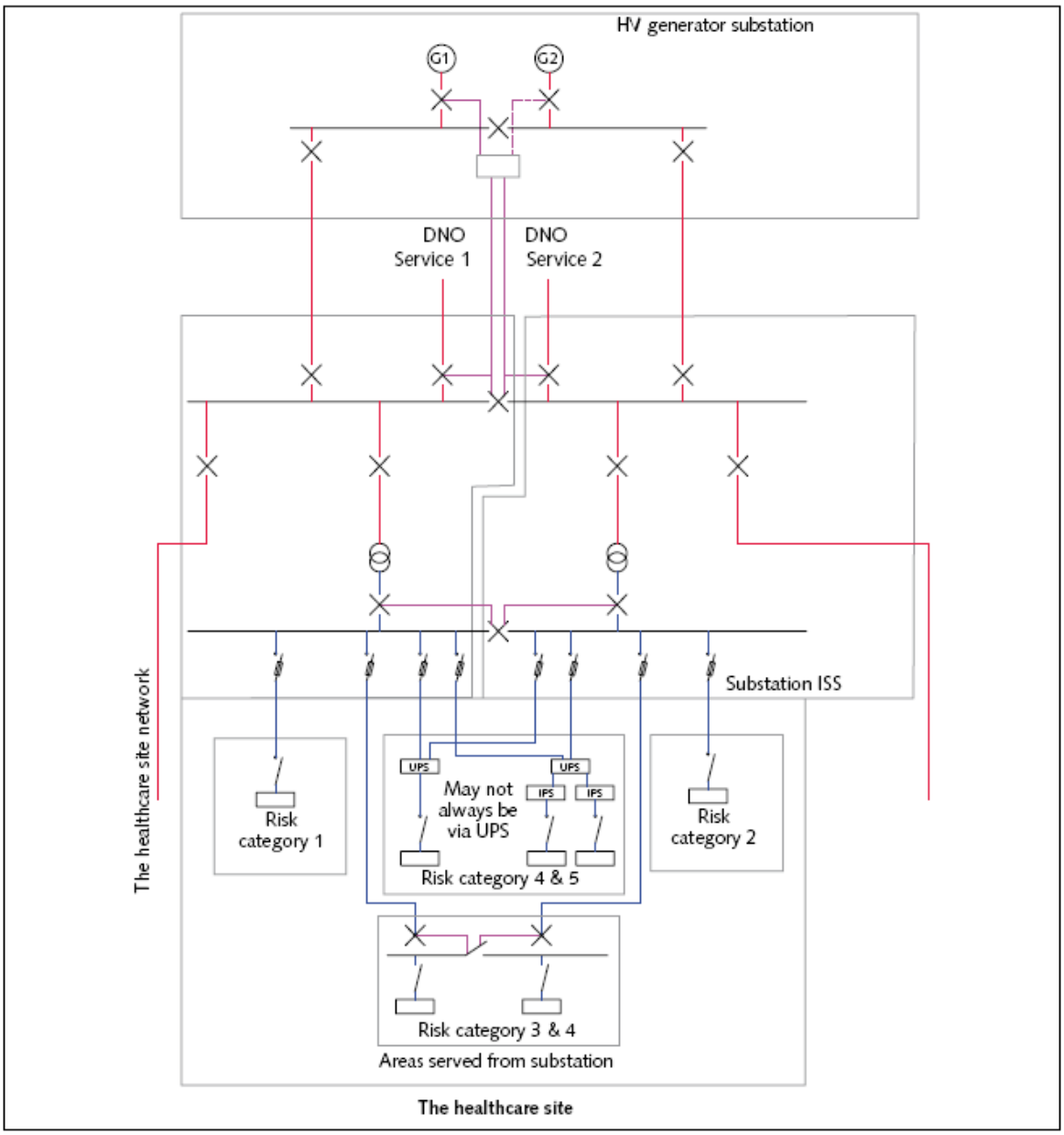

Figure 18: Dual primary and dual HV secondary supply – dual-unified infrastructure

Final circuits

6.60 This section describes how the design strategy of final sub-circuits can assist in the security of the supply at the point of use. The nature and type of distribution to the final distribution boards are described in paragraphs 6.31–6.59 (for low voltage). For simplicity, it will be assumed that the final distribution board only has one supply, but adjacent distribution boards (where referred to) are supplied from a different sub-distribution panel.

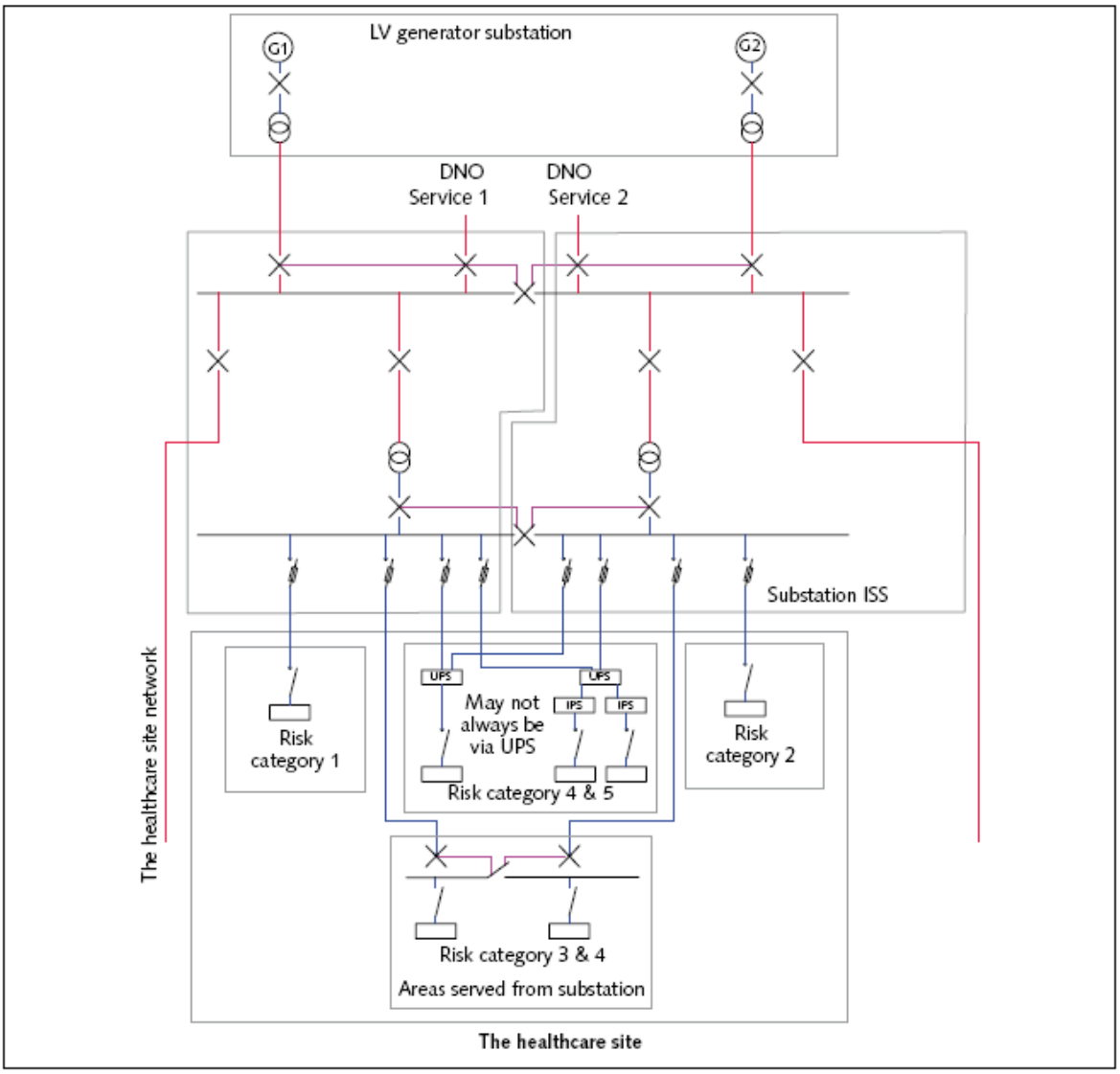

Figure 19: Dual primary dual LV secondary – dual-unified infrastructure

Fixed equipment

6.61 Designers should carefully consider how to provide protection of the final circuit to fixed equipment such as fluoroscopy machines. For example, two supplies with an auto-changeover switch could be provided. Alternatively, a UPS could be provided that would provide sufficient power for task completion in the event of circuit failure.

Power outlets

6.62 Power outlets include sockets, spurs and connection units regardless of how the circuit is wired (ring or radial). Assessments of the advantages of arranging circuits in an interleaved manner per room or bed should be made. For example, if the interruption to a socket sub-circuit resulted in no available power in an out-patient consulting room, the effect might not be too dramatic – whereas in clinical risk Category 4 and 5 areas, the patient environment should have at least two IPS circuits at the bedhead, ideally derived from different sides of a common substation (see Figure 19). Electric bed motors, patient

warming systems etc, which do not require the IPS facility, will be connected to a socket circuit from the TN-S system. The outgoing circuits should be interleaved between two adjoining theatres, or for 50% of sockets at the bedhead where an IPS monitors the outlets. Designers should consider the advantages of providing a UPS for each of the IPS systems in any clinical risk Category 5 area.

Lighting circuits

6.63 The distribution strategy for final circuits supplying luminaries need not be significantly different from the strategy employed for the low-power outlets in the same area. Where the secondary power plant does not provide 100% cover of the lighting circuits, lighting circuits (in one area) derived from distribution boards can be interleaved with secondary power supplies and those with primary power supplies only. Alternatively, interleaving lighting circuits from the same distribution board may be an acceptable derogation. It may be possible to justify only one lighting circuit in non-clinical areas.

7. Primary power – distribution centres

HV substations

7.1 Guidance on the number, type and location of any HV substations incorporated within the site's electrical distribution is given in Section 6. This section provides guidance on the design of HV substations owned by the healthcare organisation (or nominated agent). This Scottish Health Technical Memorandum does not govern substations that are owned by the external DNO, usually limited to the main intake point. However, designers and stakeholders should liaise with the external DNO to ensure that such substations have suitable access and space provision. HV substations that include an integral space for the external DNO's HV cables and equipment may be appropriate, providing that adequate control and areas of responsibility can be clearly defined. For the purpose of this guidance, HV substations are deemed to be the total area of the HV switchgear and transformer enclosure.

Location

7.2 External and internal locations can be suitably adapted for HV substations provided the design adheres to the principle of the following guidance. External substations can be located at ground or roof level. Internal substations can be located at any floor, including ground level.

7.3 HV substations located in close proximity to the principal LV switchboard afford the best opportunity to regulate earth faults between the two items (see paragraphs 7.52–7.54 for the location of LV switchrooms).

7.4 External substations should be located away from any live vegetation by a minimum distance of 3m. The clear zone includes above the construction and subterranean areas. Low-maintenance grassed areas are an acceptable derogation from this requirement.

7.5 The location of internal substations should be in accordance with the recommendations given in Firecode (Scottish Health Technical Memorandum 81) and the adjacencies described therein.

7.6 HV substations should not be located under bulk water (or any other fluid) storage areas.

Construction

7.7 External HV substations should be constructed on well-drained surfaces (with catchments for any spilled oil, if appropriate). The electrical equipment should not be within reach from outside the perimeter fence of the substation.

7.8 External HV substations can be constructed from brick, concrete or GRP, or be of steel fabrication to the same enclosure standard of an internal HV substation.

7.9 Where external substations have a metallic enclosure construction or the substation is open and surrounded by a metallic fence, see BS7430:1998 for earthing arrangements.

7.10 Construction of internal substations should include adequate fire precautions to satisfy the recommendations given in SHTM Firecode suite of documents. The construction of internal HV substations should be sufficiently robust to contain the effects of an electrical explosion emanating from within, and should provide suitable acoustic attenuation. HV substations should be constructed to minimise the effect of electrical interference.

7.11 Walls and fire-resisting partitions forming the HV substation must comply with statutory Building (Scotland) Regulations section 2 or be of an equivalent fire-resisting steel-fabricated modular construction. Internal walls should have a suitable finish to reduce dust formation and facilitate cleaning.

7.12 HV substations should be constructed to prevent the ingress of water, including from flood. Specific precautions are required where cables enter the substation from external areas (including subterranean).

7.13 Floors and ceilings should be constructed from reinforced concrete or equivalent fire-resisting construction. Floors should have a non-slip, dust-reducing finish.

7.14 HV switchroom doors should open outwards and have a total clear opening to allow replacement of switchgear and transformers (see paragraphs 7.17–7.19).

7.15 Substations should be constructed without windows or skylights to minimise the effect of solar heat gain.

7.16 The construction of any HV substation, including the HV side of a transformer, should be designed so as to prevent unauthorised access.

Access and egress

7.17 External substations should have good access for road vehicles to facilitate plant replacement and maintenance. Where external substations are on the roof, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle individual HV switches, circuit breakers or transformers. External substations should be so arranged and constructed as to prevent unauthorised access. Gates or other purpose-made openings should provide adequate clearance for plant replacement, inclusive of any manual handling equipment and personnel. There should be a minimum of two sets of gates, on opposite sides, to provide suitable escape routes. For external substations, additional gates will be required to ensure that the maximum travel distance to a safe haven is no greater than 9m.

7.18 Internal substations should have good access for road vehicles to facilitate plant replacement and maintenance. This will generally mean that they are located on the perimeter of the ground floor or in separated dedicated buildings. Where

internal substations are not at ground-floor level, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle individual HV switches, circuit breakers or transformers. Internal substations should be so arranged and constructed to prevent unauthorised access. Door openings should provide adequate clearance for plant replacement, inclusive of any manual handling equipment and personnel. There should be a minimum of two sets of door openings connecting directly to a safe haven, on opposite sides, to provide suitable escape routes. Additional door openings will be required to ensure that the maximum travel distance to a safe haven is no greater than 9m.

7.19 The access to any HV substation, including the HV side of a transformer, should be arranged so as to prevent unauthorised access (see Scottish Health Technical Memorandum 06-03).

Layout

7.20 The layout of HV substations will depend partially on the distribution strategy employed (see Section 6). Internal HV substations should have level room height of 1m greater than the equipment height, and a clear maintenance space of a minimum 0.8m on the sides and rear of equipment and 1 m plus the equipment depth in front of the equipment. The requirement may be derogated where the HV equipment is combined onto a switchboard or close-coupled with the transformer. However, it is essential to ensure that all cables and equipment can be serviced and replaced without any modification to the room. Where the distribution strategy has dual supplies and multiple transformers per substation, a physical fire barrier between each section may improve the fire precautions and inherent system resilience. Where the HV equipment includes a withdrawable section (see Section 9), the depth of the equipment should be added to the clear maintenance space. The maintenance space will include the headroom above all HV equipment and transformer. The headroom should be a minimum of 1m measured between the soffit (and the underside of any drop beam) and the highest point of the equipment. Designers should liaise with the structural engineer for the coordination of services within the HV substation. Risk assessments should be undertaken to determine the amount of space to be set aside for future expansion and flexibility (see Section 3).

7.21 HV cables used for the supply and interconnection of HV equipment and transformers (including the LV secondary side cables) are best laid in a cable trench or duct. Suitably-installed busbars would be an acceptable derogation from this requirement. Cable trenches or ducts should be of adequate cross-section to facilitate the pulling-in and replacement of additional cables. Cables should be positively fixed to the sidewalls of cable trenches and ducts, and so arranged as to prevent the need for cable crossover.

7.22 HV equipment should sit partially over the cable trench to facilitate final cable connection. Such arrangements will require adequate sidewall construction and edge-wall protection.

7.23 Cable trenches and ducts should have a natural drainage fall, and be sealed to prevent the ingress of water, where they pass through walls. Similarly, the cable

trench/duct should provide the same fire integrity as the wall, where the trench/duct passes under the wall, that is, preventing ingress of gas or foam fire-extinguishing fluids.

7.24 HV substations should not be used for any purpose other than HV equipment and cables. The room should not be used for the storage of other items at any time. The room should not be used as a conduit for other engineering services, including drainage.

Fire precautions

7.25 HV substation construction must satisfy the requirements of the Scottish Building Regulations section 2. Designers should comply with the “medical adjacencies” as defined in the Firecode series. A full risk assessment (in conjunction with the healthcare premises’ fire officer, the local authority’s fire officer and a specialist fire consultant) should be made, to address the form of suitable fire-fighting equipment and precautions.

7.26 Internal automatic fire-extinguishing equipment of a gaseous type should be considered where the HV equipment contains flammable material (for example mineral oil). Specialist fire engineers should undertake the design of such fire-fighting equipment.

7.27 The risk of a fire should also be determined by the effect of an electrical fault causing explosions. Such electrical faults will include those that can be assumed to happen and those that may arise from unauthorised interference.

7.28 The fire-extinguishing equipment should include an audible and visual alarm system within the room, immediately outside the room, and to a suitable 24-hour staffed location.

7.29 Fire-extinguishing equipment of the Halon or CO_2 type should be replaced and not considered for new installations.

7.30 Where the HV substation is part of a ring network, consideration may be given to having the two network incomers in two rooms separated by a four-hour fire-rated partition wall, the two sections being linked by a fully rated cable.

Environmental requirements

7.31 External open-air HV substations do not require any environmental requirements. Lighting should be provided for security and possible emergency working. Maintenance staff should be protected from bad weather during emergency working. External HV substations of GRP or steel fabrications should have the same environmental conditions as an internal HV substation (given below). Internal HV substations should be illuminated by maintained lighting to an average level of 150 lux at floor level. The illumination should not cast shadows on any instrumentation and working surfaces of the equipment. Escape lighting should provide an average of 5 lux at floor level for three hours, and be supported by grade A standby lighting. Internal HV substations should have natural ventilation to prevent moisture and condensation. HV switchgear

would not normally contribute to internal heat gains of the switchroom. Transformers typically radiate between 1.5% and 2% of their rating as heat, which should be removed by crossflow (low to high opposite sides) natural ventilation. The supply and extract air for an HV substation should connect directly to an external wall and should be arranged to prevent short-circuiting. Thermostatically-controlled low-level background heating should be arranged to maintain a room temperature not less than 10°C. Consideration may be given to the provision of LV or SELV sockets, derived from a resilient routed secondary source (standby generator) for the use of competent persons (see Scottish Health Technical Memorandum 06-02).

Equipment and notices provided

7.32 HV substations should include the following equipment as a minimum set (see Scottish Health Technical Memorandum 06-03):

- safety posters as identified by Scottish Health Technical Memorandum 06-02, including first aid/electric shock treatment;
- single line diagrams as identified by Scottish Health Technical Memorandum 06-02;
- rubber mats;
- a mimic board – intake sub only (including where appropriate key locks, keys and site logbook);
- a sign positively identifying the LV earthing as a TN-S system;
- a battery charger (for the instruments and power-driven switches, including trip circuits);
- storage space for maintenance tools, with tools;
- fixed lifting equipment (subject to height restrictions).

Transformer enclosures

7.33 The adopted distribution strategy (see Section 6) should be used to determine the number of transformers per substation.

Location

7.34 The potential for harmonic interference, fault level, and zone of protection should be addressed when locating transformers. The transformer should be located within 1m to 3m from the respective HV switchgear, and as close as possible to the respective LV switchgear. External transformers should be located away from any live vegetation by a minimum distance of 3m. The clear zone includes above the construction and subterranean areas. Low-maintenance grassed areas are an acceptable derogation from this requirement.

7.35 The location of internal transformer enclosures should be in accordance with the recommendations given in Firecode and the adjacencies described therein.

Construction

7.36 External transformer open compounds should be constructed on well-drained surfaces (with catchments slightly greater than the volume of oil, for any spilled oil, as appropriate). The electrical equipment should be placed beyond the reach of personnel stood external to the substation and/or transformer.

7.37 External transformer enclosures of GRP or steel fabrication should have the same environmental conditions as an internal HV substation.

7.38 Construction of internal transformer rooms should include adequate fire precautions to satisfy the recommendations given in Firecode. Where an oil-filled transformer is installed, a bund area should be provided sufficient to hold more than the capacity of oil within the transformer. The transformer enclosure should also provide suitable acoustic attenuation and should be designed to minimise the effect of electrical interference.

Access and egress

7.39 External transformers should have good access for road vehicles to facilitate plant replacement and maintenance. Where external transformers are on the roof, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle the transformer. External transformers should form an integral part of the HV enclosure and do not require a dedicated access and egress opening, provided the layout does not restrict the plant replacement and maintenance routes.

7.40 Internal transformers should have good access for road vehicles to facilitate plant replacement and maintenance. This will generally mean that they are located on the perimeter of the ground floor or in separated dedicated buildings. Where internal transformers are not at ground-floor level, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle the transformer. Internal transformers should be so arranged and constructed as to prevent unauthorised access. Door openings should provide adequate clearance for plant replacement, inclusive of any manual handling equipment and personnel. The footprint of a typical single transformer enclosure (including maintenance areas) is 4m x 4m, and hence consideration may be given to the provision of only one door opening. Where the distribution strategy requires two transformers per substation, each transformer should be located in its own enclosure.

Fire precautions

7.41 Transformer enclosures and/or rooms must satisfy the requirements of the Building (Scotland) Regulations section 2. Transformer locations should satisfy the medical adjacencies as defined in the SHTM Firecode series. Designers and stakeholders should carry out a full risk assessment (in conjunction with the healthcare premises' fire officer, the local authority's fire officer and a specialist fire consultant) to address the form of suitable fire-fighting equipment and precautions.

7.42 Automatic fire-extinguishing equipment should be provided where internally-located transformers contain flammable material (for example mineral oil). Specialist fire engineers should undertake the design of such fire-fighting equipment.

7.43 The risk of a fire should also be determined by the effect of an electrical fault causing explosions. Such electrical faults will include those that can be assumed to happen and those that may arise from unauthorised interference. The fire-extinguishing equipment should include an audible and visual alarm system within the substation area, immediately outside the substation, and within a suitable 24-hour staffed location (telephonist).

7.44 Transformers suitably rated for external location and located in the open air of a compound may not require any specific fire precautions or extinguishing equipment.

7.45 Fire-extinguishing equipment of the Halon or CO_2 type should be replaced and not considered for new installations.

Environmental requirements

7.46 External open-air transformers do not require any environmental requirements. Artificial lighting should be provided for security and possible emergency working. Maintenance staff should be protected from bad weather during emergency working. Internal transformer enclosures should be illuminated by artificial lighting to an average level of 150 lux at floor level. The illumination should not cast shadows on any instrumentation and working surfaces of the equipment. Emergency lighting should provide an average of 5 lux at floor level for three hours. Internal transformer enclosures should have natural ventilation to prevent moisture and condensation, and overheating of the space and equipment. The radiated heat from a transformer is a function of the non-load losses (iron losses) and the full-load losses (copper I2R losses). Total losses for a fluid-cooled transformer will be between 1.5% and 2% of their rating, and for dry-type (cast resin) transformers the total losses are between 1% and 1.5%. Natural ventilation may be achieved by a crossflow of air as illustrated in Figure 20. The total area of an opening may be calculated from a typical formula, for example:

$0.90S^1 = S = (0.18P/(\sqrt{H}))$

where

S and S^1 = lower and upper total opening areas, respectively (m^2)

P = sum of the no-load and full-load losses of the transformer (kW)

H = height difference between the centre lines of the two openings (m).

7.47 The above formula should be corrected for ambient room temperatures above 20°C and/or altitudes above 1,000m.

7.48 Where natural ventilation cannot be secured to maintain a room temperature of

20°C, designers may wish to consider forced ventilation with an airflow rate (q) calculated by:

q = 0.081P (for fluid transformers)

q = 0.05P (for dry-type cast-resin transformers)

where

P = total losses of the transformer (kW).

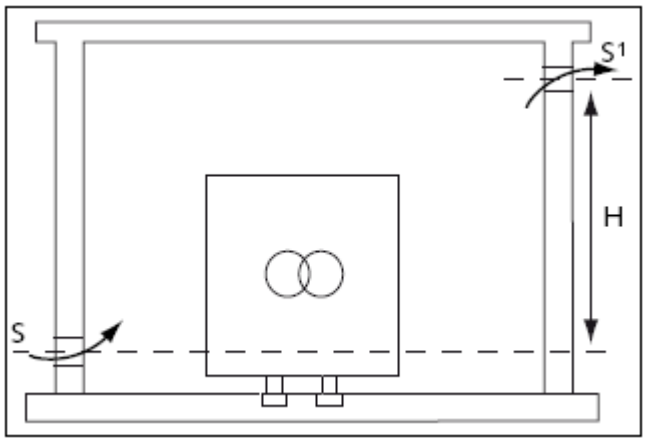

Figure 20: Air-flow through a transformer room

7.49 An alternative to the crossflow arrangement may be to have the external wall fully louvred such that there is a 40%–60% free-air area. Provisions for adequate ventilation rates of transformer rooms are a significant factor in determining the location of internal transformer rooms. The transformer room should be thermostatically controlled with low-level background heating to maintain a room temperature above 10°C.

7.50 Two 100%-rated transformers normally operating at 50% and with a common load reduce the copper losses to 40% of the full-load losses.

LV switchrooms

7.51 Guidance on the number, type and location of any LV switchrooms incorporated within the site's electrical distribution is given in paragraphs 7.52–7.54. This section provides guidance on the design of LV switchrooms owned by the healthcare organisation (or nominated agent). LV switchrooms that are owned by the external DNO and usually limited to the main intake point are not governed by Scottish Health Technical Memoranda. However, a liaison with the external DNO will ensure that such switchrooms have suitable access and space provision. LV switchrooms that include an integral space for the external DNO's LV cables and equipment may be appropriate providing that adequate control and areas of responsibility can be clearly defined.

Location

7.52 External and internal locations can be suitably adapted for LV switchrooms,

provided the design adheres to the principle of the following guidance. External switchrooms can be located at ground level or on the roof level. Internal LV switchrooms can be located at each floor level.

7.53 The location of internal LV switchrooms should be in accordance with the recommendations given in Firecode and the adjacencies described therein.

7.54 LV switchrooms should not be located under bulk water (or any other fluid) storage areas.

Construction

7.55 External LV switchrooms can be constructed from GRP or be of steel fabrication provided the enclosure complies with the requirements of internal LV switchrooms.

7.56 Construction of internal switchrooms should include adequate fire precautions and satisfy the recommendations given in Firecode. The construction of internal LV switchrooms should be sufficiently robust to contain the effects of an electrical explosion emanating from within. The construction of LV switchrooms should provide suitable acoustic attenuation and should minimise the effect of electrical interference.

7.57 Walls and fire-resisting partitions forming the LV switchrooms must comply with statutory Building (Scotland) Regulations section 2 or be of an equivalent fire-resisting, steel-fabricated modular construction. Internal walls should have a suitable finish to reduce dust formation and facilitate cleaning.

7.58 LV switchrooms should be constructed to prevent the ingress of water, including from flood. Specific precautions are required where cables enter the switchroom from external areas (including subterranean).

7.59 Floors and ceilings should be constructed from reinforced concrete or equivalent fire-resisting construction. Floors should have a non-slip, dust-reducing finish.

7.60 Doors should open outwards and have a total clear opening to allow replacement of switchgear (see paragraphs 7.62–7.63 below).

7.61 LV switchrooms do not require windows or skylights, which may otherwise increase the effect of solar heat gain.

Access and egress

7.62 External switchrooms should have good access for road vehicles to facilitate plant replacement and maintenance. Where external LV switchrooms are on the roof, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle the LV equipment. External switchrooms should be so arranged and constructed as to prevent unauthorised access. See Scottish Health Technical Memorandum 06-02. Door openings should provide adequate clearance for

plant replacement, inclusive of any manual handling equipment and personnel. There should be a minimum of two sets of doors, on opposite sides, to provide suitable escape routes. For internal switchrooms, additional doors may be required to ensure that the maximum travel distance to a safe haven is no greater than 9m.

7.63 Internal switchrooms should have good access for lifting equipment to facilitate plant replacement and maintenance. This will generally mean that they are located on the principal circulation corridors. Where internal switchrooms are not at ground-floor level, a clear method statement describing the arrangements for plant replacement and maintenance should be provided, without the need to dismantle the LV equipment. Internal switchrooms should be so arranged and constructed as to prevent unauthorised access. See Scottish Health Technical Memorandum 06-02. Door openings should provide adequate clearance for plant replacement, inclusive of any manual handling equipment and personnel. There should be a minimum of two sets of door openings connecting directly to a safe haven, on opposite sides, to provide suitable escape routes. Additional door openings will be required to ensure that the maximum travel distance to a safe haven is no greater than 9m.

Layout

7.64 The layout of LV switchrooms will depend partially on the distribution strategy employed (see Section 6). LV switchrooms should have a clear maintenance space of a minimum 0.8m on all sides of equipment contained therein. The room height should be even, and at least 1m greater than the equipment height. It is essential that all cables and equipment can be serviced and replaced without modification to the room. Where the distribution strategy has dual supplies and/or interleaved sub-main distribution, a physical fire barrier between each section may improve the fire precautions and inherent system resilience. Where the LV switchgear includes a withdrawable section (see Section 9), the depth of the switchgear should be added to the clear maintenance space. The maintenance space will include the headroom above all LV equipment. The headroom should be a minimum of 1 m measured between the soffit (and/or the underside of any drop beam) and the highest point of the equipment. A risk assessment to determine the amount of space set aside for future expansion (see Section 3) should be undertaken. LV switchrooms should not be used for any purpose other than LV switchgear, controls and cables. The room should not be used for the storage of other items at any time. The room should not be used as a conduit for other engineering services, including drainage.

Fire precautions

7.65 LV switchroom construction must comply with the requirements of the Building (Scotland) Regulations section 2. The location should comply with the medical adjacencies as defined in the Firecode series. A full risk assessment should be made in conjunction with the healthcare premises' fire officer, the local authority's fire officer and a specialist fire consultant to address the form of suitable fire- fighting equipment and fire alarm and detection systems.

7.66 The risk of a fire should also be determined by the effect of an electrical fault causing explosions. Such electrical faults will include those that can be assumed to happen and those that may arise from unauthorised interference.

Environmental requirements

7.67 External LV switchrooms of GRP or steel fabrication should have the same environmental conditions as an internal LV switchroom (given below). Internal LV switchrooms should be illuminated by artificial lighting to an average level of 150 lux at floor level. The illumination should not cast shadows on any instrumentation and working surfaces of the switchgear. Emergency lighting should provide an average of 5 lux at floor level for three hours. Internal LV switchrooms should have adequate natural ventilation to prevent build-up of moisture and condensation. LV switchrooms should be arranged so as not to give concern for internal heat gain. The supply and extract air for LV switchrooms should connect directly to an external wall and should be arranged to prevent the air flow short-circuiting. Thermostatically-controlled low-level background heating should maintain a room temperature not less than 10°C. Designers should consider the provision of LV or SELV sockets, derived from a resilient routed secondary source (standby generator) for the use of competent persons (see Scottish Health Technical Memorandum 06-02).

Equipment and notices required to be provided

7.68 LV substations should include the following equipment as a minimum set:

- safety posters as identified by Scottish Health Technical Memorandum 06-02, including first aid/electric shock treatment;
- single line diagrams as identified by Scottish Health Technical Memorandum 06-02;
- rubber mats;
- a mimic board (including, where appropriate, key locks, keys and site logbook);
- a sign positively identifying that the LV earthing is a TN-S system;
- a battery charger (for the instruments and power-driven switches including trip circuits);
- storage space for maintenance tools, with tools;
- fixed lifting equipment (subject to height restrictions);
- other equipment such as safety keys as required by local rules.

7.69 Note that a sign positively identifying the LV earthing as a TN-S system should also be located at each final distribution board, motor control centre and similar locations.

8. Secondary power centres and plant

8.1 This section deals with secondary power sources (SPSs) either directly connected to the PEI or connected to a secondary electrical infrastructure (segregated essential/non-essential, A and B etc).

8.2 The use and operating configurations of CHP plant are comparable with standby generators; but with CHP, the thermal energy produced can be harnessed. It is for this reason that CHP plant may be considered as an SPS but not as standby plant. The electrical connection and operating arrangements for CHP plant are discussed in this Scottish Health Technical Memorandum only as a generator operating in parallel with the PES (see paragraphs 8.7 to 8.11). Installation with photovoltaic and/or wind turbines as an SPS is set out in the Energy Network Association's Engineering Recommendations G.83/1.

8.3 Opportunities exist to allow the secondary electrical power sources, such as CHP plant, to become the prime power source and the DNO connection to become the SPS. Designers and stakeholders should consider the holistic risk strategy for such arrangements. Non-technical issues can influence the operating viability of alternative energies such as CHP, including reduced carbon emissions and the rejection of excess thermal energy. The design process should evaluate the resilience of generating plant (such as CHP plant) with multiple sets running at below full duty, or having spare capacity on the DNO connection to the PES.

8.4 The section concentrates on standby generators provided with unified and/or segregated electrical infrastructures. The configurations are presented generally in order of resilience, from low to high. The selection of a particular configuration will be dependent on the clinical risks and non-clinical risks. The selected configuration should clearly be consistent with the distribution strategy (see Section 6).

8.5 The configurations presented in this chapter should not be taken as being definitive, prescriptive or restrictive. The selected configurations and assessment are intended as a guide to best practice, which should not restrict any design innovation. Healthcare organisations may not have any control over their DNO configuration, and therefore the reliability of a duplicated DNO connection (to the PES) as an SPS should be the subject of a risk assessment. Areas within a healthcare facility (or the whole healthcare facility) where the clinical risk is equal to or greater than Category 3 will always require some form of standby supply. The design process should assess the benefit provided by standby generators where the clinical risk areas are Category 1 or Category 2.

8.6 Where permanent standby provision is installed, the addition of strategically-located mobile generator plug-in points may be an alternative solution for the maintenance provision of embedded units. Such arrangements may be particularly useful where the electrical infrastructure is a unified system. Where mobile generators are considered as part of the electrical resilience, consideration should be given to the hook-up location and the ease of installing

potentially very long, trirated cables. Designers and stakeholders should remain mindful of the fact that mobile generators are in fact “mobile” and should be physically secured.

Secondary power general arrangements

8.7 The use of alternative electrical energy sources has become more widespread in the UK since the late 1990s. All forms of such energy have unique availability and viability considerations outside the scope of this Scottish Health Technical Memorandum. A useful source of such data can be found on either the CIBSE or BSRIA websites. Designers and stakeholders may wish to consider these energy sources as a way to reduce the carbon emissions locally and the possible benefits available from the renewable obligations commitment (ROCS).

Photovoltaic power secondary power source

8.8 Photovoltaic cells may be a useful background supplementary energy source. Over the normal range of weather conditions, these units can provide an average of 15% to 20% of their total rated output. The use of photovoltaic cells is therefore limited to smaller healthcare premises, or dedicated small circuits of larger healthcare premises.

8.9 CIBSE Technical Memorandum TM 25 and Guide L provide useful guides to the current applications of photovoltaic cells (PV). Any PV system that is used on the site’s electrical systems should run only in parallel with the PES supply. There should be a form of positive isolation between the PV output and the incoming PES to prevent island-mode operation and/or back-feeding into the PES via the DNO. These requirements are set out in the Energy Networks Association’s Engineering Recommendations G.83/1.

Wind turbine power source

8.10 Any wind turbine system that is used on the site’s electrical systems should run only in parallel with the PES supply. There should be a form of positive isolation between the wind turbine output and the incoming PES to prevent island-mode operation and/or back-feeding into the PES via the DNO. These requirements are set out in the Energy Networks Association’s Engineering Recommendations G.75/1 and G.83/1, and the Technical Report ETR 113.

8.11 The use of wind turbines should include an assessment of the available wind and potential output of any wind turbine that may be on site, including the space and access requirements.

General – secondary power plant location

8.12 An approach to the DNO should be made to establish an indicative reliability factor for the PES. This will place the designer team in an auditable position when determining the standby power plant location.

8.13 Where the distribution strategy has placed the first single point of failure (see Section 6) nearer to the point of use, the standby plant should be connected at the intake point. Where the first single point of failure is much nearer the intake point, distributed secondary power centres should be provided.

8.14 The physical location of SPS plant and primary plant (substation switchroom) should be considered in similar ways. This should address the access for maintenance requirements. With SPSs such as photovoltaic cells and/or wind turbines, these may be located on a flat roof where they may optimise their respective prime energy source (sun or wind).

8.15 Other secondary power plant locations should be considered by taking account of the medical adjacencies and environmental conditions. The medical adjacencies are identified in the Firecode series of documents.

8.16 Where the SPS is the standby power plant, the environmental conditions include exhaust terminations (the Clean Air Act) and noise emission (see paragraphs 8.91–8.93). Where the healthcare site includes a CHP plant, the CHP plant should be located close to the boiler plant to minimise the water distribution pipework (and hence distribution losses). Locating the CHP plant close to the boiler plant will provide other benefits, including a common location for boiler flue and exhaust locations to comply with the Clean Air Act, as well as a common location for the fuel.

Essential power capacity

8.17 An assessment of the essential power requirement should be made from an understanding of the clinical risk areas that require power to be restored as set out in Appendix 1 (see also Section 4). Further consideration should be given to the clinical risk areas that have certain items that should be reconnected within 0.5 seconds. Such items may initially remain connected to a supply, by either internal batteries or a UPS system. Within all clinical risk areas above Category 2, there will inevitably be some equipment of a non-clinical and business continuity risk category. Such risks might compromise the provision of healthcare treatment if they were not also connected to the standby power source after an initial delay in excess of 15 seconds, for example building services environmental control, medical support services etc.

8.18 Assessments for essential power requirements for new developments should be based on the ratings of the above equipment and the general power density of the healthcare premises with an acceptable allowance for growth. Actual detailed load profiles of existing sites may be a useful audit of the essential power capacity assessment, where the profile covers at least one year. “Camera shot” measurements should be assessed with the risk associated with oversized plant, which may be more flexible and accommodate the allowance of growth.

8.19 When assessing the size and type of emergency power plant, designers and stakeholders should be aware that electrical outages can be very short (less than a few minutes) or for many hours. Consequently, all emergency generating

sets should be designed and rated to provide continuous full load for prolonged periods. Where the essential power plant is not connected to the full electrical load, thought should be given to the temporary connections of plant such as the chilled water systems. The provision may require a manual or automatic control system with the ability to “load shed” a limited number of the secondary services such as non-essential lighting. The schedule should be reviewed annually as part of the maintenance regime.

Essential and emergency power provision

8.20 Standby power systems should always be available to provide electrical power to those areas that will enable the healthcare facility to carry out essential functions. The designation of these areas within the healthcare facility should be decided at design stage with involvement of all the stakeholders, and particularly clinicians. The framework of such decision-making should include the clinical risk categories identified in paragraphs 4.11–4.23. Within this general objective, the aim should be to keep electrical installations as simple as practicable and avoid unnecessary segregation of essential and non-essential circuits. Consequently, the design team should contribute towards the medical planning process.

8.21 Developments in clear separate phases should design in the emergency power supply for the final steady state, as far as practicable, at the initial design stage. This will enable the total emergency power supply requirement to be assessed in the planning stages and appropriate areas of accommodation to be allocated.

8.22 For ac standby power supplies, in island mode, required to supply only segregated essential services, a fully-rated four-pole main auto-changeover switch should be provided. It should be connected to supply power to the healthcare facility from two sources, either from the DNO’s normal supply via the main switchboard to the essential services switchboard, or in an emergency, from the ac standby power supply to only the essential services switchboard. Thought should be given to the rating of all associated cables with the respective loads and mode of operating the essential power source (island or parallel).

Standby generators

Design criteria

8.23 A range of system designs is considered below, for both LV and HV systems. In small healthcare premises, the most economical and convenient arrangement may be a single diesel standby generator set to supply power to the essential services. However, for larger premises the better arrangement is to share the load between two or more machines. A system of two or more standby generators, with interlocked and interconnected switching, may be necessary to ensure only a single running supply to essential loads.

8.24 The choice between LV and HV generation is usually dependent on the nature

of the total site supplies; 11 kV generators have a higher unit cost but can be cheaper or more convenient to distribute electricity to the points of use.

8.25 The design criteria for the standby generator system should consider the advantages of managing the maximum demand profile (from the PES) by operating the generators in parallel. This may be achieved by running any one of the multiple sets in parallel with the PES during high maximum demand periods.

8.26 LV standby generators connected to the HV network may provide a practical solution. However, consideration needs to be given to the space required for the additional transformer(s) and earthing arrangements. Standby generator arrangements including step-up transformers should comply with the Energy Networks Association's Engineering Recommendations G.84. Designers and stakeholders should also consider the capital and life-cycle costs of such transformers and associated switchgear and equipment.

Component parts

8.27 In its basic form, the generating set configuration is formed by an engine, alternator and control panel with associated bed frame. Failure of any of these items will cause the generating set to fail.

8.28 The generating set represents a single point of failure, and maintenance routines should be developed to reduce the risk of failure. Some of the commonest reasons for failure are given in Table 3. The quality of standby power plant should be assessed by a risk assessment.

Fault	Typical cause
Overload	Inadequate testing onto actual site load
Cold engine	Engine heater turned off or heater failed
Flat batteries	Battery charger turned off, charger failed, or batteries too cold
Cold room	Room heater turned off or when the generating set is at standby, room air change rate set too high

Table 3: Typical causes of generator set failure

Generator configuration

8.29 Standby generators can be arranged in various ways as described below. Each configuration provides different opportunities for routine testing of the generator. Full electrical system tests for a PES failure (blackout) are described in Scottish Health Technical Memorandum 06-01 Part B.

Mobile plug-in generator island operation

8.30 A basic LV system comprising one PPS and a mobile secondary generator is illustrated in block format in Figure 21. This is a simple unified system, with standby supply provision likely to be via a plug-in point for a mobile standby

generator. Such a simple system may provide a back-up supply to healthcare premises where the clinical risk is no greater than Category 2. Where there is no requirement for a standby supply within 15 seconds, and essential health and safety supplies are provided by UPS or battery units, a plug-in point for a mobile generator may be adequate. The benefit of having such a mobile plug-in point, either for such a simple system, or as an addition for any other supply configuration, is the facilities it offers to effect planned maintenance of the fixed wiring system or downtime of permanent standby generators. The design process should reconcile the availability and security of mobile generators with the benefits of embedded distribution and standby generator resilience. When evaluating the clinical risks against viability of fixed generator provision, the realistic response time to collect and connect a mobile generator (for any scenario) should be considered, particularly if the generator has to be hired. Where it is considered advantageous to provide a mobile plug-in point, managers should consider the purchase of a mobile unit to be kept at a central location, or make emergency arrangements for mobile generators of suitable rating to be obtainable elsewhere at short notice. In planning an installation, it is desirable to reserve a dedicated fenced-off location for mobile generators where they may be easily connected to an allocated switch or plug-in point.

8.31 The connecting of a mobile generator should comply with the Energy Networks Association's Engineering Recommendations G.84, and may be achieved by a plug-in facility (up to 175kVA) rated to BS EN 60309-1:1999, IEC 60309-1:1999. An external earth lead connection to the generator star point and, separately, to the generator metalwork should be provided. An earth bar connection should be available for connection to the earth terminal of the generator base plate, regardless of its type and size.

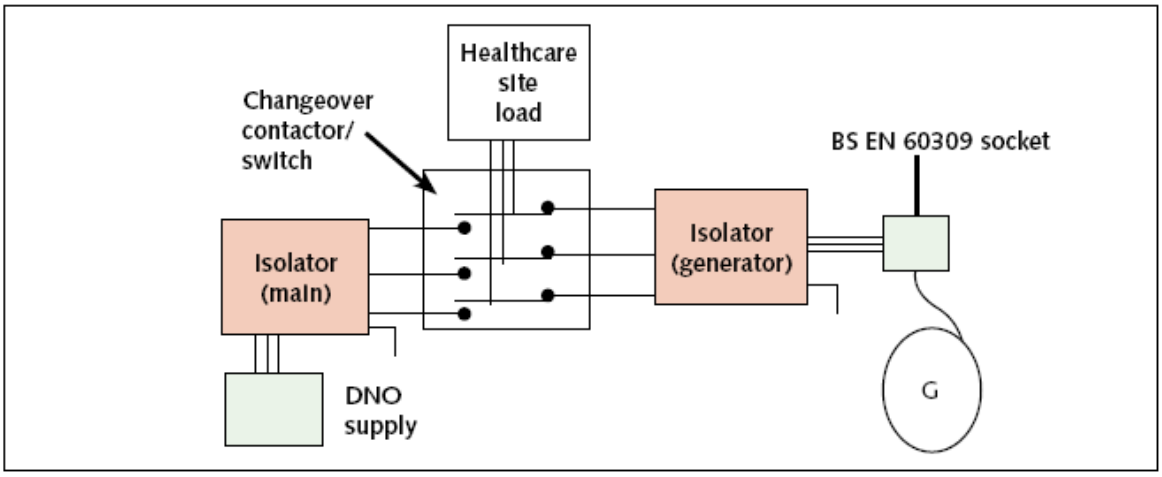

Figure 21: Mobile generator connection

8.32 The electrical supply regulations do not permit a mobile generator to feed back into the PES, as such connections may feed a fault into the PES. Therefore, it is essential that positive isolation from the PES be made before and while any healthcare organisation's mobile generator set is used to energise any part of the electrical network.

Generator(s) in island operation

8.33 Island operation represents the simplest generator control arrangement requirements. Each ac generator will supply electrical power to a discrete, segregated part of the network. There will be no facility or opportunity to connect the generator output to the normal DNO connection.

8.34 Where the SPS plant is connected in island mode and the distribution strategy allows for the classic segregated non-essential and essential circuits (see paragraphs 6.40–6.42), any single room (or space) will have only non-essential or essential circuits and not both circuit types. Where the clinical risk Category 3, 4 and 5 areas are dispersed or are a small percentage of the overall electrical AMD, the safety requirement tends to drive the standby generator rating up. Designers and stakeholders should consider the implications of not being able to test the generators in parallel with the DNO supply. This may mean that the non-essential circuits have to be turned off when the physical essential load is used to test the generators. The alternative to this (preferred) strategy will be to test the generators with a load bank. All generator testing and power restoring (after a DNO outage) will require a short interruption to the electrical power. Standby generator operating in island mode will not require compliance with the Energy Networks Association's Engineering Requirements G.59/1.

8.35 Operating standby generating power plant in island mode may be considered for all clinical risk category areas.

8.36 Figure 22 shows a classic LV system comprising a single PPS with an SPS (the standby generator). The generator(s) is configured to operate in island mode only.

8.37 The electrical system resilience will be N+1 as there is an embedded secondary power source (the generator). Where the clinical risk Category 4 area forms only a small part of the healthcare premises, the generator control may be adjusted such that the healthcare premises areas less than clinical risk Category 4 are only connected to the standby generator when the actual demand is less than the generator rating (see Figure 22). Where a significant percentage of floor area is used as clinical risk Category 4 or above, more than one generator should be provided – rated so that the full essential circuits' AMD can be supported while one standby generator is not available (due to maintenance or faults). Under such circumstances, the generator resilience would also be defined as N+1.

Generator(s) operating in parallel with PES

8.38 Parallel operation represents a more refined control arrangement in the mode of standby generator running. Each ac generator will supply electrical power to any part of the internal electrical infrastructure depending on voltage and the type of parallel operation. For parallel operation with the PES, the generator control regime should be compliant with the Energy Networks Association's Engineering Requirements G.59/1 (short- or long-term).

8.39 Short-term parallel operation requirements of G.59/1 allow the embedded

generators to run (synchronised) in parallel with the PES for periods between 1 and 5 min, subject to approval of the local DNO. Designers and stakeholders should consider the advantage of this arrangement as a means of having a no-break return to normal PES supply following an outage. The disadvantage of such an arrangement is that the whole building electrical load cannot be used to test the standby generator power capacity. This may mean that the non-essential circuits have to be turned off, when the physical essential load is used to test the generators. However, as the sets meet the G.59/1 requirements for short-term parallel operation, the sets can be synchronised with the PES supply and then the non-essential circuits re-energised before the generators are isolated from the load. The alternative to this (preferred) strategy will be to test the generators with a load bank.

8.40 Where the standby power plant is connected in short-term parallel operation and the distribution strategy allows for the classic segregated non-essential and essential circuits (see paragraphs 6.40–6.42), any single room (or space) will have only non-essential or essential circuits and not both circuit types. Where the clinical risk Category 3, 4 and 5 areas are dispersed or are a small percentage of the overall electrical AMD, the safety requirement tends to drive the standby generator rating up. Designers and stakeholders should consider the implications of not being able to test the generators in parallel with the DNO supply.

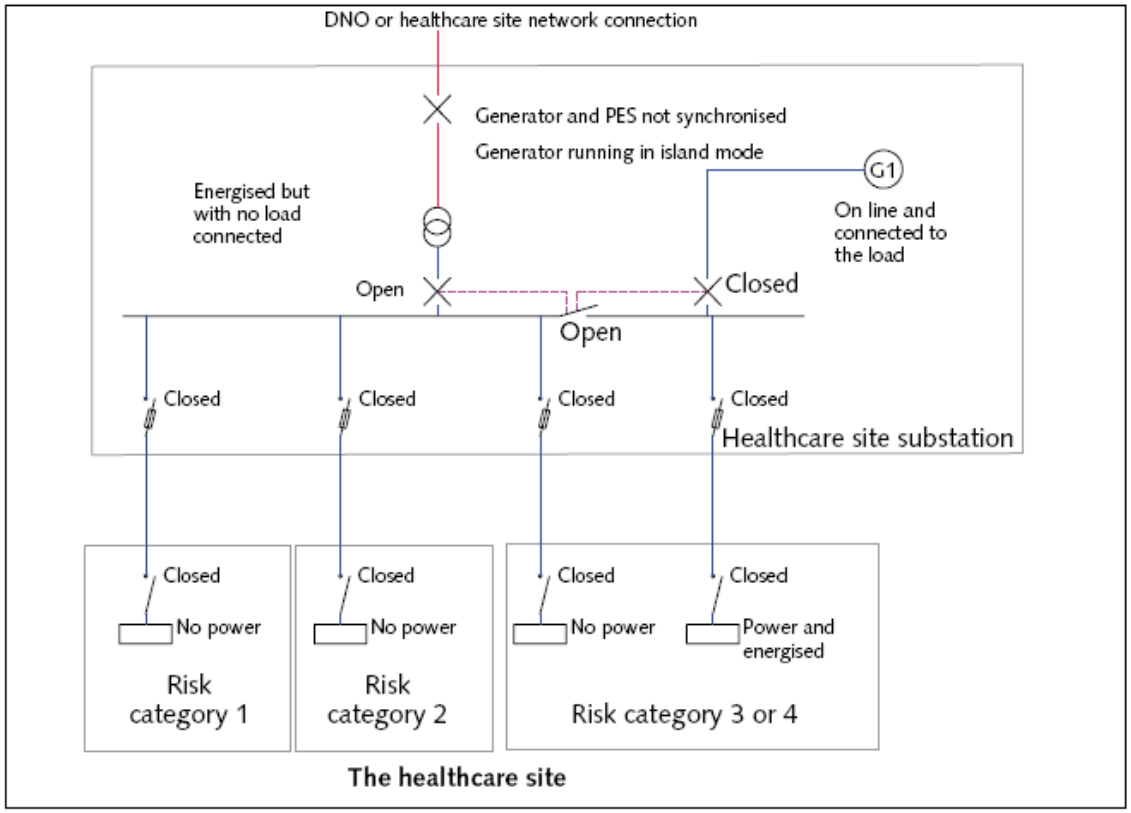

Figure 22: Generator(s) in island operation

8.41 The long-term parallel operation requirements of G.59/1 allow the embedded standby generators to run (synchronised) in parallel with the PES for any unspecified period of time. Advantages are available with arrangements that provide a facility to test the generators with the essential circuits of the building

load. Where the standby generator capacity is less than 100% of the AMD, the generators will run up and synchronise with the PES (for the test regime), and consequently there will not be a need to isolate any part of the electrical system while testing the generators.

8.42 Where the standby power plant is connected in long-term parallel operation and the distribution strategy allows for the classic segregated non-essential and essential circuits (see paragraphs 6.40–6.42), any single room (or space) may have a mixture of non-essential and essential circuit types.

8.43 Best-practice standby-generator connecting arrangements will allow for long-term parallel operation with the PES (that is, fully compliant with G.59/1). Assessments of the advantages for business continuity with the additional control and switchgear regulation should be made.

8.44 Operating standby generating power plant in short- or long-term parallel operation may be considered for all clinical risk categories provided that any areas of Category 5 have an intermediate tertiary power source UPS.

8.45 Figure 25 shows a classic LV system comprising a single PPS with an SPS (in this case a standby generator). The generator(s) is configured to operate in island mode only.

8.46 The electrical system resilience will be N+1, as there is an embedded SPS (the standby generator). Where a significant percentage of floor area is used as clinical risk Category 4 or above, more than one standby generator should be provided – rated so that the full essential circuits' AMD can be supported while one generator is not available (due to maintenance or faults). Under such circumstances, the generator resilience would also be defined as N+1.

8.47 This chapter has discussed the various operating configurations for standby generators based on the generators having a terminal voltage up to 11kV and/or each generator having an output of less than 5 MW (see Figures 22 and 23; also see Figure 18, which can be used as the configuration for an HV generator connection). Where the site has generators above 20kV and/or 5MW, its design should ensure that the generators are fully compliant with the Energy Networks Association's Engineering Requirements G.75/1.

LV generators feeding HV ring main

8.48 The design process might consider using LV (0.4kV) standby generators connected to the HV network (11kV), via step-up transformers, where the distribution strategy includes for an HV network. Generators in this configuration can operate either in parallel or in island mode as described in paragraphs 8.29–8.47. When the standby generators have a design potential to allow for parallel operation, the electrical system should include neutral-switching contactors.

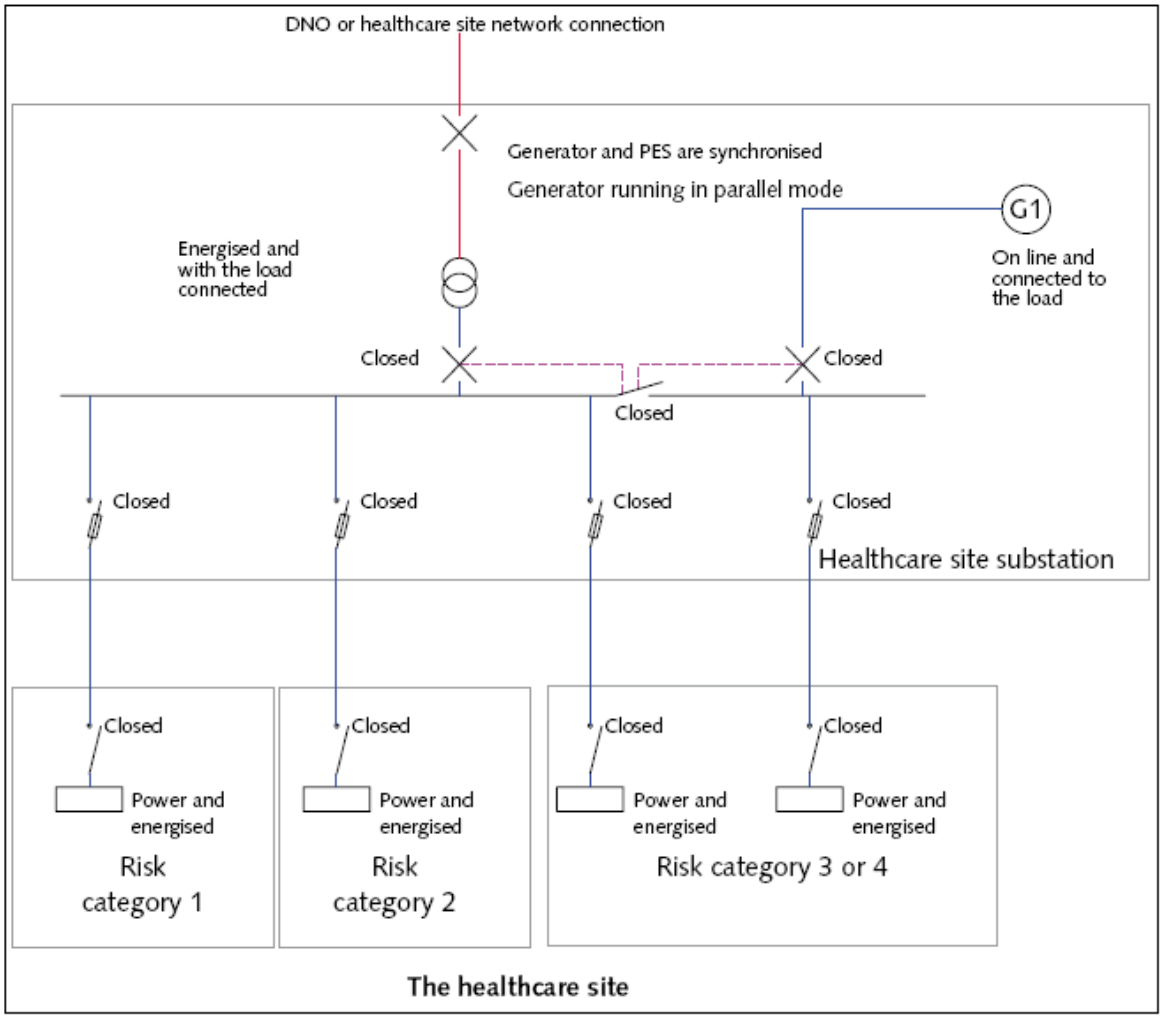

Figure 23: Generator(s) operating in parallel with PES

Generator control

Generating set management

8.49 The generating sets are defined as a standby system. The modes of operation should be well-defined and clearly stated.

8.50 Where the healthcare facility has SPSs including power sources from alternative energy plant (CHP, wind turbines, photovoltaic), designers should liaise with the local DNO to ensure compliance with the requirements of the Energy Networks Association's Engineering Requirements G.83/1.

8.51 Designers are also required to prevent these power sources feeding back into the PES at the instance of an under-/over-voltage or an under-/over-frequency of the SPSs in either the power source or PES. However, such power sources may be arranged to continue to supply the internal essential distribution, and allow the standby generators to synchronise to the CHP supply. (Note – subject to the rating and step load response of the CHP, such arrangements may require the non-essential loads to be isolated, while the standby generators are initialised and connected).

8.52 Detection of any under-voltage on any phase should be made at the input terminals of the point of common coupling of the primary supply and secondary supply (generator).

8.53 Where the generator(s) cover the full essential load, the phase failure detection will be at the intake point.

8.54 Where the generator(s) provide cover to only part of the electrical load, this will be at the respective switchboard (point of segregation of local non-essential and essential circuits).

8.55 Detection monitoring is required on all phases of the normal supply, such that any single-phase voltage failure in the normal supply initiates a start signal to the essential generator controls.

8.56 The engine-driven generator set for the supply of essential circuit power and lighting should be designed for automatic starting in the event of either a total failure of supply or a prolonged variation in supply voltage from its specified limits. A short delay of between 0.5 and 6.0 seconds is normally chosen at the voltage detector device to discriminate against a fall in normal voltage due to a voltage transient or auto-reclose switching operation (that is, a time delay to establish that the under-voltage is an outage rather than a disturbance). When the chosen time delay confirms the loss of normal supply voltage, the engine start is initiated. A time delay of up to 15 seconds (following the initial confirmation time) is allowed between loss of normal supply and connection of the standby generator to the essential circuits. The essential circuits are defined as those which cannot accept an interruption of electrical energy greater that 15 seconds plus the detection time (that is, clinical risk Category 4 and above). The ac standby generator circuit breaker should close when the generated voltage and frequency are at 95% of nominal values and before the auto-changeover load switch operates. The initial step load applied to the generator should be less than the maximum acceptance factor to prevent the generator's protection shutting the set down again.

8.57 The time-delayed start of the motor and high inductive loads may be achieved by the individual motor controls or by a centralised network control (see Section 9).

8.58 Regardless of the actual duration of the outage (PES or internal distribution), provision should be made to ensure a minimum run-time of 20 minutes to allow the generator engine lubrications to reach operating temperatures and fully circulate. The minimum run-time will also facilitate the recharging of the batteries. The minimum run-time should be exclusive of the time required to establish a returned and stable PES supply. Where the mains supply has been restored prior to load transfer, this will mean the generator may be operated off-load. Where the mains has been re-established within the minimum run-time, the load will be transferred back to the DNO supply and the generator will continue to run off-load until completing the minimum run time.

8.59 The source of run/stop signals should be clear, to ensure that the set automatically runs when mains failures occur at points in the systems that are to

be supplied by the set. The position of any simulate-mains-failure switches and mains-return push-buttons should be decided with respect to the system as a whole and in particular the needs of the operator.

8.60 The opportunities to maintain and/or test will affect the management control requirements. For example, the maintenance requirements may require a level of redundancy in sets, which will then require sequencing controls (see paragraphs 8.61–8.64). Test regimes should facilitate the generator(s) to run in parallel with the PES for business continuity and clinical risk control. Additional details are available in Scottish Health Technical Memorandum 06-01 Part B: "Operational management".

Multi-set operation

8.61 For standby generators connected to different points within the network, arrangements with parallel-operated sets (which have collective redundancy) should be adopted. Where the clinical risk areas are Category 4 or above, arrangements with multiple generator sets that have inbuilt redundancy should be adopted.

8.62 Where the SPS is via multiple standby generator sets, the total run-up time (detection time of between 0.5 and 6.0 seconds plus run-up of less than 15 seconds) should include the time it will take to synchronise sufficient sets so that their combined acceptance load is greater than assessed essential load (clinical risk Category 3 and above).

8.63 In applications where the system is operating with an N+1 capacity, it should be decided whether the resilient set should operate continuously throughout a mains failure or only run on the failure of a running set. All sets should be started at the instance of a mains failure. After the generator operation has stabilised (normally less than five minutes), the number of online sets is adjusted to suit the actual demand.

8.64 If the number of sets that operate is to be varied to match the required load, care should be exercised in defining the power levels that disconnect a set from load. This figure, which may vary over months or years, should be reviewed on a regular basis. The risk of stopping a running set due to light load running, compared with the reduced risk of operating with excess capacity, should be considered.

Mains return

8.65 To return the electrical power source back to the DNO service, a minimum delay should be agreed to allow the DNO service to be established and stabilised, otherwise the risk of repeated outages (caused by the number of auto-reclose devices) may follow. This should be a minimum of five minutes, and determined by local experience.

8.66 Designers should give further consideration to how the load is actually transferred, either manually or under an automated control system. Where the load is transferred manually, a key switch will be required for this function, and

the transfer can be coordinated to the benefits of the healthcare premises. This mode of operation may only require a short-term (less than five minutes) parallel operation under the G.59/1 requirements. The load transfer under an automated control system should be gradual to minimise transient voltages, which may otherwise cause an outage of either the DNO supply or the running standby generators. Where the load transfer from the generator(s) to the DNO supply is gradual, a long-term (greater than five minuets) parallel operation agreement under the G.59/1 Regulations will be required.

8.67 Long-term parallel operation of generators with the PES as described by the G.59/1 Regulations has clear advantages for testing generators with the minimum inconvenience to end-users. See the routine online testing of primary and secondary power sources in Scottish Health Technical Memorandum 06-01 Part B.

8.68 Additional information can be found in Section 9 for the automated management and control of a stage transfer system.

8.69 When all electrical loads have been transferred back to the DNO supply, the standby generator(s) should be allowed to run on for a period to facilitate natural cooling of the engine. This period can be a pre-set time of say ten minutes or at pre-set return temperatures of the lubricant and/or water cooling systems.

Computerised load management of generators

8.70 The electrical infrastructure and distribution strategy may minimise the effect of an electrical fault to the clinical risks areas. However, the most resilient system cannot eliminate the risk. The highest risk of generator failure is during the first five minutes of the set starting online. While the standby generators are providing the only electrical power, variation in demand may result in the generators running on a light load. This is particularly the case with multiple sets. Similarly, the demand variations may cause the generator to become overloaded.

8.71 Where the standby generators do not provide support for the total electrical system of the site, problems may arise during prolonged outages (of the PES). For example, where the chiller plant is not supported by default, building internal temperatures may arise above acceptable levels.

8.72 The design process may consider supervisory control and data acquisition (SCADA) computer systems to control automatically the generators and switchgear status and connected load. This function may also be provided using a PLC system.

Standards and references

8.73 Generating sets should be specified that are compliant with the relevant parts of the following specifications. Particular attention should be given to the governing system of the engine and the voltage regulation system of the

alternator:

- generating sets are specified in BS7698, ISO 8528;
- engines are specified in BS5514, ISO 3046;
- alternators are specified in BS4999.

Generator engines

8.74 The choice of generator engine type is determined by the required output and speed. For generators up to 50kVA, the prime mover may be either a petrol or a diesel engine with four or six cylinders. Generators between 5 kVA and up to 500kVA are best driven by diesel engines with six or eight cylinders in Vee-formation. Generators in the range of 500kVA to 1,500kVA are best driven by diesel engines having 12 or 16 cylinders in Vee formation. From the early 2000s some engine manufacturers have been making 20-cylinder engines used to drive 1,500kVA to 2MVA generators. The advantage here is that with more cylinder displacement and equal engine speed, a greater load acceptance factor can be applied to the generator.

8.75 The larger engines should all have turbocharged units fitted, while the smaller sets (less than 100kVA) may be more economical with natural aspiration.

8.76 Engines should be continuously rated, as defined in BS5514, ISO 3046. They should be capable of operating at the rated load for a period of 12 consecutive hours inclusive of an overload of 10% for a period not exceeding one hour, the prescribed maintenance having been carried out. This is known as a Class A rating.

8.77 Diesel or gas engines should generally be manufactured in accordance with BS 5514, ISO 3046. Four categories of load acceptance are available for various types of engine operation on the basis of percentage load acceptance for the Class A rating:

- Category 1 – 100% load acceptance;
- Category 2 – 80% load acceptance;
- Category 3 – 60% load acceptance;
- Category 4 – 25% load acceptance.

8.78 The advantages of higher acceptance factors should be reconciled with the increased cost of larger generator sets, and the time taken to reach acceptance point with synchronised sets. Naturally-aspirated generators have a higher acceptance factor for a given output rating, but are also physically larger. Generators that can satisfy the Category 2 or 3 of a Class A specification to BS5514, ISO 3046 may be more economic and appropriate for most healthcare premises.

Batteries and battery charging

8.79 For most generating sets, the means of starting is by an electric starter motor. Air start is available, but for economic reasons is generally restricted to generators greater than 2MVA for sets at 0.4kV or greater than 3MVA for sets at 11 kV.

8.80 The reliability and maintenance of batteries is extremely important. For a generating set to start consistently, the batteries should be in good condition and maintained fully charged while the set is both running and stationary. The maintenance procedures should include the requirements given by the particular battery manufacturer.

8.81 Usually, two battery-charging systems are supplied with a generating set:

- a charger for operation while the set is stationary, usually in the control panel;
- a belt-driven charge alternator that maintains the battery when the set is running.

8.82 For both charging systems the battery should be charged at the correct “float voltage”, and for engine starting the battery should be adequately sized for the “breakaway” (initial starting) voltage to be acceptable to the engine manufacturer. The use of a BEMS should be considered for the monitoring of the battery condition.

8.83 Table 4 below gives a range of battery types in ascending cost order. The type of battery to be selected should be assessed with regard to the risk, cost and planned maintenance. The length of battery life should be checked with the battery manufacturer.

Lead acid	3 to 5 years
Sealed lead acid	3 to 7 years
Planté	5 to 10 years
Ni-Cad (Nickel cadmium)	>10 years

Table 4: Battery types

Fuel and fuel storage

8.84 The design process should evaluate the fire and pollution implications of storing diesel fuel (the generators’ prime energy source). Further advice is available from a guidance note for The Water Environment (Oil Storage) (Scotland) Regulations 2006 as published by The Scottish Government. Designers should refer to the SHTM Firecode series and medical adjacencies when determining the location of any bulk fuel storage. The volume of diesel fuel oil stored within the day tank and arranged for gravity feed of fuel oil to the engine should be no more than the greater of 750 litres or the equivalent of 10 hours’ full-load (maximum capacity) running of the generating set. In addition, a fuel oil main reserve for 200 hours’ full-load running for each standby generator set should

be available on site. Where the standby generators are decentralised, fuel should be pumped from the centralised storage area.

8.85 Where the fuel is not pumped to decentralised standby generator(s), a hand-operated semi-rotary oil pump should be available for transferring fuel oil from oil drums or other vessels to the standby generator(s) day tank. The hand pump should have a filter fitted with screw caps to prevent ingress of dirt when in storage. Where the oil-fired boiler burner plant (or CHP plant) can use the same low- sulphur fuel as the generators, designers may wish to consider sharing the bulk fuel storage. Under such strategies, the stored fuel volume should be assessed on the worse-case demand of 200 hours' continuous full-load generator(s) demand or 10 days' winter peak thermal boiler-plant demand. Designers should give consideration to how to minimise the effect of stratifying fuel oil where the stored generator fuel is not shared with the boiler plant, which may mitigate such effects. There are ranges of systems for fuel storage and supply that can be considered, and a brief description of some follows.

8.86 Figure 24 shows a basic system comprising a day tank and isolating valve with bulk fill point and hand pump. The tank could be filled using the bulk fill point or via the hand pump from fuel brought to the side of the day tank. However, the generator has no automatic means of maintaining the fuel tank full.

8.87 The addition of bulk tank storage as well as a day tank, as in Figure 25, allows extra capacity to be kept on site. The day tank can now be filled either from the bulk tank, or via the hand pump from fuel brought to the side of the day tank. The bulk tank can fill the day tank either by gravity feed or as a pumped supply. Where the day tank is automatically maintained full by the transfer pumps, at least one pump, powered by an extra LV source or diesel, should be provided. This may assist when the day tank is empty, the generator has stopped and there is no mains electrical power.

8.88 Where fuel can be dumped from day tank to bulk tank, it is important to reduce, by design, the chance of accidental system operation. The entire generating set installation is at risk if the fuel dump is accidentally released, since the day tank would be empty, and during a mains failure there is no supply available to operate the transfer pumps. Where a 24V dc supply is required to maintain the dump valve closed, the source of that supply should be carefully considered, as a reduction or failure of this voltage would also cause all fuel to be dumped from the day tank. Operation of the dump valve should also be monitored and alarmed. The bulk tank capacity should maintain sufficient empty space to receive the full contents of the day tank.

8.89 The addition of the fire safety-valve feature needs to be carefully considered and risk assessed against the potential disruption of a premature generator set failure. If the generator is sited away from other buildings and provided with automatic fire detection, the ability to maintain electrical supply while making a managerial decision regarding the fire condition may be preferential in terms of risk. In addition to the guidance given by Defra, installations must comply with local regulations from the fire department, and local authority. For large generating sets, the quantity of fuel to be stored could become significant in both the day and bulk tanks. Both the size and the location of bulk fuel tanks

should be carefully considered. Fuel in the bulk tank can remain unused for significant periods and may deteriorate. It should be subject to routine testing. The risk associated with fuel leakage should be assessed. Containment may be required for day tank, bulk tank and associated fuel transfer pipework, both from the bulk tank to the day tank and from the day tank to the engine. The use of tank bunds and double-skinned transfer pipes should be considered. To reduce the possibility of fuel spillage, controls should be included to ensure that should a day tank become overfilled, any fuel transfer systems are automatically switched off; similarly if a bulk tank is overfilled, visual indication is given at the fill point.

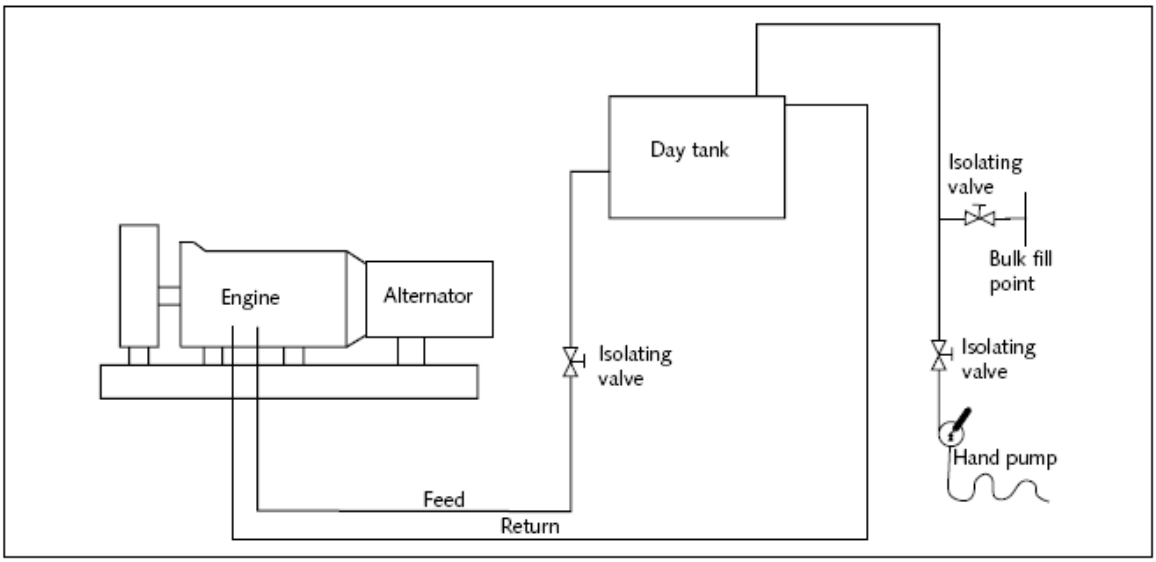

Figure 24: Fuel day tank with hand fill

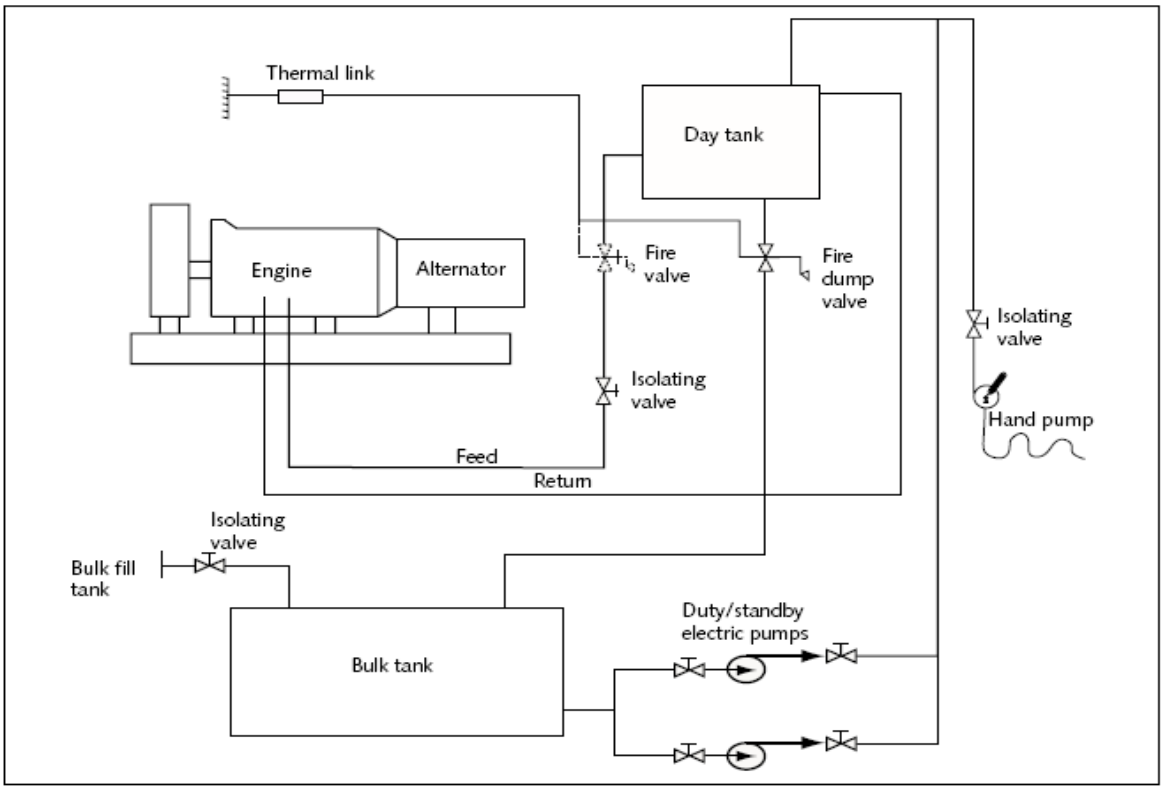

Figure 25: Fuel day and bulk tanks with dual pumps and fire dump

Exhaust systems

8.90 The exhaust system associated with a generating set should include a silencing system that reduces the noise level to acceptable limits at the point of discharge. Due consideration should also be given to the position of the discharged gases with regard to smell and gas condensation temperatures. The engine exhaust will be the hottest part of the generating set and will operate in the region of 450°C at full load. The system should be lagged where it is considered to present a safety hazard or heating problem. Design of exhaust systems should take due consideration of the possibility of condensation from the exhaust gases at the final exit to avoid the possibility of corrosion. Where the discharge point of the gases is remote from the generating set, it may be necessary to increase the diameter of the pipework to overcome any back-pressure. Exhaust gases are a fire and pollution hazard, and are increasingly regulated, with the need to fit catalytic converters and particulate filters. Installations must comply with local regulations for environmental health, fire safety officers and local authorities, and must comply with the Clean Air Act. The final termination point of the exhaust should be kept away from any fenestration and/or air intakes.

Environmental considerations

8.91 A generating set should be configured to operate on low-sulphur fuels. Noise from standby generators can cause significant disturbance if not attenuated. Designers should address the air intake noise by suitable attenuation so that the sound pressure level in the generator enclosure is less than 85 dB(A), or operatives should wear personal protective equipment (PPE). The generator enclosure and air removal system should also be attenuated so that the sound pressure level satisfies the local environmental conditions. This will require an understanding of the night time background noise levels near the generator house. The need for PPE should be assessed, and a risk assessment should be undertaken.

8.92 The following is a list of typical conditions in a generating set that will require operational procedures to provide a safe environment:

- hot surfaces:
  - a running engine operates at approximately 90°C and the exhaust at 550°C, which requires guarding;
- rotating parts:
  - all moving parts should be protected by guards;
- batteries filled with acid:
  - leakage, venting, filling together with electrical connection and disconnection should be controlled;
  - procedure for cleaning a spill, together with controlled disposal of waste materials;

- antifreeze that can spill:
  - procedure for cleaning a spill, together with controlled disposal of waste materials;
- noise levels that typically exceed 105dB(A) in close proximity to set:
  - the use of ear protection is essential;
- electricity generation at voltages of 0.4kV or 11kV:
  - all protective cover plates should be in position.

8.93 The maintenance of a generating set will periodically result in batteries, lube oil and antifreeze requiring to be replaced. Each of these items has environmental consequences, and a safe disposal policy should be enforced that includes an audit trail documenting the controlled disposal.

9. Protection and switchgear

9.1 This chapter considers the various types of switchgear at 11kV and 0.4kV that may be appropriate for healthcare premises. It is important to review the distribution strategy (see Section 6) before selecting switchgear and protection types. This is of particular importance when making modifications to existing electrical network(s). An understanding of the implications for maintenance and the spare-part requirements should be ensured before selecting different generic types of switchgear. Detail of spatial planning for switchgear is provided in Sections 7 and 8.

High-voltage switchgear

9.2 The type of HV switchgear selected should be comparable with the type of HV substation. While this statement may seem obvious, many manufacturers are making compact ingress protection-rated enclosures for internal switchgear to be used semi-externally. Similarly, some installers are housing typical external switchgear (ring main units) inside buildings due to the competitive pressures for available land space and reduced component cost.

9.3 The main forms of HV switchgear are oil, SF_6 and vacuum, all of which can be used for a switch disconnector or circuit breaker. Switchgear assemblies (functional units) can be in the form of a single component or multiple units, linked via a busbar, to form a composite HV switchpanel. Functional units can be withdrawable, semi-withdrawable or fixed-pattern. The differences offered by each system are the compactness and opportunities for servicing or replacing faulty functional units. (Many devices include two functions: for example, disconnector and circuit breaker in one device, except that the switch is often a single-function device.)

Withdrawable units

9.4 Withdrawable units are generally truck-mounted components which sit in a specific chamber and connect between the common busbar and cableway. Withdrawable units tend to have the largest physical size of all switchgear for a given rating. The units have a very safe interlock and shutter mechanism that prevents access to live parts when the truck is removed. The truck can be located in the “cable busbar” position, “cable earth” position or “busbar earth” position, just by the relative position of the truck in the housing. To replace a withdrawable unit, the unit is lowered from its normal in-service position and wheeled away from the chamber. Withdrawable units can be replaced (with a spare unit) within half an hour. With withdrawable units it is possible to prove a circuit dead, while the truck has been removed, with the aid of a purpose-built “voltage indicating stick”. There is no equivalent method of proving a circuit dead on the other types of HV switchgear. Note that the oilswitch oil circuit breaker is only available as a withdrawable unit. Where the withdrawable unit includes electrical interlocks, the electrical interlock integrity to other

withdrawable units should be maintained when the device has been withdrawn.

Semi-withdrawable units

9.5 Semi-withdrawable units are generally frame-mounted components which sit in a specific chamber and connect between the common busbar and cableway. Semi-withdrawable units tend to have the medium physical size of all switchgear for a given rating. The units have a very safe interlock and shutter mechanism that prevents access to live parts when the unit is withdrawn from its frame. The unit only has one service position and provision for cable earthing. To replace a semi- withdrawable unit, the unit is released from its normal in-service position; fixing bolts have to be removed before the unit can be fully removed. Semi-withdrawable units can be replaced (with a spare unit) within one to two hours. In order to prove a circuit dead, specially-connected indicating lamps are connected between cable and busbar. However, there is not a 100% foolproof method of proving the lamp circuit.

Fixed-pattern units

9.6 Fixed-pattern units are frame-mounted components which sit in a specific chamber and connect between the common busbar and cableway. Fixed-pattern units tend to have the smallest physical size of all switchgear for a given rating. The units have a safe interlock and shutter mechanism that prevent access to live parts. However, the units cannot be withdrawn or used for cable/busbar earthing, as the unit only has one service position. To replace a fixed-pattern unit, the full switchpanel has to be isolated and stripped down. Fixed-pattern units will therefore take the longest time of all switch assembly types to replace. In order to prove dead, specially-connected indicating lamps are connected between cable and busbar. However, there is not a 100% foolproof method of proving the lamp circuit. Consideration should be given to the method of cable earthing where fixed-pattern units are used. Cable earths may be difficult when fixed-pattern units are used at both ends of the cable. It is also recommended that every switchpanel has a local means of earthing the busbars.

9.7 Where the switchgear device includes a circuit-breaker function, thought should be given to the type of arc-interrupting material (oil, SF_6 or vacuum) in terms of the environment, health and safety, and maintenance requirements.

9.8 Oil switchgear has a good legacy and reliability; however, any controlled or fault operation of the switchgear creates a controlled spark interrupted by the oil, which degrades the oil. Hence, the oil circuit breaker device (OCB) should be serviced after any three fault operations of the breaker. Mineral oils are not environmentally friendly, and special disposal requirements should be observed. Silicon oil is a suitable replacement for mineral oil, but the switchgear maintenance requirement remains unchanged.

9.9 SF_6 switchgear uses the properties of sulphur hexafluoride (SF_6) for arc interruption and hence is smaller than the OCB for the same rating. Under normal use, SF_6 is a colourless, odourless, non-toxic and non-flammable gas,

giving advantages for internally located switchgear. The switchgear maintenance requirements are related to a fault condition or a lowering of the gas pressure (normally held at 1 bar g). The SF_6 circuit breaker can still operate satisfactorily with a reduced gas pressure. The disadvantage of SF_6 is that the gas can dissociate and produce an odour when exposed to a high-energy spark of a fault condition. The dissociated gas can produce particulate dust and other by-products that are a skin irritant. The health and safety aspects of SF_6 have tended to drop this form of circuit breaker from favour. Where SF_6 switchgear is used, appropriate hazard signs should be fixed to the switchroom doors.

9.10 Vacuum switchgear uses a vacuum chamber to interrupt the arc generated by the circuit breaker tripping or automatically opens under fault conditions. The disadvantage of vacuum switchgear is the instability of the arc under fault conditions. As the vacuum bellows opens, the spark can collapse and remake three or four times before the energy is sufficiently lowered to effect isolation. The repetitive arcing may cause HV transients in the load circuit.

9.11 The selection of any particular switchgear type should include a review of the life-cycle costs of the respective types. However, best-practice designs are focussed on the implications of a fire arising from any explosion within the HV equipment. Equally important will be the protection type that can be used and the method of reconfiguring the HV network following a fault. The selection of the particular switchgear type should also consider the means of earthing the cable (at both ends).

High-voltage busbar sections

9.12 As mentioned in the previous section, certain switchgear types allow for earthing cables and busbars. In addition, they provide a means positively to prove dead. Where the selected type of switchgear does not allow this function, the HV switchpanel should be split into two sections separated by a cable length. If the cable terminates onto each section of the switchpanel via a disconnector circuit breaker combination, it may be possible to replicate the advantages of the withdrawable device (except, that is, the opportunity for fast replacement times).

9.13 One clear advantage of the cable link on the HV bus section is the opportunity to build a fire barrier between the two sections of the panel. Similar facilities can be achieved with two ring main units used on a common substation.

High-voltage protection devices

9.14 On HV networks, the protective devices are fuse links or relays which automatically operate local or remote circuit breakers. At high voltage the opportunities to grade fuse links and provide a level of discrimination are significantly less than those for the LV fuse link, particularly as the HV current approaches 45A (800 kVA). Relays can have very fast operating time compared with fuses, which explains why relays are the preferred protective device for voltages above low voltage, typically 50ms, 2.5 cycles (digital/numerical relays)

and for electromechanical relays 150ms (7 cycles). Time fuse links are used for some HV applications.

High-rupture-capacity (HRC) fuse links to BS2692, IEC 60298

9.15 These fuse links are suitable for fitting into HV ring main units. They are equipped with a striker pin (actuated by a small pyrotechnic device), which is used to operate a trip mechanism disconnecting all phases. The speed of the device at large currents is such that they are able to limit the current to the fault. The size of the fuse is determined by the transformer size and its inrush current (normally 12 times transformer full load for 0.1 s). The range of fuses available are from 5 A to 125 A, covering transformer sizes from 50kVA to 1,600kVA. To assist with network discrimination it is recommended that HRC fuses are limited to protection of transformers up to and including 800kVA.

Time fuse links to ESIS 12.6

9.16 Time fuse links, also known as time-lag fuses (TLF), are designed to Electricity Supply Industry Standard (ESIS) 12.6. The links are used in conjunction with a current transformer (CT) to operate an HV circuit breaker via an ac trip coil. The range of fuses available is 3A, 5A, 7.5A, 10A, 12.5A and 15A. When used with the appropriate CT ratio they can be used to protect transformers having a range from 200kVA to 2,000kVA. TLFs are normally designed to protect against overcurrent and earth faults. The yellow phase is used for earth fault protection and the fuse on this phase is either reduced or omitted; this makes grading between TLFs in series with each other very difficult.

Inverse definite minimum time (IDMT) relays

9.17 The two previous devices are current-operated only. The IDMT relay in its basic electro-mechanical form is adjustable both in the current setting known as a plug setting (PS) and a time setting known as a time multiplier setting (TMS). The relay is fed via CTs by varying the CT ratio. Plug and time settings enable the relay to be used in any part of the distribution network and in series with each other. The modern relays are electronic. These have the added advantage of more settings and curves, enabling them to mimic HRC fuses, time fuse links and LV ACBs. They can also be configured to display HV current, removing the need for ammeters. The latest IDMT relay can also be connect to BEMSs or connected to the Internet for remote interrogation or operation.

Bias differential relays

9.18 Bias differential relays are used in unit protection schemes (the trade names for these relays being “Translay” and “Solkor”). They are configured in pairs at either end of a feeder cable or at a transformer. They will only operate if the fault is within their zone of protection; all other faults will cause no action. Unit protection schemes are used on closed ring networks and on interconnectors, that is, cables connecting two sources of supply (primary and secondary).

Earth fault passage indicators

9.19 Earth fault passage indicators are devices which are connected to cable entry points on HV switchgear. They are used to indicate when an earth fault has passed through the cable. Early versions dropped a coloured disc on the unit, and the Authorised Person (HV) would then walk the system and disconnect the faulty section. The latest devices can be connected individually to a central location and used as part of an automatic restoration system.

Grading of protection systems

9.20 Grading of protection systems is carried out to ensure, so far as is possible, that only the faulty equipment is disconnected when a fault occurs.

9.21 Discrimination by time separation is achieved by making the protective devices, which all detect and respond to the fault current, progressively slower to operate the further they are from the point of fault. This is the normal method of ensuring grading on open ring or radial distribution systems using HRC fuses, time fuse links and IDMT relays. In order to ensure that grading is achieved there are typical minimum acceptable time separations between the various devices, and these are as shown in Table 5 and Figure 26. However, fixed grading margins are only appropriate at high fault levels that lead to short relay operating times. At lower fault current levels with longer operating times, typically when the HCP is supported using standby generators, relays may fail to grade correctly.

9.22 Discrimination with stability is achieved by making the protective devices detect, and respond to, only faults which require their operation, thus ensuring that only the faulty equipment is isolated. This is the normal method of ensuring grading on closed ring distribution systems using unit protection relays. As the unit protection relays detect, and respond to, only faults calling for their operation, there is no necessity to build in time delays for time separation purposes.

Network reconfiguration after a fault or outage

9.23 The HV protection system should be designed to disconnect the faulty part of the system with minimum disruption. The type of HV distribution strategy (see paragraphs 6.26–6.30) and the type of functional unit used will determine the time taken to restore supplies to the health section of the network.

9.24 A fault on a radial circuit will cause all users on the circuit to be affected until the system can be reconfigured, and any users downstream of the fault will be disconnected until the fault has been repaired. On ring circuits utilising ring main units (RMUs), users on the affected parts of the ring (depending on the position of any open point) will be disconnected until the fault is located. Normally all users will be restored after reconfiguration of the system. Protection control units are now available that will reconfigure the network automatically using fault detection systems and powered switches on RMUs and circuit breakers, restoring power in minutes rather than the normal manual restoration which can take up to an hour – even longer when staff are not in attendance.

Smaller protective device (nearer to fault)	Larger protective device (further from fault)	Minimum time separation (seconds)
HRC fuse	HRC fuse	Limited options for grading using I^2t (ie let through energy) values
HRC fuse	Time fuse links	0.2
HRC fuse	IDMT relay	0.4
Time fuse links	Time fuse links	Will not grade satisfactorily
Time fuse links	IDMT relay	0.4
IDMT relay	IDMT relay	0.25-0.3

Table 5: Time separation of protective systems

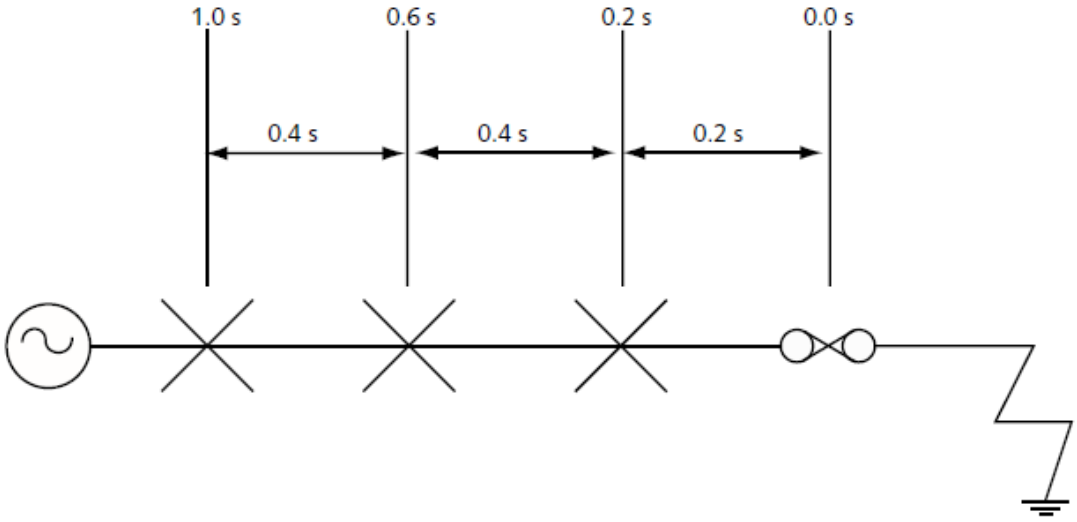

Figure 26: Progressive time separation

9.25 Networks with a closed ring topology using circuit breakers and unit protection will disconnect the section of the ring under fault, normally leaving all users unaffected.

9.26 The design of the HV protection should be consistent with the distribution strategy. The protection systems relate to the network type, and should not be the principal selection process. The advantage of using IDMT relays with adjustable settings to allow for the remodelling of the HV network is that they may also provide greater flexibility for future developments of the healthcare site.

9.27 Where the standby plant consists of HV generators, it will be essential to incorporate an automatic control system to reconfigure the network(s) after any HV fault conditions. HV protection systems that include facilities to reconfigure the network automatically should be associated with the clinical risk and business continuity assessment.

Distribution transformer types

9.28 The number and rating of transformers should be determined by the distribution

strategy (see Section 6). The transformer rating should also be selected according to the AMD, fault level, and the prospective short-circuit current (PSCC). The transformer rating should be limited to 2,000kVA. The parallel operation of power transformers is not recommended by this Scottish Health Technical Memorandum. Transformers may be operated in parallel only with due care and consideration for the increased fault level. Where more than one transformer is used in a common substation (either independent or in parallel), they should all be of the same vector group, same voltage transformation, and have a percentage impedance within 10% of each other, for example 6% and 5.4% or 6.6%.

9.29 Transformers of all types are denoted by their winding configuration, phase displacement between primary and secondary windings, and percentage impedance. The notations start with the HV winding configuration, followed by the LV winding configuration, and then phase displacement expressed in clock-hour positions. Capital letters are used to denote the higher voltage. The most common type of distribution transformer used in healthcare premises is a Dyn11. This means the primary windings are delta-connected, the secondary windings are star-connected, and the secondary windings lag the primary windings by 30°. “Zigzag” transformers have a Z as the winding notation.

9.30 Transformers used in healthcare premises fall into one of two types, defined by the method of cooling the windings. The types are fluid cooled (either mineral or synthetic oils), cast resin, and air-cooled or exposed winding type.

9.31 Transformers used for IPS units are discussed in paragraphs 16.27–16.48.

Fluid-type transformers

9.32 The windings are ideally insulated to Class F (that is, allow a 100°C differential temperature between the winding and the adjacent area). The windings are cooled by circulating oil, usually synthetic silicon oils. The oil transfers the winding heat to the external face of the transformer where it is radiated by air. This type of cooling is referred to as “oil natural circulation, air natural flow” (ONAN). Silicon oils are a dielectric fluid (K3), which are preferred because of their high flash point (greater than 300°C).

9.33 Fluid-cooled transformers less than 1,600kVA are generally hermetically sealed. This requires the transformer oil tank to take up any expansion in oil volume due to the heating. Larger oil-cooled transformers have an oil conservator located on the top of the transformer. Expansion of the oil is controlled by the volume of dried and filtered air allowed into the conservator.

9.34 Designers may wish to consider a further advantage of the oil-cooled transformer with conservator. A gas detector can be used in the conservator to operate a relay that disconnects the primary side supply if the oil contains gases caused by faults or air impurities. This type of relay is known as a “Buchholz relay”. However, the conservator and Buchholz relay tend not to be viable on transformers less than 10MVA. For transformer ratings less than 10MVA, alternatives such as the distribution strategy given in Figure 17 may be appropriate.

9.35 Where the transformer oil tank contains more than 50 litres of silicon oil, the transformer should be enclosed in a two-hour fire-compartmented enclosure. Where the fluid is a dielectric such as mineral oil (O1), high hydrocarbons (K1) or esters (K2), fire compartmentation is required with fluid capacities above 25 litres.

9.36 See paragraphs 7.33–7.50 for details of the transformer room location and construction.

Dry-type transformers

9.37 The windings are ideally insulated to Class F (that is, allow a 100°C differential temperature between the winding and the adjacent area). The resin transfers the winding heat to the transformer outer casing where the heat is radiated in much the same way as with the fluid-cooled transformer. This type of cooling is referred to as “no inner circulation and air natural flow secondary” (AN).

9.38 Cast-resin transformers may be totally enclosed in their own housing, or of the open-winding type. Clearly, the open-winding type cannot be used externally. Further safety precautions regarding access to the transformer room are required for open-winding dry-type transformers. Cast-resin transformers tend to vibrate and hum more than fluid-cooled transformers and consequently collect dust, which requires regular cleaning, say annually. (See Scottish Health Technical Memorandum 06-01 Part B.)

9.39 See paragraphs 7.33–7.50 for details of the transformer room location and construction.

Package substation

9.40 Package substations are composite units with the HV switchgear close-coupled to the transformer side. In some cases the LV switchgear is also close-coupled to the transformer. Package substations always use dry-type cast-resin transformers.

9.41 Designers and stakeholders should consider package substations, which offer a cost-effective solution in terms of the requirements and access for maintenance. Due to the close-coupled arrangement, maintenance may take longer and will affect larger parts of the systems. Care should be taken to ensure that only HV Authorised Persons (AP (HV)) have access to the HV equipment.

9.42 Package substations may provide an effective solution for dedicated single loads such as large chiller stations. Package substations may also provide effective solutions where the distribution strategy has a high resilience, such as the dual- unified network (see Section 6).

9.43 See Section 7 for details of the package substation’s location and construction.

Transformer protection

9.44 For a general overview of transformer protection systems, see paragraphs 9.14–9.27. HRC fuse links are suitable for transformers rated up to 800kVA, while TLF fuse links, which can also provide earth fault protection, are a more appropriate protection form for transformers in the range of 200kVA to 2MVA. Unit protection is not economic or effective on transformers less than 10MVA. Protection of fluid-filled transformers can be achieved with a Buchholz relay. Dry-type cast-resin transformers have a thermistor integral with the windings which will isolate the transformer on high winding temperatures caused by a fault current or other reasons. The most common faults with transformers used in healthcare premises are more to do with the cables connecting the primary and secondary windings to the network. An IDMT relay with the sensing CTs configured to give “earth fault and protection” can monitor either the HV connecting cables or the LV connecting cables. (Note that overcurrent/overload protection will be provided by the LV circuit breaker.) By connecting pilot wires between the HV and LV circuit breaker, a system known as “intertripping” can be used to ensure that no power can be supplied into the fault, regardless of the IDMT relay being on the HV or LV side.

Generator protection

9.45 Generators are essentially provided to maintain a supply when part of the internal distribution has failed, or the PES has failed. Therefore, the protection design intent should be different, and more tolerant of fault conditions, before operating any generating isolating devices.

9.46 Designers and stakeholders should consult with manufacturers regarding the generator damage curve and short circuit decrement curve before calibrating the protective devices.

9.47 The main fault condition to be considered in relation to a generator is the earth fault. Generators should be able to generate adequate fault currents to clear a system earth fault without shutting down. However, an earth fault on the local cable between the generator and network should be cleared instantly. An IDMT relay with two separate relays, one configured for restricted earth fault (REF) and the other affording overcurrent and overload protection and network earth fault protection, can be considered. However, care needs to be taken in their grading, as the generator short-circuit decrement current may influence the operation of any other IDMT relays on the network.

Low-voltage switchboards

9.48 The type of LV switchgear selected should be comparable with the type of LV substation. While this statement may seem obvious, many manufacturers are making compact IP-rated enclosures for internal switchboards to be used semi-externally.

9.49 The main feature of LV switchboard switchpanels is the form of construction

(form of separation). The forms are defined in BS EN 60439-1 and BS EN 60439-3 for final distribution boards (see Figure 27, which illustrates the main forms). Designers and stakeholders should assess the opportunities for maintenance and remodelling of the distribution when selecting the form of separation. The selection of a switchboard switchpanel form can be related to clinical risks and business continuity risks. Note that any work on a switchboard of any type should be managed under the electrical safety regulations. See Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems'.

9.50 Designers should select the form of separation for switchboards, switchpanels or final distribution boards based on the area covered and type of load connected to the outgoing circuits. Switchboards and switchpanels may serve more than one clinical function, and therefore the opportunity to isolate the switchboard switchpanel (for any form of maintenance) is reduced. A switchboard or switchpanel with a minimum form of separation (Form 4) should be used. Form 2 separation may be suitable for final distribution boards. Where space is available, all LV switchboard switchpanels should be located in dedicated electrical switchrooms, electrical risers, or plantrooms with controlled access. Where this is not achievable, electrical switchboard switchpanels should have lockable devices to prevent unauthorised access or interference. See Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems'.

Form 2

9.51 Form 2 assemblies are enclosures that provide protection against contact with any live parts and provide internal separation between the busbar and functional units, but there is no separation between individual functional units. Compliant variations include insulated or non-insulated busbars, cable terminations separated or not separated from the busbar but not from the functional units. Each functional unit should have a facility that enables it to be locked in the off (de-energised) position (see Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems'). Final distribution boards with Form 2 separation are an acceptable standard.

Form 3

9.52 Form 3 separation units are available. However, by considering the merits of distribution boards and switchpanels with Form 2 and Form 4 separation respectively, such units have little advantage within a healthcare environment.

Form 4

9.53 Form 4 assemblies are enclosures that provide protection against contact with any live parts and provide internal separation between the busbar and functional units and between functional units. Cableways are also separated from each other. Compliant variations include insulated or non-insulated busbars, cable terminations separated or not separated from their respective functional unit.

9.54 The main compliant variations of Form 4 switchboards, switchpanels are how the external cables are terminated (glanded-off). Cables can be glanded-off at the switchpanel frame, with conductors terminated in a common cableway, or separated from the cableway. Alternatively, the cables can be brought into the switchpanel and glanded-off at individual gland boxes associated with one functional unit. Each functional unit should have a facility that enables it to be locked in the off (de-energised) position (see Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems').

Motor control centre (MCC)

9.55 Motor control centres tend to include an LV protection section and a control section. Control technology continues to advance, from electromechanical devices to pneumatic controls to electronic numeric controls and so on.

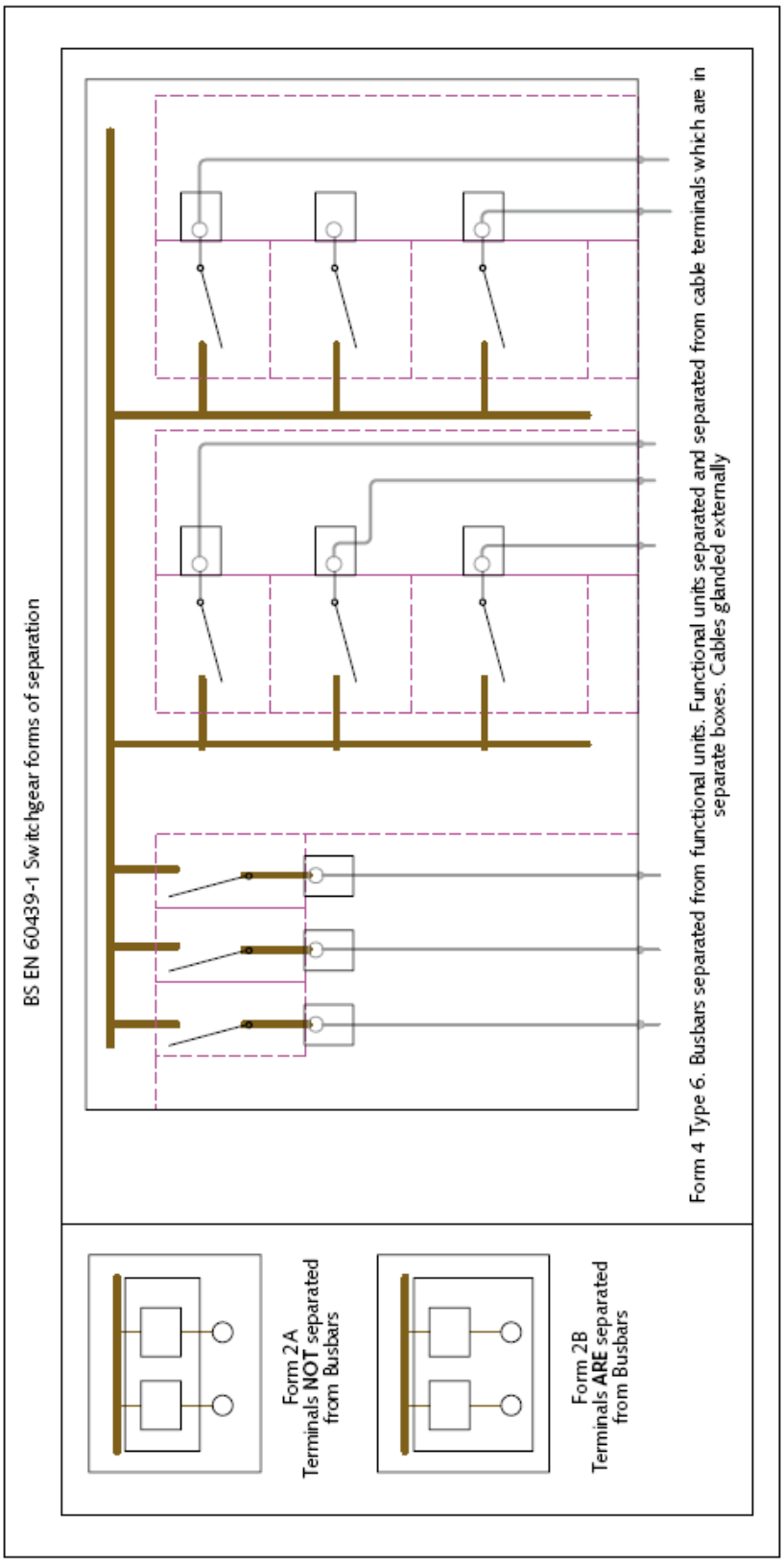

Figure 27: Forms of separation

9.56 Designers should therefore consider the main safety requirements and opportunities to isolate small sections of the MCC. Best-practice solutions separate any LV protection devices from the control section, making the two sections a minimum of Form 3 separation. Within the LV section, the form of

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separation should be at least Form 4. Where the protection and control sections are in one composite panel, it should be possible to open the control section without providing direct access to the protection section.

9.57 An MCC should be located within a plantroom (which itself has controlled access). The supply to the MCC should be limited to 250 A, in accordance with BS EN 60439-3.

Final distribution boards and consumer units

9.58 Consumer units and distribution units (DBUs) do not fall into the same forms of separation construction requirements of BS EN 60439-1. Their requirements are identified in BS EN 60439-3.

9.59 DBUs should be located within dedicated electrical switchrooms, risers or plantroom areas. Where this is not practical, the DBUs should have a local device to prevent unauthorised access, or be surrounded by a lockable cupboard.

9.60 The benefits of remodelling and design flexibility cannot be understated when selecting switchboard switchpanel forms. Standardising on one form, particularly when the building is large, has significant merits. Form 4 type 1 switchboards which have separate compartments for insulated busbars and each functional unit, with cables glanded-off externally to the panel frame and conductors terminated within the respective functional unit, may provide best-practice solutions for healthcare premises with clinical risk categories 1, 2 or 3. Form 4 type 6 switchboards have separate compartments for busbars and each functional unit, with cables glanded-off externally to the panel frame and conductors terminated in termination boxes external to the respective functional unit but in a common cableway. These may provide best-practice solutions for healthcare premises with clinical risk categories 4 or 5.

Low-voltage protection devices

9.61 The type of LV switchgear selected should be comparable with the type of LV substation. While this statement may seem obvious, many manufacturers are making compact IP-rated enclosures for internal switchgear to be used semi-externally.

9.62 The main forms of LV switchgear are air circuit breaker (ACB), high rupturing capacity (HRC) fuse, high breaking capacity (HBC) fuse, moulded-case circuit breaker (MCCB), miniature circuit breaker (MCB) cartridge fuse, and rewireable fuse. These forms of protective device can be assembled in the moving part or fixed part of the respective switchgear. Assemblies can be in the form of a single component or multiple units, linked via a busbar, to form a composite LV switchpanel. Switchpanel components can be withdrawable, semi-withdrawable or fixed-pattern. The difference offered by each system is the compactness and opportunities for servicing or replacing faulty components. In spite of the switchgear-type name, many devices include two functions, for example a disconnector and circuit breaker in one device, except that the “switch” is often

a single-function device.

Switch

9.63 A switch is a mechanical device that can carry and break a current under normal circuit conditions. The switch may be modified to allow for automated operation by other protective devices. A switch may not provide adequate separation distance between disconnected parts of a circuit conductor.

Disconnector

9.64 A disconnector is a mechanical device that carries the design current for its intended purpose. A disconnector cannot break a normal current nor make or break a fault current. The disconnector will provide adequate separation distances between disconnected parts of the circuit conductor.

Fuse

9.65 A fuse can provide the fundamental function to rupture a fault current that may flow in a correctly designed electrical circuit. The fuse can provide overcurrent protection and fault current (both short-circuit and earth fault) protection. The fuse has different characteristics, making it suitable for a range of electrical loads, for example the general range and motor range.

Circuit breaker

9.66 The circuit breaker is a more advanced form of protective device than the standard fuse. The fusing element can have a tolerance range to delay the rupturing action. The circuit breaker is available in five basic formats for LV circuit protection:

- air circuit breaker – ACB;
- moulded-case circuit breaker – MCCB;
- miniature circuit breaker – MCB;
- residual current device – RCD;
- residual current breaker with overcurrent – RCBO.

9.67 The fusing elements of all types of circuit breaker have two parts: a current transformer providing adjustable electromagnetic setting, and a bimetal strip providing adjustable thermal setting. Note that some smaller MCBs do not have an adjustable range, but still operate with a tolerance range.

9.68 The RCD provides protection against earth leakage, with typical ranges at 10mA, 30mA, 100mA, 150mA and 300mA.

9.69 The RCBO is a combination protective device of the MCB and RCD functions. However, the earth fault sensing element of 150mA and 300mA are not normally available in this combination.

9.70 MCBs and RCBOs have a range of characteristic curves, Type A, B, C or D (earlier devices were 1, 2 and 3). The separate RCD devices only sense an earth leakage current. RCBOs and RCDs used in medical locations should be type A or B and should have a tripping current of 30mA.

9.71 The design should consider the selected protective device that will clear overload currents and short-circuit faults within the prescribed disconnection times of BS7671: 2008. Clearly, the protective device rating and disconnection times are related to the earth fault loop impedance. Designers should consider the use of RCBOs or RCDs where the earth loop impedance cannot generate sufficient earth fault currents to operate the protective device within the appropriate disconnection times (5 seconds for stationary equipment and 0.4 seconds for portable equipment). Designers should be mindful of the earth leakage current that may flow in the protective conductor under normal conditions.

9.72 Designers may wish to consider the use of RCBOs/ RCDs for areas where the natural environment may be damp and hence the body contact resistance may be lowered. Such areas will include laboratories, kitchens and workshops.

9.73 Designers may wish to consider the use of RCBOs/ RCDs for dedicated cleaners' sockets.

9.74 Designers should be mindful that RCBOs may be subject to nuisance tripping caused by the occasional high earth leakage currents that may be generated when equipment is switched on.

Low-voltage busbar sections

9.75 Where the LV distribution strategy includes for dual-unified circuits supported by two 100%-rated transformers, it may be useful to link the two sections of the main LV switchpanel via a "bus coupler-bus-tie". However, maintenance access to the bus coupler may require the full isolation of the switchpanel. Although such devices have very low maintenance requirements, it may also be useful to consider splitting the LV switchpanel into two sections, linked by a cableway and two ACBs. An advantage of such an arrangement may be to install a fire barrier wall between the two sections. Designers and stakeholders should see this as an expensive option and carefully assess the merits accordingly.

Discrimination of protective devices

9.76 The IEE Regulations BS7671: 2008 require that the characteristics and setting of a protective device for overcurrent should provide any intended discrimination within its operation. While the regulations do not call for discrimination for fault currents, by default a protective device should so discriminate.

Discrimination with HBC/HBC fuses

9.77 HBC fuses will conform to the requirements of BS88.

9.78 Discrimination will ensure that the total let-through energy (I^2t) of the minor (downstream) device is not greater than the pre-arcing energy ($I^2t_{(pa)}$) of the major (upstream) device. Where the protective device has an operating range (MCB, MCCB), it is important to check that the normal operating current (I_n) of the major device is greater than *x* times the prospective short-circuit current at the downstream protective device in question (where *x* equates to the multiplying factor applied to the downstream device; see BS EN 60898-2).

Discrimination with MCB/MCCB

9.79 The MCB (or MCCB) device can provide discrimination for overload and fault current between the upstream and downstream device. In order to provide overload protection, the nominal current setting (I_n) of the upstream device should be greater than the instantaneous rating of the downstream device (which will be *x* times I_n according to the MCB type). In order to provide discrimination of fault currents (both short-circuit and earth fault), knowledge of the prospective short-circuit current (PSCC) and earth fault current is required. Discrimination will occur if these values, for the downstream device, are less that the nominal current setting of the upstream device. Manufacturers' advice should be obtained for the actual let-through energy (I^2t), which will also determine the discrimination of series MCBs.

9.80 The use of MCBs on some final circuits may cause nuisance tripping; for example using MCBs (or RCBOs) on fluorescent lighting circuits, where the non-linear transient current of the inductive control circuit may cause early tripping of the protective device through its internal CT. Consideration should therefore be given to using an RCBO/RCD with earth leakage characteristics of type A or B.

Discrimination with MCB/fuse

9.81 Discrimination between a fuse (as the upstream protective device) and an MCB for the downstream device may occur if the lower instantaneous operating current (range) of the MCB crosses the tripping curve of the fuse above the prospective fault current level and earth fault current level of the downstream device. Discrimination checks should be made based on the manufacturers' declared let-through energy (I^2t). See Table 6.

Discrimination with RCDs

9.82 RCDs will provide earth fault protection. In order to discriminate between two RCDs as the upstream and downstream protective devices, designers need to use the time-delay setting on the upstream device.

9.83 Designers may wish to consider that full discrimination may not be required on all circuits. Opportunities exist to take advantage of a grading between fuse element curves. Where the discrimination is a little uncertain and the risk of such relative high fault currents is low, the circuit is said to have "limited" discrimination and may be acceptable. The advantage here would be the reduced size of protective devices, especially with the more upstream devices.

Automatic load management of switchgear (HV, LV)

9.84 The electrical infrastructure and distribution strategy may minimise the effect of an electrical fault to the clinical risk areas, but the most resilient system will not totally eliminate the risk. The fundamental reasons electrical systems have protective devices is to limit the effect of a fault. Effective discrimination (see above) and correct selection of protective devices will isolate the smallest appropriate section of the infrastructure. Best-practice distribution strategies may provide an alternative supply route which could be initiated more quickly or safely than replacement of a protective device.

9.85 The distribution system may initiate the standby generator plant until the fault is rectified or isolated. The reconfiguration of an electrical network (whether the system is a dual-unified supply or segregated supply) may be made manually or automatically.

9.86 Where the network is an HV ring circuit (open or closed), the operation of a protective device may result in the standby generators supplying some areas.

MCB type	Nominal current (I_n)	Overload characteristics	Instantaneous Tripping range	Instantaneous Tripping
B	All	1.45 I_n	3 I_n to 5 I_n	5 I_n
C	All	1.45 I_n	5 I_n to 10 I_n	10 I_n
D	All	1.45 In	10 I_n to 20 I_n	20 I_n

Table 6

9.87 Healthcare premises with significant sections of clinical risk (Category 3 areas and above) may benefit from quick reconfigurations of the electrical distribution following a fault on the network. Therefore the use of a supervisory control and data acquisition (SCADA) computer system to control automatically the switchgear status and reconfigure the network(s) would be useful. SCADA systems are modular in design and may be added to retrospectively. The SCADA system can be applied to any part of the HV and/or LV networks including all power sources.

9.88 SCADA systems should be hard-wired with monitored circuits wherever they are used.

10. Tertiary power supplies

10.1 Tertiary power supplies (TPSs) should not be considered as a long-term energy source in the same way that primary power or secondary power units are. TPSs are generally used as a back-up supply for a given period of time (autonomy) or to start SPSs. The batteries considered are those used for uninterruptible power supplies, battery inverter units and batteries used to start standby generator engines.

10.2 Batteries used in control systems, such as motor drives on switchgear, have been excluded from this Scottish Health Technical Memorandum. Likewise, batteries used for electric vehicles are also excluded from the content of this Scottish Health Technical Memorandum. The foregoing exclusions are justified, as their respective systems do not form part of the fixed wiring systems of healthcare premises.

Batteries for uninterruptible power supplies

Battery type

10.3 There are a number of battery cell types in use today for UPS applications. The most appropriate are the valve regulated lead acid (VRLA) battery types, which are more commonly known as sealed lead acid cells. The VRLA battery is a near-zero-gassing battery cell, and hence presents a lower environmental hazard to the UPS or surrounding area. With no toxic gasses emitted from the battery, there are no special venting requirements for the battery unit. The VRLA battery is almost universally used for modern UPS systems, due to their low maintenance and because of the reduced requirements for vented gas extraction, this being a serious consideration when using wet cells.

10.4 VRLA batteries complying with BS6290-4:1997 – with threaded insert connection posts, flame-retardant case materials and a ten-year-designed life – are the minimum acceptable standard. While BS6290-4, 10-year-designed-life batteries have the initial penalty of higher investment costs than standard five-year-life batteries, they offer significant long-term benefits in terms of security of function and reduced long-term costs.

Battery life

10.5 Battery life is a function not only of load cycling, but of charging methods and the environment. VRLA batteries will function for a short time period over a wide range of temperature typically from –15°C to +50°C. However, for normal continuous use their ambient operating temperature should be ≈20°C, otherwise their life expectancy will be reduced considerably, typically to 50% at 30°C and to 25% at 40°C. Continued operation at high temperatures also may bring fire danger due to case splitting and resultant acid spillage, which in turn may result in uncontrolled battery dc earth faults. It is therefore very important that the

battery location has a suitable environment with adequate ventilation/cooling to maximise battery life. Note that in practical terms, even with the recommended regular maintenance, VRLA batteries are normally changed at 80% of their designed life. Battery life should be in accordance with the range in Table 4.

10.6 Correct charging of VRLA batteries is very important, and should be with low or minimum ac ripple and typical charge values of 2.27V per cell. At elevated temperatures, it is necessary to reduce the battery charge voltage to below 2.27V per cell to prevent over-charging.

Battery arrangements

10.7 Designers should consider the opportunities for maintenance of the UPS battery assembly. Batteries can be arranged as single or split banks. The use of split battery banks allows the UPS to remain online (at reduced battery autonomy) while half of the battery system is being serviced.

Battery autonomy

10.8 Single-conversion UPS units are generally used for small personal computers or computerised processors dedicated to medical/laboratory equipment, such as blood gas analysers. Battery autonomy is typically in minutes up to say 15 minutes, depending on the particular application. Designers should consult with staff for the actual requirement. Single-conversion UPS units are most commonly used to shut down safely systems safely following an outage of the PPS, or depending on the particular need, between the period of mains failure and SPS standby generators becoming available. The battery autonomy for single-conversion UPS units should be less than 30 minutes.

10.9 Double-conversion UPS units are most commonly used for TPS to dedicated final circuit outlets, used for example in clinical risk Category 4 or 5 areas. The most usual application of a double-conversion UPS is to provide tertiary power to IPS systems, particularly those for the IEC 60364-7-710 Group 2. The batteries maintain an electrical supply following an outage of the PPS and prior to the SPS standby generators becoming available. Where the UPS battery provides TPS to non-operating-theatre low-power applications, the battery autonomy should give clinical staff with enough time to start “hand bagging” or connecting supplementary equipment battery packs. Consequently, battery autonomy of 15–30 minutes may be appropriate. Where the UPS battery provides tertiary power to operating theatre low-power applications, the battery autonomy should give operating theatre staff enough time to facilitate “patient closure” for all theatre cases. Consequently, battery autonomy of 60 minutes may be appropriate.

10.10 Clearly, designers should consult with stakeholders and clinical staff to determine the most appropriate battery autonomy.

Batteries for inverter units

Battery type

10.11 See paragraphs 10.3–10.4.

Battery life

10.12 See paragraphs 10.5–10.6.

Battery arrangements

10.13 Three main types of battery inverter unit are used in healthcare premises. Batteries within the self-contained emergency escape lighting and signage are generally in small packs with cells connected in series or parallel series groups. Their physical size allows these battery packs to be replaced in a single step, taking only minutes. Batteries for either the central emergency escape lighting signage or operating theatre operating lamps are housed in cabinets and connected in parallel-series cell groups. Battery maintenance is achieved by disconnection of any one parallel group. Designers should consult with manufacturers to ensure that the optimum number of parallel cell groups is provided to minimise the reduction of battery autonomy during replacement.

10.14 Designers should consider the opportunities for maintenance of the inverter units' battery pack. Batteries can be arranged as a single or split bank. The use of split battery banks allows the inverter units to remain online (at reduced battery autonomy) while half of the battery system is being serviced.

Battery autonomy

10.15 Four main types of inverter unit are used in healthcare premises. Battery inverter units used for self-contained emergency escape lighting and signage have a three-hour battery autonomy as required by BS EN 1838, BS5266-7. Central battery units for emergency escape lighting should also have a three-hour battery autonomy.

10.16 Battery inverter units for theatre lamps should have a minimum of three hours' battery autonomy.

10.17 Battery inverters used for fire alarm and detection systems, or other alarm systems, should have sufficient autonomy to drive the systems (in quiescent mode) for 24 hours, followed by a 30-minute period where all sounders, indicators and communications are operated with the normal sound pressure level outputs. For a healthcare facility that may be closed over a weekend and bank-holiday period, an autonomy of 100 hours may be more appropriate. This requirement is independent of any secondary power supply (SPS) that may be available.

Generator batteries

Battery type

10.18 See paragraphs 10.3–10.4.

Battery life

10.19 See paragraphs 10.5–10.6.

Battery autonomy

10.20 Generator batteries are normally specified for *x* Ampere Hours (AHr), where the battery capacity *x* should be able to provide sufficient power when discharged by 25% to attempt three successive starts each of ten-second duration with a three- second interval, while the ambient temperature is 0°C. Generator battery systems should be capable of turning the generator engine continuously for 60 seconds at an ambient temperature of 0°C.

10.21 Usually two battery-charging systems are supplied with a generating set: the constant charger is a charger for operation while the set is stationary, usually in the control panel; and a belt-driven charge alternator maintains the battery when the set is running.

10.22 For both charging systems the battery should be charged at the correct float voltage, and for engine starting the battery should be adequately sized for the breakaway (initial starting) voltage to be acceptable to the engine manufacturer.

11. Electromagnetic compatibility

Standards

11.1 The Electromagnetic Compatibility (EMC) Regulations enact the requirements of the EMC Directive for the UK. From the UK Regulations, regulations 28 and 30 require that those who supply relevant equipment should show that:

- it conforms with the protection requirements;
- it meets the conformity assessment requirements;
- the CE marking is properly applied;
- it has an IEC declaration of conformity certificate.

11.2 Regulation 29 requires that no person should take into service relevant equipment unless it conforms to the protection requirements. For example, equipment covered by the EMC directive is taken into service when the end-user that operates the equipment, for example a building management system, first uses it. “Taking into service” does not include the area of energising, testing and commissioning of the equipment by the manufacturer before handover to the end-user. The equipment manufacturer will be in a position of overall control in ensuring that the essential protection requirements are satisfied, and assumes legal responsibility for compliance. Data should also be provided for the end-user to ensure that these requirements are satisfied throughout the operational life of the equipment.

11.3 From the point of view of the legislation, it is not sufficient to integrate CE-marked equipment and claim that the large “system” hence complies because compliant equipment has been used. Compliance of the large “system” should be demonstrated either by testing and/or by presentation of a rationale as to why the system complies.

Procurement requirements

11.4 Problems from electromagnetic interference (EMI) will be minimised by procuring equipment that complies with relevant standards, is supplied with a relevant EMC declaration of conformity (DOC), and is installed and maintained using good EMC practices.

11.5 It is essential that those designing and specifying equipment for use in the NHS environment must give their relevant purchase departments an EMC specification that is sufficiently detailed that suppliers are made aware of their contractual obligations with respect to EMC.

11.6 Procurers, system integrators and designers should be knowledgeable about the EMC performance levels that equipment is expected to meet when correctly installed and operated. To be able to distinguish between the requirements and

declarations of compliance statements for the various directives, a procurement document should be written that covers the various directives.

11.7 As a first step, EMC requirements should consider appropriate standards; a selection is provided in Tables 7 and 8. The standards are a selection for equipment that may be expected to be present in healthcare premises. This is not an exclusive list, and as standards evolve over time, the relevant websites should be consulted for changes. A complete list of all regulations quoted in this Scottish Health Technical Memorandum can be found at the end of the document.

11.8 As well as helping to set the environment, standards are used to show compliance with the EMC Directive and with UK regulations. For equipment to be legally sold within Europe, the equipment must comply with harmonised standards, reference to which has been published in the Official Journal of the European Union (OJEU). Again, reference to the European Union's website will help identify those standards that have been referenced in the OJEU.

BS EN 12015:2004	Product family standard for lifts, escalators and passenger conveyors-emissions
BS EN 12016:2004	Product family standard for lifts, escalators and passenger conveyors- immunity
BS EN 45502-2-1:2003	Active implantable medical devices. Particular requirements for active implantable medical devices intended to treat bradyarrhythmia (cardiac pacemakers)
BS EN 62040-2:2006	Uninterruptible power systems (UPS). Electromagnetic compatibility (EMC) requirements
BS EN 50098:1999	Customer premises cabling for information technology; Part 1: 1999: ISDN basic access; Part 2: 1996: 2048 kbps ISDN primary access and leased line network interface
BS EN 50130-4:1996	Product family standard – Immunity requirements for components of fire, intruder and social alarm systems
BS EN 50173-1:2002	Information technology. Generic cabling systems. General requirements and office areas
BS EN 50174:2001	Information technology. Cabling installation; Part 1: 2001: Specification and quality assurance; Part 2: 2001: Installation planning and practices inside buildings; Part 3 (draft for comment): 2002: Installation planning and practices outside buildings
BS EN 50310 2000	Application of equipotential bonding and earthing in buildings with information technology equipment
BS EN 55015:2001	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
BS EN 55022:1998	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurements
BS EN 55024:1998	Information technology equipment – Immunity characteristics – Limits and methods of measurements
BS EN 60947 (1996-2003)	BS EN 60947: Specification for LV switchgear and control gear (8 parts)

Table 7: EMC standards

BS EN 61000-3-2:2006	BS EN 61000-3-2:2006. Electromagnetic compatibility (EMC). Limits. Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
BS EN 61000-3-3:1995, IEC 61000-3-3:1994	Electromagnetic compatibility: Limits. Limitation of voltage fluctuations and flicker in LV supply systems for equipment with rated current ≤ 16 A
BS IEC 61000-3-4:1998	Electromagnetic compatibility. Limits. Limitation of emission of harmonic currents in LV power supply systems for equipment with rated current greater than 16 A
BS EN 61000-3-11:2001, IEC 61000-3-11:2000	Electromagnetic compatibility. Limits. Limitation of voltage changes, voltage fluctuations and flicker in public LV supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection
BS EN 61000-6-1:2001	Generic Standards – Immunity for Residential, commercial and Light industrial Environments
BS EN 61000-6-2:2005	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments
BS EN 61000-6-3:2001	Generic Standards – Emission for Residential, Commercial and Light Industrial environments
BS EN 61000-6-4:2001	Generic Standards – Emission for Industrial Environments
BS EN 61547:1996, IEC 61547:1995	Equipment for general lighting purposes. EMC immunity requirements
BS EN 61800-3:2004	Adjustable speed electrical power drive systems – EMC product standard including specific test methods

Table 7 continued: EMC standards

Type of equipment	Applicable standard(s)
Access control units	Generic for emissions BS EN 50130-4:1996
Air handling units	Generic
Audio amplifiers	Generic
Battery charger	Generic
Boilers	Generic
CCTV control panels	Generic but not BS EN 55022/BS EN 55024
Chillers	Generic
DRUPS	BS EN 62040-2
EDS	BS EN 61000-6-2 BS EN 61000-6-4
Extract fans	Generic
Fire detection and voice alarm system	BS EN 50130-4:1996 BS EN 50270
HV switchgear	Generic
HVAC control system	BS EN 60730-2
ISM equipment	BS EN 55011 BS EN 55014-1 BS EN 55014-2
IT equipment used in BMS/EMS, CCTV, access control, intruder alarm, and fire detection systems	BS EN 55022 BS EN 55024
Lifts	BS EN 12015-2004(emission) BS EN 12016:2004(immunity)
Lighting equipment	BS EN 55015:2001 BS EN 61547:1996, IEC 61547:1995
LV switchgear	BS EN 60947
Power distribution units	Generic
Water pumps (for either potable or fire water)	Generic

Table 8: EMC standard by equipment type

EMC phenomena

11.9 EMC phenomena are divided into radiated and conducted aspects, and a special case for electrostatic discharge (ESD), that is, radiated emissions, conducted emissions, radiated immunity and conducted immunity.

Standards and levels

11.10 In any analysis of the healthcare environment or for setting procurement requirements for equipment to be installed in those environments, the first reference is to EMC standards. Those standards that are specific to the health environment will have included in them the relevant phenomena that the equipment can be expected to operate to.

11.11 Given the information in Tables 9–11, the system designer who is advising on the type of equipment for procurement and/or installation should advise the suppliers of the relevant standards for any compliant equipment.

Specification	Frequency (MHz)	Limit (dB(uV/m))	Comments
BS EN 61000-6-3	300-230/230-1000	30/37	
BS EN 61000-6-4	30-230/230-1000	40/47	
BS EN 12015	30-230/230-1000	40/47	
BS EN 50130-4	30-230/230-1000	30/37	
BS EN 55015(1)	0.009-0.07 0.07-0.15 0.15-2.2 2.2-3 3-30	88 (1) 88-58 (1) (2) 58-26 (1) (2) 58 (1) 22 (1)	Measured in a 2 m diameter loop
BS EN 55022	30-230/230-1000	30/37 40/47	Class B Class A
BS EN 62040-2.2006	30-230/230/1000	30/37 40/47	Class B Class A
BS EN 61800-3	30-230/230-1000	30/37 40/47 40/47 40/47	First environment Unrestricted <25 A Restricted <25 A Unrestricted >25 A Restricted >25 A

Table 9: Radiated emissions levels for some typical equipment standards

Notes:

(1) Conducted emissions on AC port.

(2) Conductor disturbances.

Specification	Frequency (MHz)	Modulation (% AM)	Applied test level (V)			
			Power port	Signal port	Functional earch	
BS EN 61000-6-1	0.15-80	80% 1 kHz	3	3	3	
BS EN 61000-6-2	0.15-80	80% 1 kHz	10	10	10	ITU bands: 3 V
BS EN 12016	N/A	N/A	N/A	N/A	N/A	
BS EN 50130-4	0.15-100	80% 1 kHz	10	10	N/A	CCTV: 3 V
BS EN 55024	0.15-80	80% 1 kHz	3	3	N/A	
BS EN 62040-2:2006	N/A	N/A		N/A	N/A	
BS EN 618000-3	N/A	N/A		N/A	N/A	
BS EN 61547:1996, IEC 61547:1995		80% 1 kHz		N/A	N/A	

Table 10: Conducted immunity levels for some typical equipment standards

Specification	Discharge (kV)	
	Air	Contact
BS EN 61000-6-1	8	4
BS EN 61000-6-2	8	4
BS EN 12016	8	4
BS EN 50130-4	8	6
BS EN 55024	8	4
BS EN 62040-2:2006	8	6
BS EN 61800-3	8	6
BS EN 61547:1996, IEC 61547:1995	8	4

Table 11: Electrostatic discharge (ESD) test levels for some typical equipment standards

Electromagnetic environment

11.12 The environment within a building is made up of sources that are located within the building (that is, equipment that is the source of electromagnetic radiation, for example transformers, MRI suites) and sources that are generated externally to the building. The external sources will usually be intentional transmitters, together with strong radiating unintentional transmitters such as railways (see Table 12).

Frequency (MHz)	Description
70-85	Fire and rescue radio
122.15	Air band communications
153.675	Pagers
170.65	PMR mobiles
197.325	PMR mobiles
427.7	PMR base station
461.65	PMR mobiles
380-420	TETRA
450	Police radio
486-606	TV broadcasting band
903-951	GSM
1812-75	DCS base station
2144.25	3G UMTS base station

Table 12: Electromagnetic sources

11.13 Emergency services' mobile units (PMR and TETRA) will also be present, as these operate at much higher transmission levels than GSM mobiles and can be expected to be present in the non-specialist areas of healthcare premises, that is, clinical risk categories 1–3 inclusive. Building and system control panels located in corridors will be subject to these higher levels.

11.14 In hospitals particularly, cable lengths in excess of 30m, running either horizontally or vertically, will be encountered. These lengths are ideal for picking up and conducting frequencies up to around 400MHz. System designers should always consider the use of screened cables, metal trunking and cable ladders to minimise interference into plant or building systems equipment.

Designing systems for EMI control

11.15 Electromagnetic interference (EMI) does not stop at interfaces, either conducted on cables or radiated. The positioning of M&E systems within the building has the potential to affect the performance of other installed systems.

11.16 The electromagnetic environment should be divided into zones where equipment will be compatible for both emissions and immunity. At boundaries, a risk assessment will be required to determine whether mitigation measures need to be implemented to reduce the potential cross-boundary interference.

EMC control for power systems

11.17 Uninterruptible power supplies (UPS) and battery rectifiers are a source of mains-injected harmonic interference. For this reason, they should be located in zones away from equipment which may be affected by their emissions, for example IT systems.

11.18 Power transformers are a concentrated source of low-frequency magnetic interference. For each type, their location and cubicle screening should be

considered in relation to sensitive equipment (that is, those likely to be affected by radiated magnetic fields). This particularly applies to theatres where cathode ray tube systems are used, as on-screen distortion effects will occur.

11.19 The influence of the transformer and the route of unscreened or single-core main LV cables should not be ignored. There may be magnetic coupling with the steel and reinforcement bars of the building structure, thus inducing a network of currents flowing in the steel to earth with associated localised secondary magnetic fields.

EMC control for cables and cable-containment systems

11.20 Single-phase power cables, including power feeds and lighting circuits, carrying up to 250V should not be grouped with sensitive cables (that is, data cables).

11.21 No data, telecommunications or any other sensitive cabling should be placed near three-phase cables, as these are normally used for heavy electrical inductive loads, for example air-conditioning, welding equipment and motors.

11.22 All cabling should avoid any close proximity to radio or television transmitters, beacons and overhead transmission lines.

11.23 Cables carrying high-level impulse energy produce a large frequency distribution of disturbances due to their fast rise times. Special precautions need to be taken with these types of cabling: efficient screening, clean earthing at both ends, and an increase in the separation with adjacent cables would need to be implemented.

11.24 All cables should be terminated whenever possible in accordance with their intended terminating impedance.

11.25 The characteristic impedance of cables should be selected to match closely the impedance of the terminating equipment. This reduces the amplitude of standing waves created by reflections due to mismatches in impedance transition.

11.26 All power-cable screens or armour should be bonded at both ends of the run to an earth plate using 360° peripheral glands.

EMC control for general systems

11.27 Personal transmitters/receivers, main transmitters and local radar devices should be evaluated to ensure that they do not cause random operations or failure of electronically controlled equipment. Personal transmitter/receivers are particularly likely to cause this problem.

11.28 Checks should be made with these devices on all new plant installed, at a convenient time, to ensure there is no susceptibility.

Intentional apertures

11.29 Apertures are always required in rooms to allow services to enter and leave. Rooms that are required to have a screen to prevent electromagnetic interference (EMI) in the healthcare environment, rarely require the same performance as a screened room used for EMC measurements. However, the same techniques for screening apertures can be used to allow services to enter.

11.30 Where holes in the shield are essential for such items as ducting, pipework or cables, the hole should be filled by placing a mesh screen over the hole and ensuring that the duct, pipework or cables are electrically connected to the mesh screen.

11.31 A mesh screen has an attenuation determined by the size of the largest hole in the mesh. It is better to use a number of similar size apertures to run multiple items through the mesh, than one large aperture that takes all the items required to go through the screen.

11.32 If a large aperture is unavoidable, the principle of using a “waveguide beyond cut-off” can be used (see Figure 28, below). Using this type of aperture will enable cables etc to pass through, although attenuation performance is reduced. Multiple waveguides should be used (see Figure 29) where many services need to pass through a screening shield.

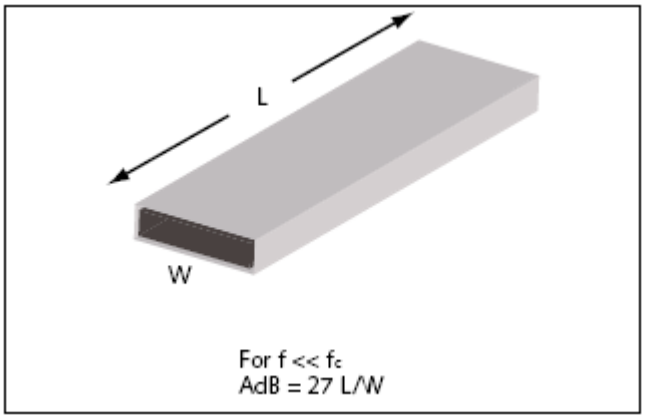

Figure 28: Single waveguide

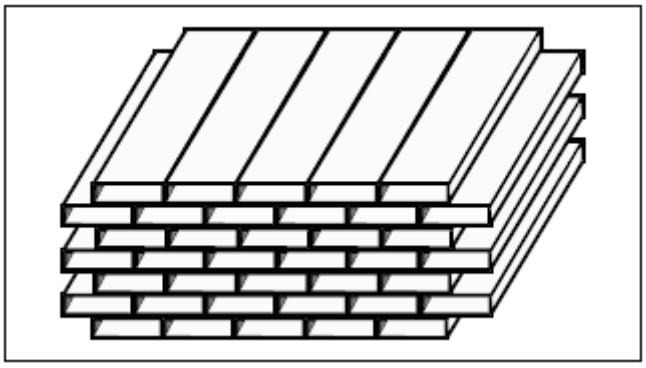

Figure 29: Waveguide array

11.33 Where screened cables need to penetrate through a screen, conductive cable penetration blocks (see Figure 30 overleaf) should be considered to maintain

the continuity of the cable screens and screened room.

Figure 30: EMC compliance measures

Cable segregation and separation

11.34 To reduce the possibility of power-cable to signal-cable coupling and the associated EMC risks, the best approach is to use separation between power and sensitive service cables. It is advised to run fire alarm cables in a separate conduit from other service types. Signal and telecommunications cables should not be run in the same tray as power cables. Table 13 indicates the separation distances between power and signal cables, where the cables are not screened or screened at their respective voltage level.

11.35 Attention is drawn to the fact the screening should be bonded to an earth return at both ends of the cable.

Cable screening, trunking and trays

11.36 Various types of cable tray or conduit may be used and run in parallel over an appreciable distance. The crosstalk between the cables they contain may be important. The recommended separation distance between the cables in the trays depends on two parameters:

- the quality of the cable tray as protective earth conductor (PEC);
- low transfer impedance (high shielding effectiveness).

Crosstalk characteristics

11.37 Cables with a low crosstalk may require shielding against the (magnetic) fields causing the crosstalk currents.

11.38 Using trays or racks of sufficient wall thickness to separate cables can provide both PEC and reduction in crosstalk. They can often be laid next to each other. Another solution is to keep some distance between shallow conduits for the different types of cable, for example by stacking them (see Figure 31 overleaf).

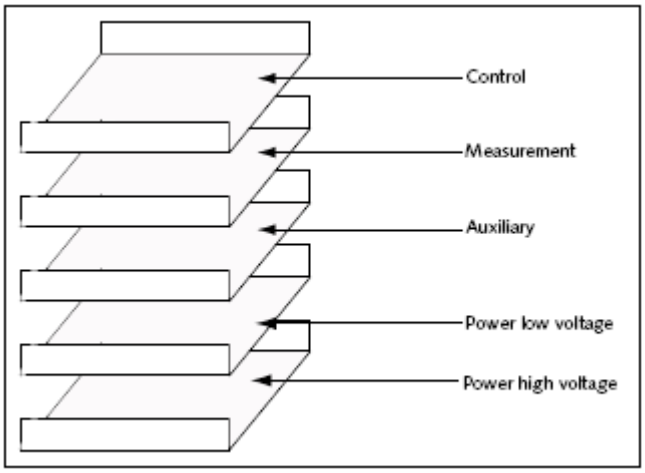

Figure 31: Stacking cable trays to avoid crosstalk

11.39 Cable-tray stacking achieves a combination of separation of segregated cable types with the additional benefit of screening introduced by the trays themselves. Solid trays with no gaps are the ideal tray type for this application. Trays often have slots for easy attachment of cables; the most beneficial of these are those with a short slot parallel to the axis of the tray. Those with slots perpendicular to the tray axis should not be used.

11.40 Caged trays constructed with large gaps in the screen should certainly not be used where electromagnetic screening is an issue, as they offer no screening benefits and are generally insufficient as parallel earthing conductors.

Not enclosed environment for example on tray/basket	Minimum separation distances for various power cables (mm)		
Signal cable	**No metallic sheath or screen for example twin and earth or singles**	**Steel wire armoured**	**MICC**
Plain	**150**	**125**	**Touching**
UTP	**75 below 100 MHz**	**50**	**Touching**
Screened	**Touching**	**Touching**	**Touching**
Enclosed environment for example trunking		**Metal separator**	**Plastic separator**
Unscreened power lines, or electrical equipment and unscreened data IT lines		**150**	**300**
Unscreened power lines, or electrical equipment and screened data IT lines		**30**	**70**
Screened power lines, or electrical equipment and unscreened data IT lines		**2**	
Screened power lines, or electrical equipment and screened data IT lines		**1**	**2**

Table 13: Recommended minimum separation distance between power and signal cables

Trunking and tray interconnection and termination

11.41 When a metallic cable tray or trunking system is implemented, inevitably sections will need to be interconnected for extended runs. Particular care will be necessary in order to maintain electrical continuity between the various sections. Ideally, the parts should be welded over their full perimeter, although it is recognised that this is not always achievable in practice. Riveted, bolted or screwed joints are adequate if the contact surfaces are good conductors (there should be no insulating coating or paint). Ensure that they are safeguarded against corrosion and that good electrical contact between the separate sections can be maintained.

11.42 It is important that the shape of the metallic section should be maintained over the full length of the run. Bonding via a short earth wire connection between two sections of the tray or trunking system may have a low dc resistance, but will have high impedance to high-frequency (a few MHz upwards) currents.

11.43 This means that for extended runs the centremost sections are effectively floating at high frequencies, thus reducing performance. This has both personnel safety and EMC implications. Figure 32 shows the recommended practice for interconnecting cable trays and trunking systems.

11.44 For right-angle and corner interfaces, the same principles should be applied with L-shaped joints attaching interconnecting sections.

Using conductive structural supports as runs for cables

11.45 Metallic structural support elements in buildings can also serve EMC objectives where room for cable trays or trunking is limited. Steel beams of L-, H-, U- or T-section can form a continuous earthed structure that offers relatively large cross- sections and therefore low impedance and large surfaces with many potential intermediate connections to earth. Cables can be laid against such beams as shown in Figure 33.

Identification of critical systems

11.46 Mechanical and electrical equipment being procured currently will have been designed to comply with either the light or heavy industrial generic or product-specific standards. Such equipment will be generally immune when located in its intended environment. Designers should identify environments where levels higher than those specified in standards will be encountered, and apply mitigating measures, for example prevention of the use of mobile phones close to control systems while screening enclosure doors are open. Many M&E systems not normally considered critical are critical when their misoperation causes reduced operational efficiency, for example heating and ventilation systems, fire alarm systems.

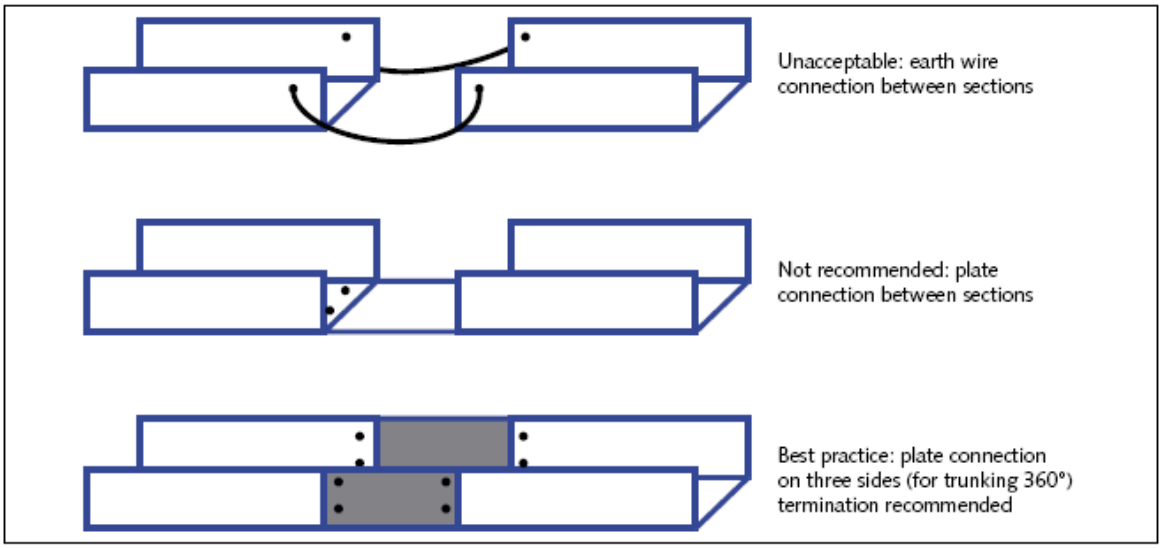

Figure 32: Recommended interconnection of cable trays and trunking

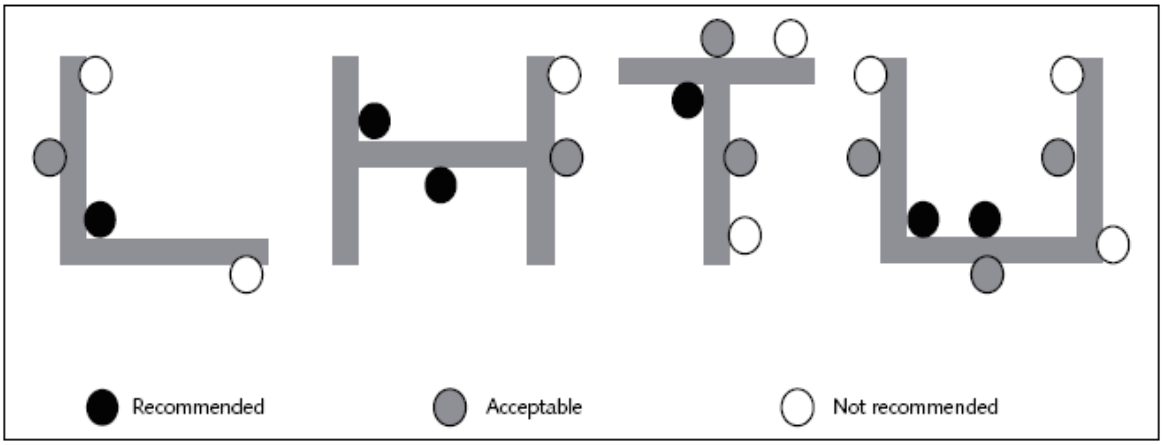

Figure 33: Location of cables inside metallic structural supports

Earthing and bonding

11.47 Earthing and bonding (or equipotential bonding) is often confused. The terms are defined in the following way. Earthing is the connection of the exposed conductive parts of an installation to the main earthing terminal of that installation. Bonding is an electrical connection maintaining various exposed conductive parts and extraneous conductive parts at substantially the same potential. Earthing arrangements are described in detail in Section 13.

11.48 Earthing is also used to contribute to the mitigation of disturbances for installations with sensitive and interconnected electronic and electrical systems. These requirements, that is, shunting of unwanted power-frequency and high-frequency currents and lowering the voltage difference between two points of the system, are the same for lightning, personnel safety, installation protection and EMC. Each one of these considerations places constraints on the design, since lightning and personnel safety dictate the design of the earth electrode; safety and installation protection dictate the size for the earthing conductors; and EMC behaviour requirements determine the layout of the earthing network.

11.49 Given the above, the following EMC implementation rules are recommended.

11.50 Wherever possible, the TN-S system should be used. Exceptions exist with IT configured systems, or where a high continuity of supply is required by the application (for example in hospitals) or by national regulations.

11.51 Non-linear loads (fluorescent lamps, switched-mode power supplies etc) on distribution networks can generate harmonic currents which may overload the neutral conductor. Correction methods for such systems are provided in Section 5. The controlled earth return current of a TN-S system is shown in Figure 36.

11.52 A clean earth will utilise dedicated earth conductors, which are fed back to the main earth terminal (MET).

11.53 The intent for any earthing system should be to maintain a low impedance at most harmonic frequencies. This means maintaining an equipotential between all the cabinets in the data centre. The likelihood that this can be achieved is increased by a localised connection to the mesh bonding network of the room.

11.54 The mesh bonding network is intended to be created by the use of interbonding sections of the 1.2m^2 earth mesh (25mm^2 copper straps) in the raised flooring using bonding straps between 50% of the pedestal supports for each floor panel. At least a 16mm^2 earthing conductor should be connected to the nearest point on the mesh bonding network from the local distribution board's earth bar. All underfloor cable trays and risers which pass through the raised floor should be bonded to the earth mesh using an earth strap. All surrounding metallic cable trays, conduits, pipework, risers and ducts in the roof void should be interbonded using earth straps or preferably solid metal strips which are galvanically compatible with the contact metal. Galvanic potentials should not exceed 300mV otherwise there is a potential risk of long-term degradation of the bonds.

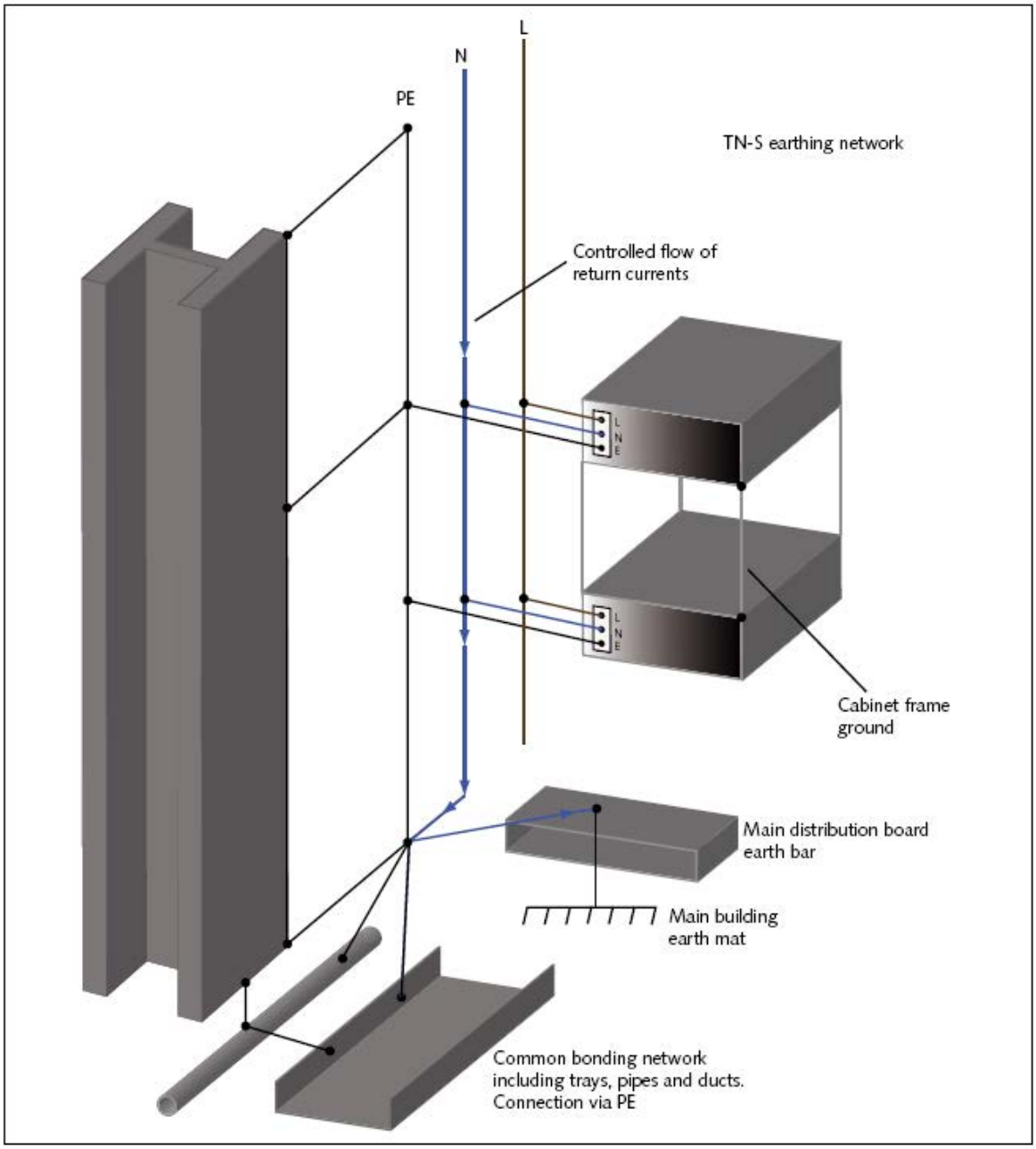

Figure 34: Controlled returned current flow in a TN-S installation

12. Wiring systems

12.1 All wiring systems will be of a form defined in the IEE Regulations BS7671: 2008. Where appropriate, the primary internal distribution will be a three-phase HV network. The next tier of distribution will be a mixture of three-phase and single-phase LV systems.

High voltage

12.2 HV wiring systems will, in general, be used only for distributing high power around the site. This Scottish Health Technical Memorandum does not promote the use of HV equipment. However, consideration may be given to the use of HV chiller plant where the chillers have a high mechanical duty and hence electrical load requirement. The manufacturer's advice should be used.

12.3 Certain radiographic and diagnostic equipment generates a high voltage as part of the equipment process. Such applications are not part of the fixed wiring systems and are therefore not covered by this Scottish Health Technical Memorandum.

Low voltage

12.4 All LV systems will be installed as TN-S systems as defined by the IEE Regulations BS7671: 2008, unless the wiring is of a type defined below.

Medical IT

12.5 The system may also be known as an isolated power supply (IPS; see Definitions). The system will include a monitoring device with an alarm for disconnection, insulation failure, overload and high temperature. Medical IT wiring systems will in general be limited to a medical location of Group 1 or Group 2 areas (see Definitions) and post-mortem facilities.

Protected extra low voltage systems

12.6 In general, PELV systems as described by the IEE Regulations BS7671: 2008 are not covered by this Scottish Health Technical Memorandum. PELV systems may be used within medical locations Group 1 or 2. PELV systems may also be considered appropriate for wet areas such as kitchens, trolley wash-down areas or mortuaries.

12.7 The nominal limit for PELV is 50V ac or 120V ripple-free dc. However, as prescribed by BS EN 60601-1, IEC 60601-1, this limit is reduced to 25V ac and 60V ripple-free dc when these systems are used in medical locations of Group 1 and Group 2.

Separated extra low voltage systems

12.8 The nominal limit for SELV is 50V ac and 120V ripple-free dc. However, as prescribed by BS EN 60601-1, IEC 60601-1, this limit is reduced to 25V ac and 60V ripple-free dc when these systems are used in medical locations of Group 1 and Group 2.

12.9 Normally, protection by insulation of live parts and by barriers or enclosures applies only to SELV systems where the nominal voltage exceeds 25V ac or 60V ripple-free dc. Where the SELV system is within a medical location Group 1 or 2, protection by insulation of live parts and by barriers or enclosures should always be provided. Placing live parts out of reach, only, is not acceptable within medical locations Group 1 or Group 2.

13. Earthing

13.1 The earthing arrangements for the full electrical system should comply with the requirements of BS7430: 1998 and BS7671: 2008. In general terms, the earthing arrangements will take the form of a TN-S system. The exception to this fundamental requirement will be that certain areas, defined in this chapter, will meet the earthing requirements of an IT-earthed system.

High-voltage earthing methods

13.2 Where the PES is rated at high voltage (11kV) and the termination point is at low voltage (0.4kV), the responsibility of the HV earthing will lie with the DNO. Where the healthcare organisation meters and purchases electricity at a high voltage, but has no internal HV network, the DNO will remain responsible for the earthing provision of the HV earthing. Designers will need to liaise with the DNO whenever any new development or significant internal remodelling of the healthcare facility's electrical services is undertaken. Managers of healthcare premises will be required to provide the DNO with full access rights to any part of the facility that they may require to access in order to maintain the HV earthing systems. Where the electrical distribution strategy includes an HV network, the designer of the electrical system should ensure that the electrical systems are adequately earthed. Where the healthcare facility includes more than one HV substation, each substation should be linked by an HV earth conductor. This will be particularly important where a single building is served from more than one HV substation.

13.3 A suitably-sized copper conductor will collectively bond all exposed metalwork associated with HV equipment at an HV substation. The cross-bonding conductor should have a green-yellow sheath and be buried at a depth of 600 mm within the substation area. Where the substation is not at ground or at subterrain level, the substation exposed metalwork will be earthed via a copper drain wire of the HV network cable.

High-voltage network cables

13.4 All HV cables forming part of the HV distribution network should have a copper screen as part of the protection of the cable in accordance with BS6622: 2007 as part of the armouring of the cable. HV cable glands should be rated above the prospective fault current of the system to which they are assembled. The glands should have integral earth lugs from which equipotential bonding copper strip connects to the main copper earth bar. Consideration may be given, if required, to the cable armour secured at the cable gland being isolated or separated from the equipment by an island-type insulating gland. In order to prevent dangerous high earth fault currents circulating within the structure of the healthcare facility, the HV cable earths should not come into direct contact with any exposed conductive part of the facility.

High-voltage generator earths

13.5 All HV generators will be earthed. Designers should evaluate the earthing by a neutral earthing reactor or an earthing transformer. Thought should be given to the potential for circulating neutral currents and/or harmonic currents in the delta- wound generator stator, and how these may be negated with the addition of an earthing transformer. The generator earthing arrangements should ensure that an adequate fault current can be developed to operate any protective device within the electrical network. Figures 37 and 38 show typical high-voltage generator earthing configurations.

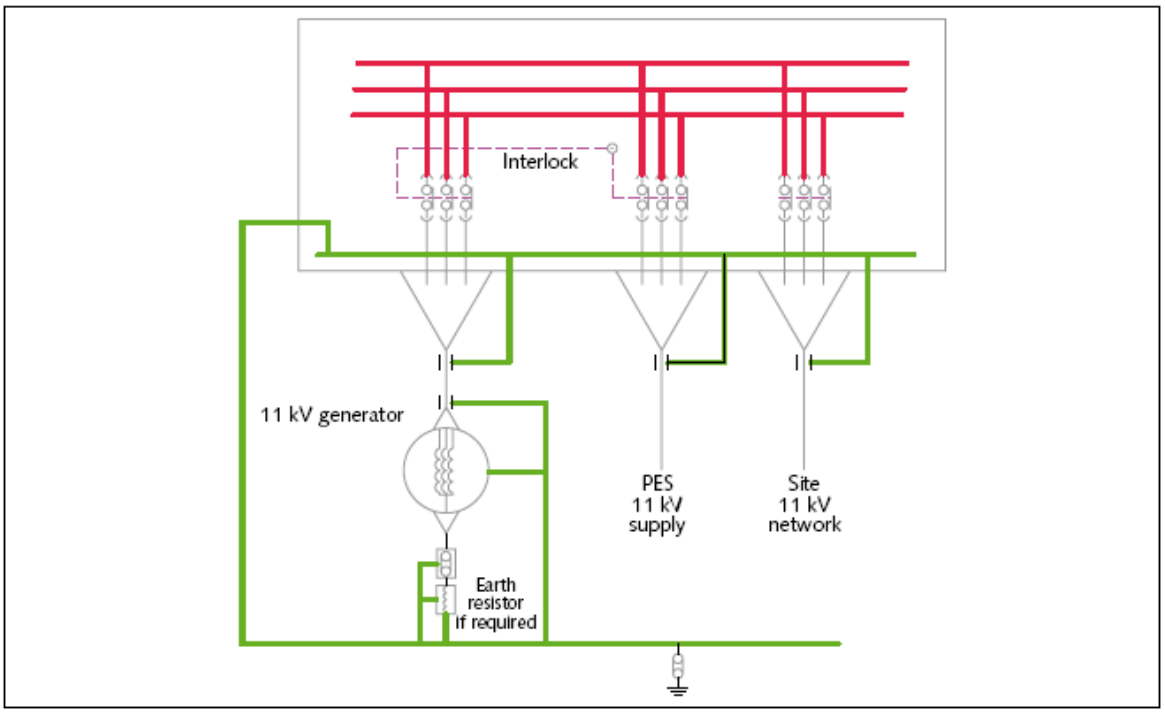

Figure 35: HV generator earths – island mode

Low-voltage main earthing methods

13.6 Where the PES is rated at low voltage (0.4kV), designers will liaise with the DNO to determine the responsibility of earthing the PES supply cable, which will usually be with the healthcare organisation.

13.7 A suitable supplementary equipotential bonding copper conductor will collectively bond all exposed metalwork and conductive parts associated with the LV switchpanels in the switchroom to the local ERB. The cross-bonding conductor will be a bare hard-drawn copper tape of a minimum cross- sectional area of 50mm by 6mm and in accordance with BS7671 IEE Regulation 543. A suitable copper earth cable or tape will bond each ERB to the respective LV substation main earthing terminal (MET). A suitable supplementary equipotential bonding copper conductor will collectively bond all exposed metalwork and conductive parts associated with the LV substation to the local MET. All extraneous metalwork will be cross-bonded and either directly or indirectly connected to the MET. The MET will be directly connected to the star point of the respective distribution transformer secondary winding. All

transformers associated with the primary and secondary electrical distribution (see Sections 7 and 8) should have a dedicated MET directly connected to the earth electrode with the earthing conductor. The earthing conductor will be sized to carry, without risk of danger, the greatest earth fault current and earth leakage currents likely to occur, having due regard for the thermal and electromechanical stresses. An earthing conductor and demountable link will interconnect each MET where the substation has multiple distribution transformers.

13.8 Where appropriate, any fixed equipment clean earths will be bonded to the MET of the respective LV substation either directly or via an ERB in the LV switchroom.

13.9 Where appropriate, any information management and technology clean earths will be bonded to the MET of the respective LV substation.

13.10 Where the LV and HV system earths are separated, the resistance of the LV earth electrode should be less than 20 Ω.

13.11 Where the electrical system includes both HV and LV networks, designers may wish to interconnect the earths from the two earthing systems. Subject to approval of the DNO, this may be achievable if the combined earth resistance is less than 1 Ω, and any earth fault current does not give a rise of a 430V potential in the parallel earth circuits. Where the combined earth resistance cannot be reduced to 1 Ω, the LV earth electrode should be at least 3m from the HV earth electrode and/or any HV extraneous conductive metalwork.

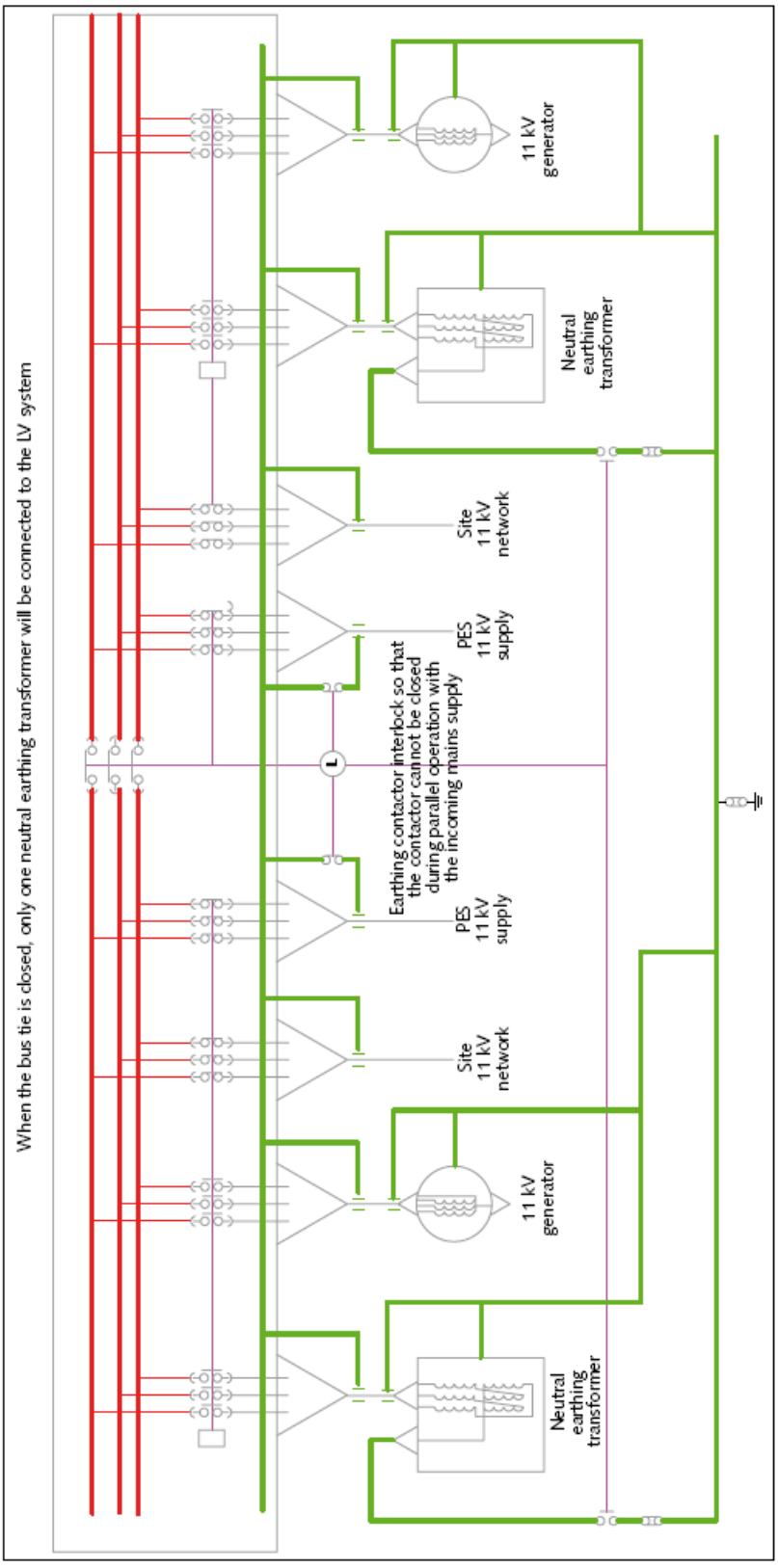

Figure 36: HV generator earths – parallel operation (TN-S)

Low-voltage generator earths

13.12 It should be ensured that an adequate fault current can be developed to operate any protective device within the electrical network. The earthing arrangement may require an earthing reactor or earthing transformer.

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13.13 The resistance of the generator star-point-connected earth electrode should be less than 20 Ω.

13.14 Figure 37 shows a typical earthing configuration.

Switchroom earths

13.15 All LV distribution switchrooms should have a visible earth reference terminal made from hard-drawn bare copper.

13.16 A suitably-sized copper conductor will collectively bond all extraneous and exposed conductive parts associated with the switchroom LV switchgear to the local ERB. The circuit protective conductor (CPC) from each final distribution board should be bonded to the local ERB, and covered by a green-yellow sheath. All extraneous metalwork will be cross-bonded and either directly or indirectly connected to the ERB.

13.17 Where appropriate, any fixed equipment clean earths will be bonded to the ERB of the respective LV switchroom.

Earths for radiographic rooms

13.18 In general terms the designer of the electrical hard-wired system will have a responsibility for the earthing system to the ERB within each radiographic room (see also paragraph 13.23).

13.19 In all radiographic rooms an ERB will be provided. Designers should liaise with the radiographic equipment manufacturer to establish the size of the earthing conductor and associated ERB. An individual earthing conductor will be directly connected to the ERB (of each radiographic room) and the MET at the respective distribution board.

13.20 Where the radiographic room has high electromagnetic field radiation, such as in a magnetic resonance imaging (MRI) room, the room will be provided with a Faraday cage to isolate any such magnetic fields from the building structure and surrounding rooms. The ERB in these rooms will be made of a non-magnetic material and housed in a non-magnetic enclosure (usually clean ABS). The ERB will be directly bonded to the room side of the Faraday cage. An earthing conductor will be directly connected between the Faraday cage and the MET of the respective substation.

13.21 The Faraday cage will have suitable apertures for the provision of any EMC filter equipment for conductors of any electrical or communication system. The radiographic equipment manufacturer/supplier should specify the detail of the filter equipment.

13.22 All fixed electrical equipment connection points will be positively bonded to the ERB with a resistance no greater than 0.1 Ω.

13.23 The electrical installation for radiographic diagnostic and imaging facilities

should comply with the Medicines and Healthcare products Regulatory Agency (MHRA) document 'Medical Electrical Installation Guidance Notes' (MEIGaN).

Medical IT or isolated power supply earths

13.24 Isolated power supply (IPS) circuits should have an IT earthing system as defined by BS7430: 1998 and BS7671: 2008.

13.25 In all areas defined as a clinical risk Category 4 or 5, an ERB will be provided adjacent to the local final distribution board of the IPS.

13.26 The IPS circuits will be bonded to a protective earth terminal (PET), which should be easily accessible from the IPS distribution board and IPS isolation transformer housing. An earthing conductor will be directly bonded between the PET and a local ERB. Both the PET and ERB will be visible and accessible by authorised people only. See Scottish Health Technical Memorandum 06-02: 'Electrical safety guidance for low voltage systems'.

13.27 Where the IPS serves a diagnostic room, the PET/ ERB should be located within the room (see the MEIGaN).

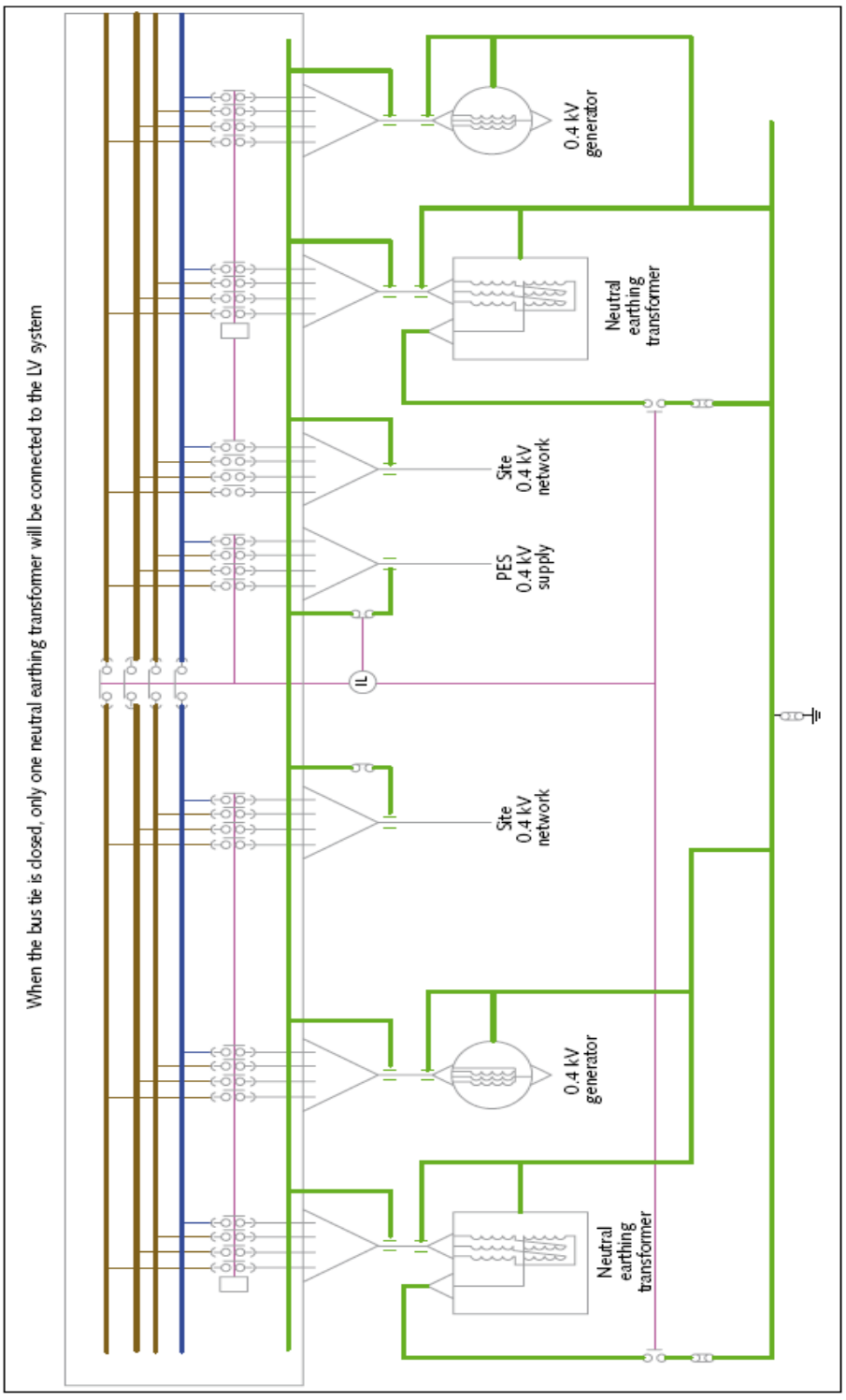

Figure 37: LV generator earths (TN-S)

Microshock

13.28 Microshock is the passage of a low level of electricity through the body which causes no perceptible sensation. The threshold of sensation is at about the 1mA level. The subject cannot detect currents below this level. These low-level events are of no consequence unless the current passes through the cardiac muscle, in which case ventricular tachycardia or ventricular fibrillation may be triggered. Currents of the order of 10μA can be enough to initiate ventricular

fibrillation.

13.29 A patient undergoing any procedure which involves the placing of an electrical conductor in the central circulatory system is particularly at risk. In this context, an electrical conductor includes insulated wires such as cardiac pacing electrodes or intracardiac ECG electrodes, or an insulated tube (catheter) filled with conducting fluid inserted into the central circulatory system.

13.30 In order to limit any potential rise due to the effects of leakage current, the voltage between the hard-wired system and the ERB should not be greater than 20mV. A further voltage of 30mV is allowed between the exposed conductive parts of the medical equipment and its supply cord (BS EN 60601-1, IEC 60601-1). This means that the maximum obtainable voltage between the exposed conductive parts of the medical equipment and the ERB should not exceed 50mV. To achieve this low voltage the maximum resistance between the socket-outlet terminals, fixed equipment terminal or extraneous metalwork should be 0.2 Ω (0.1 Ω from any point to the ERB).

13.31 Figure 38 shows a typical earthing arrangement.

Circuit protective conductors

13.32 All parts of the LV distribution including final circuits will have a separate circuit protective conductor (CPC). The size of the conductor will be assessed from the prospective short-circuit current (PSCC) and the current-carrying capacity of the conductor. The assessment will take the form of the calculation:

$$S = \frac{\sqrt{I^2t}}{k}$$

(given in BS7671: 2008)

where

S = the nominal cross-section area of the conductor in mm^2;

I = fault current;

t = the operating time of the disconnecting device in seconds corresponding to the fault current;

k = a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.

13.33 Where circuit cables or conductors have an integral metallic sheath, the sheath will not be used as the sole earth return path. Designers should consider the use of multicore cables with an earth conductor, or where this is not possible, installing a separate CPC.

Functional earth

13.34 Functional earthing systems are a method used to provide a zero reference point or a signalling path for communications equipment. A functional earth does not strictly provide any protection against electric shock or danger. Functional earths should comply with the requirements of Chapter 47 of the IEE Regulations BS7671: 2008.

13.35 The functional earth conductor may be connected directly or indirectly to the main earthing terminal (MET) in an installation where earth currents flow due to the normal function of load equipment.

13.36 Functional earths for telecommunication systems should be installed with a cream-coloured sheath. The telecommunications engineer should determine the functional earth conductor size and install it in accordance with BS6701.

Monitored earthing systems

13.37 Where it is assessed that a high degree of earth integrity is required, an earth monitoring system provides a means of maintaining a high degree of confidence in the impedance level of the protective conductor from the monitoring unit to the remote protected equipment. The monitoring unit may be connected between the source of energy (if accessible) and the equipment to be protected. The source of energy may be, for example, a generator or a transformer. It is therefore essential that any plug, socket and flexible cable provide not only the main protective path but also a return path, which is usually known as the pilot conductor.

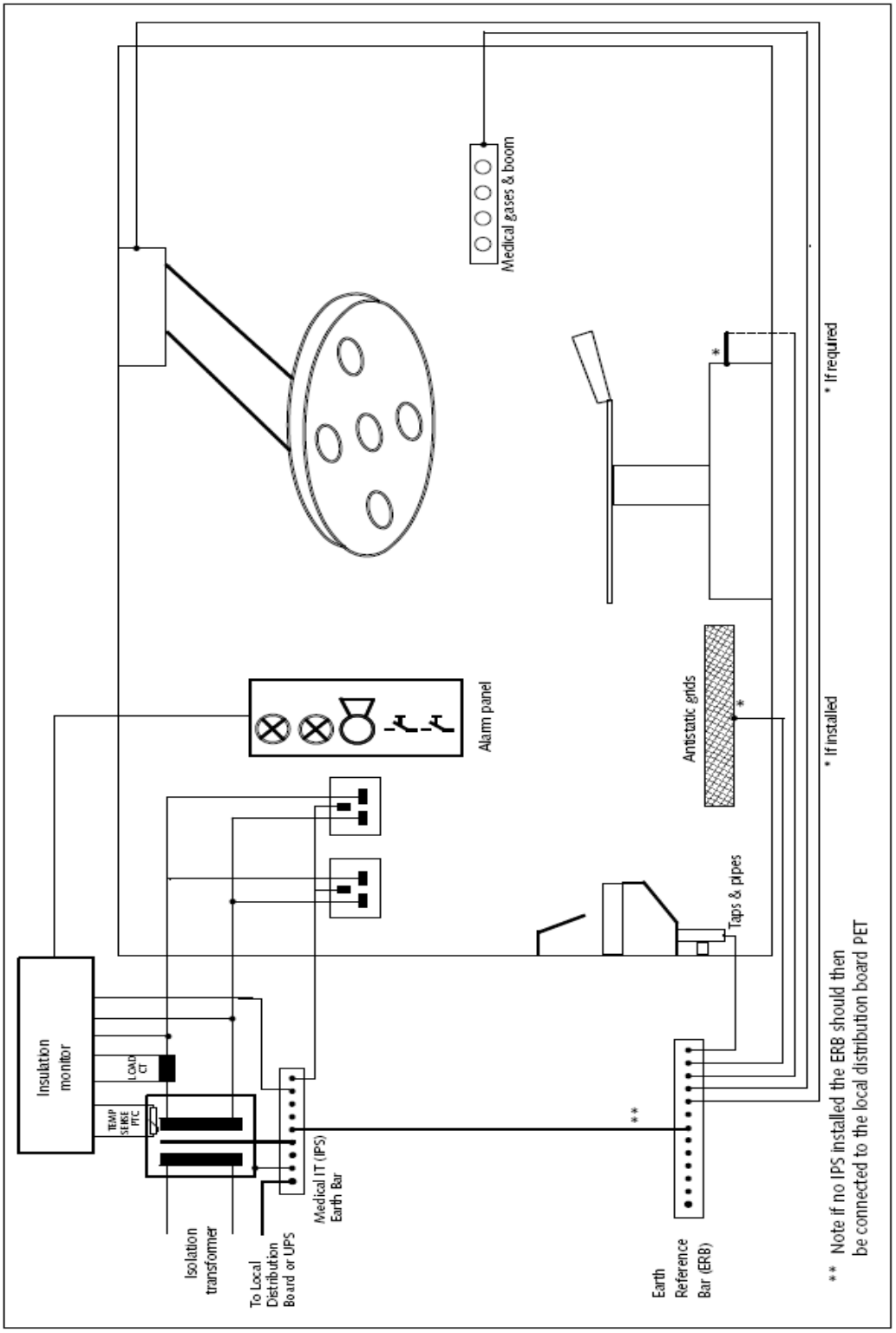

Figure 38: IPS theatre earthing arrangement

13.38 The system proves or monitors the protective conductor and pilot conductor loop in a flexible trailing cable supplying transportable or mobile equipment, the proving or monitoring unit being arranged to disconnect the supply to the equipment at the point of connection of the trailing cable to the wiring installation. A wall-mounted protective-conductor proving or monitoring unit is

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directly connected to a section of the fixed electrical installation and is arranged to feed the flexible trailing cable, which may be connected to the unit either by means of a plug and socket or by a permanent connection. When connected in this manner, both the trailing cable and the equipment will be disconnected when the unit operates in the event of failure of the monitored loop.

Lightning protection

13.39 The energy of a lightning flash can be very high, with typical strikes currents in excess of 20kA within the UK. The damage from lightning strikes can be very significant and blow electrical components off the wall in the worst case. The damage may not be limited to items that have direct contact to the conducting path of the lightning protection system (LPS). Air (or other conducting materials) are locally ionised around a lightning flash or conducting path, which can induce damaging currents in electrical equipment not directly connected to the LPS. In poorly designed or installed LPSs, flashover of high currents can occur between the LPS conducting path and items not bonded to the LPS. Flashover and/or ionised fields can cause damage to communications systems and electromagnetically stored data.

13.40 BS EN 62305 provides maps with the statistical frequency of lightning strikes and their energy values throughout the UK.

13.41 Designers should carry out a risk assessment based on the approach given in BS EN 62305 to determine the need (or otherwise) of an LPS. The risk assessment should consider the location of the healthcare premises (urban/rural, high/low), and the value of the equipment and data stored, as well as any protection afforded by the proximity of taller buildings.

Lightning protection system components

13.42 The LPS consist of three principal components as listed below.

Air terminals – finials

13.43 The air terminals consist of a copper or aluminium tape installed around the roof, and cross-bonded to all exposed metalwork and plant. The air terminals can be insulated with a PVC sheath, or be bare. Metal roofs can be used as the air terminals providing that the conductivity and thickness of metal does not impede the discharge of the lightning strike. Air terminals can be laid under a slate roof subject to building regulations and approval of the building control officer.

Down conductors

13.44 The down conductors consist of aluminium or copper tapes clipped down the exterior façade of the healthcare premises at a maximum spacing of 20m. Each down conductor should be cross-bonded to any exposed metalwork within 1m of the conductor and installed at least 1m from any entrance way. Where the

down conductor cannot be installed on the external façade, a segregated internal duct (conforming to the requirements of BS EN 62305) may be utilised. Designers should consider the location of data communications and electromagnetic storage systems before using the steel structure of any healthcare building.

Earth electrodes

13.45 The earth electrode consists of a high-conductive metal rod connecting the down conductor to the mass of earth. The resistance to earth of an LPS network should not be greater than 10 Ω, with the resistance of each individual electrode less than ten times the number of earth electrodes in the LPS. Where the soil resistivity is high, the earth electrode can consist of a high-conductive metal plate or mesh. In very poor soil resistivity areas, the local resistance can be improved by the use of high-conductive concrete, such as bentonite, to provide a bond between the electrode and mass of earth. Each earth electrode should have a test point close to ground level to aid the routine testing of the LPS. See Scottish Health Technical Memorandum 06-01, Part B: “Operational management”.

Ionised fields

13.46 The effect of a lightning flash can ionise the air surrounding the flash up to several metres. The ionised air can give rise to high transient currents in cables and equipment. Designers should consider the use of “surge arrestors” to mitigate the effects of such transient currents.

13.47 Surge arrestors can be located in one of three locations:

- Type A on all cables as they enter/leave a building;
- Type B on each main distribution switchboard;
- Type C on the equipment itself (or the equipment’s supply lead).

13.48 Surge arrestors should be capable of attenuating the induced ionised current such that the transient current is no greater than twice the steady-state normal supply current.

13.49 Further details on the design and installation of an LPS can be found in BS EN 62305 and BS EN 50164-2: 2002.

14. Containment

14.1 Due diligence should be given to the protection of all cable routes throughout the healthcare premises. The various types of cable and busbar system are described in Section 15. This section addresses the method of installation. Where the primary distribution cables etc are installed external to any building, the cables should be direct-buried. Where the cable route passes under roadways etc, the cables should be installed in ducts of not less than 100mm diameter. Appropriate inspection chambers should also be provided. Main cables, where direct buried in open ground, should be initially laid in, covered by sifted soil or sand, and over-covered with reinforced interlocking fibre boards or concrete tiles to BS2484:1995. Boards or tiles afford protection against hand tools but not against mechanical excavators. Red warning tapes for HV cable routes and yellow warning tapes for LV cable routes should be provided, and placed 300mm above the tile or cable. Accurately located concrete surface markers should be provided at intervals of approximately 6.5m (where practicable) in open ground, road crossings etc along the cable route, and at any change of direction or entry to buildings.

14.2 Electrical services of any type and/or voltage band installed on or in any containment type should have a current-carrying capacity for the grouping of cables and local environment of the containment system. Advice for de-rating a cable's current-carrying capacity from the nominal values is given in BS7671 IEE Wiring Regulations. Additional information can be obtained from the cable manufacturer.

14.3 Where single-core cables are used for heavy-current three-phase circuits, the cables of the three phases should be laid in close proximity in trefoil or flat formation, mechanically braced, and tied along the route. Eddy currents should be reduced, for example by the use of non-ferrous clamps, fittings, spacers, non-ferrous gland plates and cable terminations.

14.4 The routing of any containment system should preserve the recommended segregation distances from other services, including other electrical services. General containment routes should not be installed in lift shafts including dumb waiters (see BS EN 81 for more information). Containments should not be routed in laundry shafts.

14.5 Where cable containments pass through a fire compartment wall, a fire-stopping material will be used to make good the opening. A fire barrier should be installed within the containment (close to the fire compartment wall), where the containment has an internal air space (for example trunking systems).

Trenches, service tunnels and ducts

14.6 Where cables of any type and/or voltage band are installed in a trench, service tunnel or duct, they should be installed on other containment types such as ladder rack or tray work. The arrangement of the secondary containment should

keep the cables out of any accumulated water and not impede access along the trench/tunnel/duct. Trenches, service tunnels and ducts should be self-draining.

14.7 Where the containment system is used for other services, the space should have natural ventilation. The effect that other services, such as heating pipes, in the same trench or duct may have on the local environment should be taken into account.

14.8 Section 11 gives details on how cables should be arranged in voltage-band groups and the respective separation distances to achieve EMC.

14.9 HV cables should not be routed in enclosed areas close to flammable gases such as piped medical oxygen.

14.10 When sizing a trench/tunnel/duct, consideration for maintenance access should be assessed. The recommended minimum clearances are given in Defence Works Functional Standard DMG 08: 'Space requirements for plant access operation and maintenance'. Manholes or access holes should be provided for entry into cable tunnels and ducts. SELV lighting and a power supply at entrances to trenches and service tunnels should be provided. The provision for portable forced ventilation systems for use of maintenance staff may be required under the Health and Safety at Work etc Regulations.

14.11 On main cable routes where additional cables may subsequently be required, spare cable ducts, trenches or service tunnel space should be provided.

14.12 Where HV cables are installed, they should be identified with "DANGER 11,000 Volts" notices provided at points where access to HV cables can be obtained.

14.13 Open trenches (ha-has) are not a recommended containment system for electrical services. Where such trenches are used, the cables should have additional mechanical protection. Additional safety precautions for the public should also be reviewed.

Ladder rack – tray – basketry

14.14 Steel cable trays and aluminium or steel ladder-rack can simplify installation where several cables are to be installed in close proximity. In damp areas and in order to reduce the risk of corrosion by electrolytic or water action, the containment should have a galvanised finish.

14.15 Such containments should only carry cables of one voltage band. Basketry can be considered for a mixture of cables at low voltage and voltage bands below, provided all such cables are insulated to LV grades.

14.16 Where these types of containment are installed in a common service route, each containment system should preserve the segregation of the various voltage bands. The highest voltage band should be installed on the lowest containment rail. The containments should not be used to support any other services.

14.17 Manufacturers' data should be used to assess the maximum mechanical loading and fixing arrangements of each containment system.

14.18 Such fixings should not be connected to any demountable building element (for example ceiling tiles, wall partitions) or other engineering services.

14.19 Metallic ladder-rack, tray or basketry should be electrically continuous and may be used as a supplementary earth return path. Each length of the containment should be mechanically joined with overlapping fillets on all three sides, and it is recommended that these are supplemented with copper links to ensure earth continuity. Where the installation topology prohibits the mechanical jointing of the containment system, an earth cable (of 6mm^2 minimum size) should be used to provide the earth continuity.

14.20 In order to limit the effect of electromagnetic radiation and reduce high fault currents, the containment system should not form the only earth return path of any circuit on the containment.

Trunking – conduits

14.21 Steel trunking for cables represents the most satisfactory type of installation where a number of circuits can conveniently follow the same path. Cable trunking is suitable for use in voids, above suspended ceilings, in surface applications and in service risers. Trunking layouts should be predetermined and be dimensionally coordinated with other building components to enable standard prefabricated lengths to be used whenever practicable.

14.22 In installations with segregated essential and non-essential circuits, complete segregation of non-essential and essential sub-circuit wiring is desirable, but may not be possible in all instances. Where either the essential or the non-essential wiring is less than, say, 30% of the total wiring, separate containment systems may not be practical or justified. See Section 6 for more information.

14.23 Circuits for emergency and escape lighting from a central battery system should always be segregated from both essential and non-essential circuits (guidance is given in BS5266), and those circuits should be wired in an appropriate fire-resistant cable (see Section 15).

14.24 Extra-LV circuits can be installed with LV circuits operating at the mains potential providing that the insulation is equally rated to the maximum circuit voltage present. Wires of mixed service should be suitably screened to reduce inter-circuit electromagnetic interference.

14.25 Small TP & N cables installed in trunking should be tied or clipped together in small convenient bunches. Groups of four single-core larger cables, comprising a three-phase supply and neutral, should be laid in trefoil, interleaved at suitable intervals and labelled to assist identification of circuits. The number and size of any cable bunch in any trunking should not exceed that allowed in the IEE Wiring Regulations Guidance Note 1 Selection, Appendix A.

14.26 Metal trunking should have a suitable anti-rust finish (for example zinc-coated

steel). For damp environments, galvanised trunking will provide suitable protection.

14.27 All equipotential contact surfaces should be free of rust or corrosion or have an anodised finish to ensure electrical continuity to earth and between trunking sections. Tinned copper bonding links should be used across all trunking section joints to complete the equipotential bond and earth connection. The metallic trunking or metal conduits should not be used as the sole earth return path of the circuits within the containment.

14.28 All conduits and trunking systems should be solidly fixed. Such fixings should exclude the use of demountable building elements (for example ceiling tiles, wall partitions) or other engineering services. All fixing systems should be suitable for the mass of the containment and wiring systems.

14.29 Approved non-flammable fire barriers and penetration seals should be inserted in cable trunking where it penetrates floors and partitions which are intended to form fire barriers (that is, fire compartment walls). The outside of the trunking should also be locally fire-insulated on both sides for 500mm to prevent heat transfer by conduction along the metal trunking and the passage of smoke. Unenclosed cables entering/ leaving barriers or seals should also be fire-protected with ready-mixed inert material or fire-resistant paint.

14.30 Fire barriers and penetration seals should be provided for all cable installations entering/leaving switchrooms and plant cubicles where gland plate sealing is not provided. Underfloor trunkings or flush lay-in trunkings are a useful containment system for services to “island” (mid-floor area) equipment such as radiography units and theatre tables, computer hub rooms and laboratory benches. In such locations, it is essential that the manufacturer, structural engineer and architect all be consulted.

14.31 Where large quantities of data and computer equipment are installed, such as hub room and floor-distribution patch cupboards, raised floors with removable square sections to permit sub-floor access for any later cable works are recommended.

14.32 Cables bunched in steel conduit of 20mm, 25mm or 32mm diameter are economical. Conduits less than 20mm in diameter are not recommended.

14.33 The number and sizes of cables pulled into any trunking and/or conduit should not exceed the circuit-loading guidance in the IEE Wiring Regulations Guidance 1 Selection Appendix A and BS7671 Chapter 52. The conduit system for each distribution board should be kept separate, and cables from different distribution boards should not be enclosed in the same conduit.

14.34 Conduit should be heavy-gauge quality to BS31. Enamel finish is satisfactory for indoor dry locations. A passivated, galvanised, Class 4 finish should be specified where damp conditions are likely. The use of only passivated, galvanised, Class 4 finishes may be more cost-effective, as it will negate the need of any retrospective touch-up painting of installed metallic conduits and trunking.

14.35 The effect of electromagnetic interference from non-metallic trunking and conduits should be evaluated before they are used. Electromagnetic energy can be radiated from or absorbed by wiring systems unless they are adequately screened and earthed (see Section 11). Electrical containments should be resilient to effects from thermal and/or mechanical impact. The risks may be acceptable in clinical risk category 2 and 3 areas, but is unlikely to be acceptable in clinical risk category 4 and 5 areas (see paragraphs 4.11–4.34 for more information). It is best practice to use metallic trunking and/or conduits.

Preformed wiring containment

14.36 Preformed wiring consists of wiring systems that are manufactured off-site, and the individual circuit conductors are installed in a form of containment. The containment in this case is generally a spiral metallic sheath or interweaved metal-and-paper spiral wrap. The system is delivered with pre-made terminations and in standard lengths (primary runs are 40–50m while final circuits are 3m, 4m and 5m). Most systems have a range of distribution boxes and fuse boxes and therefore the installed system becomes a spider's web of cables. The systems allow for lighting and low power. Lighting circuits can have additional control wires for switching and lighting control systems. Low-power circuits can be wired as radial or ring circuits. Preformed wiring systems tend to be sized at 50mm diameter, while the final runs are typical 20mm diameter. The number of multi-circuits in any one length of preformed system may be dependent on the installation. However, all conductors of any one circuit should be installed in the same wiring lengths. The system sheath should not be relied on for any part of the earth loop impedance.

Layout considerations

14.37 Designers should consider how to provide for any flexibility and/or spare capacity within the system. As the systems are preformed, it is not possible to cut into an existing length, and the installed routes follow the building room layouts. Designers should therefore consider providing the spare capacity at local distribution points or at the fuse box. A spare capacity of 25% should be made available, partly at the distribution boards and partly at the ends of the primary routes. Alternatively, consideration can be given to all spare capacity being available at one location only.

Fire precautions

14.38 Where preformed wiring systems penetrate floors and partitions which are themselves intended to form fire barriers (that is, fire compartment walls), the outside of the trunking should also be locally fire-insulated on both sides for 500mm to prevent heat transfer by conduction along the metal trunking, and the passage of smoke. Containments should be treated in such a way as to prevent any smoke that may travel on the inside of containments from linking separate fire compartments.

Remodelling and extensions

14.39 Preformed wiring systems do not provide an easy way for additional circuits to be pulled into existing wiring systems. Hence, any circuits to be added retrospectively will require additional preformed lengths, which in turn erode the spare capacity. Consideration can be given to providing facilities for re-modelling by allowing other cabling systems to be installed (retrospectively) from a common distribution board used for preformed wiring systems.

Circuit segregation

14.40 Designers should consider the holistic, coordinated installation with all other electrical and non-electrical services within the installation area. Designers should obtain the manufacturer's data on the system's compliance with electromagnetic radiation and absorption, which will need to be specific for the particular environment (see Section 11 for additional information).

14.41 All primary preformed wiring systems that may be used should be secured on secondary containments such as tray work. Similarly, all final runs of preformed wiring system should be solidly fixed. Such fixings should exclude the use of demountable building elements (for example ceiling tiles, wall partitions) or other engineering services. Clearly, all fixing systems should be suitable for the mass of the preformed wiring system, and not leave any catenary effect.

14.42 Wiring systems installed within a clinical risk Category 5 area should be exclusive to the use of equipment and fittings in that location.

Access for maintenance

14.43 Designers and stakeholders should consider the risks associated with the installed routes for preformed wiring and the need to provide suitable access for maintenance. (See Scottish Health Technical Memorandum 00 and Defence Works Functional Standard DMG 08 'Space Requirements for Plant Access' for additional information).

Suitable locations

14.44 Designers and stakeholders should consider the risk associated with installing the systems in certain locations. Clinical risk Category 1 areas should not be adversely affected by preformed wiring systems. The risks may be acceptable in clinical risk category 2 and 3 areas, but may present a higher risk in clinical risk category 4 and 5 areas.

15. Cable and busbar types

15.1 All current-carrying conductors (cables, busbars etc) should be suitably sized to carry their design load after the application of any de-rating factors generated by their installation environment and in accordance with manufacturers' data. All cables should be of an approved type tested by an external body such as the British Approvals Services for Electrical Cables (BASEC) or CBS ENELEC. The conductor size should limit the volt drop between the network origin and point of use to the values given in BS7671 IEE Wiring Regulations. Designers may optimise the conductor power dissipation (I^2R losses) by designing the final circuits to carry the majority of the permissible volt drop.

15.2 The environmental protection grades and electrical properties can be found in BS7671.

15.3 Each condition of external influence is designated by a code comprising a group of two capital letters and a number, as follows. The first letter relates to the general category of external influence:

A Environment

B Utilisation

C Construction of buildings

The second letter relates to the nature of the external influence:

. . . A

. . . B

. . . C

The number relates to the class within each external influence:

. 1

. 2

. 3

15.4 For example, the code AA4 signifies:

A = Environment

AA = Environment – Ambient temperature

AA4 = Environment – Ambient temperature – range –5°C to +40°C.

15.5 Further advice should be obtained from cable manufacturers' data sheets to validate the appropriateness of the cable for the intended application.

15.6 Cross-linked polyethylene (XLPE) is well established at higher voltages and is the preferred type of cable construction. XLPE cables have an improved operating temperature (90°C) over PVC, which means that XLPE cables do not require de- rating (for temperature) as much as an equivalent PVC cable. This can be a particular advantage in plantroom and energy-centre locations. Significantly higher symmetrical short-circuit ratings are also possible, corresponding to a conductor temperature of 250°C during fault conditions. This is compared to 150°C for PVC cables. XLPE will ignite and burn readily, but has low smoke and fume-emission characteristics.

15.7 Elastomeric (or thermoset) materials return to their original shape and dimensions after deformation. They tend to have a wider operational temperature range and superior mechanical properties compared with general-purpose thermoplastic materials. This makes them particularly suited to cable sheathing applications, especially in harsh environments. Elastomeric materials are suitable for all cable applications. Ethylene vinyl acetate forms the basis of most modern low-smoke zero-halogen cable sheaths.

15.8 Designers should evaluate whether the cable will be suitable for all normal and fault conditions. The fault calculations should include both overload and short-circuit condition (between live conductors and/or live conductor phase to earth). The fault conditions should be modelled for all circuit conditions, which will vary according to the number of motors etc running. Cables should be suitable for power supplies from the DNO as well as any secondary power supplies (SPS).

15.9 Where the primary power is supported by parallel-running CHP plant, the fault calculations should reflect various power supply ratios of no CHP, 25% CHP and say 50% CHP.

15.10 Designers should consider the use of computer software applications to simulate all scenarios for fault calculation and cable selection. Any software used for such purposes should have an auditable quality control system such as ISO 9001.

15.11 Where there is large radiographic equipment which derives radiation from short-impulse high voltages, the distribution cables may not be required to be rated at the full load. Designers should liaise with the radiographic equipment suppliers to determine any opportunity to use under-sized cables.

15.12 This chapter addresses the various cable types available for each system within the electrical network of healthcare premises.

High-voltage distribution

15.13 HV cables have a higher power density than the equivalent-sized LV cable. Therefore, where an electrical network includes an HV system, the HV system should be made to cover as large an area as is practical (see Section 6).

15.14 The grades of cable insulation normally used are XLPE cables complying with BS6346: 1997.

15.15 HV cables may be direct-buried, laid in a trench or, where practical, installed on heavy-duty cable trays.

15.16 HV cable boxes should be made of fabricated steel, and terminations should be air insulated up to 11kV. Spacing between the terminals must conform to BS4999-145 or IEC standards requirements for the rated voltage.

15.17 All HV terminations and terminating cable tails should also be encapsulated in heat-shrinkable, voltage-graded plastic insulation, approved and guaranteed by a reputable manufacturer for the rated voltage.

15.18 Steel cable boxes for the HV terminations of rotating machines should be provided with an aluminium foil explosion diaphragm and, as a safety precaution, the boxes should preferably be orientated to face a nearby reinforced concrete vertical surface or 200mm brick wall. A splash-protected breather hole with an external replaceable silica gel dryer with screwed insert should be provided to prevent the accumulation of condensed water vapour within the cable box.

15.19 All cables should be marked and terminated in an approved manner to indicate phases. The far and near phase cable ends should be checked by a continuity meter to confirm identical phase markings.

Low-voltage distribution

15.20 Multi-core LV distribution cables should have a black outer sheath to denote their voltage rating.

15.21 The core colours should be as defined in BS7671: 2008.

15.22 LV distribution conductors are made from copper or aluminium. Aluminium cables as rated are larger, require greater space, are difficult to lay, and require larger glands and cable lugs for terminations. Copper conductors have a better thermal and mechanical impact resistance and are more durable.

Cable identification

15.23 The colour of the conductor sheath of multi-core LV three-phase distribution cables should be as illustrated in Figure 39.

15.24 Where single-core LV distribution cables are installed, the phase colour should be brown with a blue neutral conductor as in Figure 40.

15.25 Note: where single-core cables are installed for LV distribution, all conductors of a common circuit should be enclosed in the same metallic containment such as trunking. In accordance with IEC 60364-7-710 any wiring system within Group 2 locations should be exclusive to the use of equipment and fittings in that location (see BS7671: 2008). The terminations of single-core LV conductors should be identified by the appropriate colour or notation, which may include IPS circuit identification.

15.26 Existing installations may continue to use the pre-April 2004 BS7671 conductor sheath phase colours (red, yellow and blue), black neutral and yellow-green protective conductors. However, these should be replaced when modifications are undertaken to the electrical system.

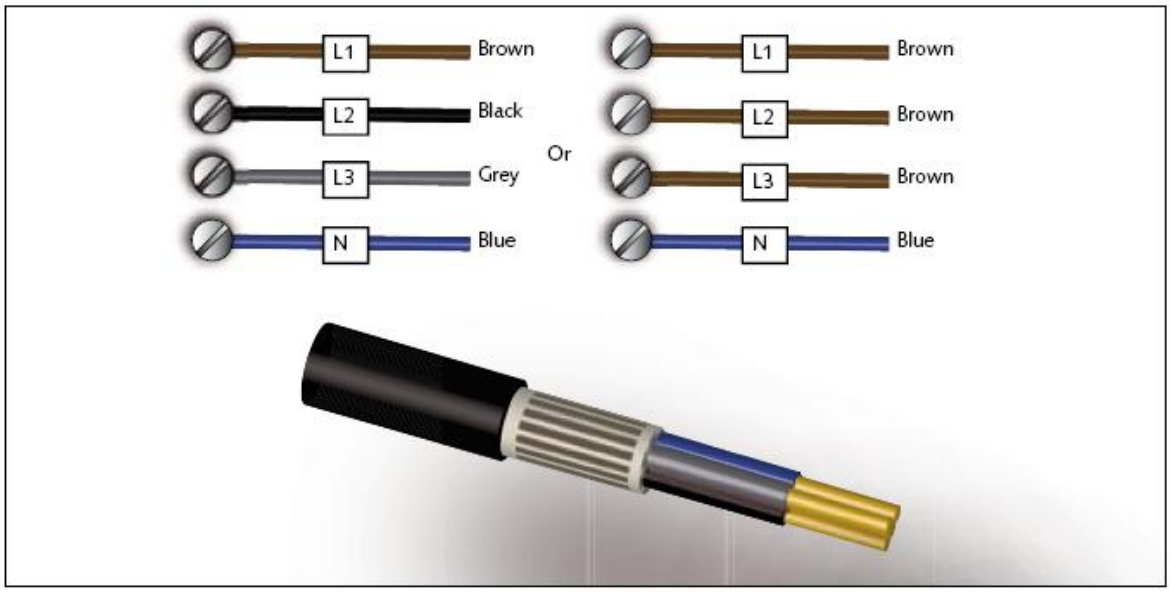

Figure 39: LV three-phase multi-core cable identification

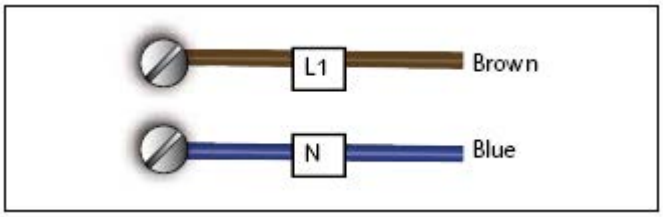

Figure 40: LV single-core cable identification

15.27 Note: where the conductors form an IPS circuit, both conductors should be coloured brown and identified as L1 and L2. In composite cables, conductors can be sleeved brown.

15.28 The LV distribution strategy should focus on the cable size with a view to installing the cable and giving access for maintenance. Designers should allow adequate space for the bending radius of cables (including the respective containment system – see Section 14).

15.29 Distribution and sub-main cables above 240mm^2 are difficult to install, which means either having smaller distribution circuits (which in turn means more switchgear) or installing single-core cables. Where the distribution uses single-core cables, each core should be laid in a trefoil arrangement. In order to limit electromagnetic radiation (see Section 11), the group should be 0.75 diameters from a wall or any other distribution cable (cable group), and generally means more space.

Busbar distribution

15.30 LV busbar distribution systems are becoming a cost-effective solution for high-

current circuits. LV busbar systems with current ratings from 63A to 2.5kA (depending on type) are available, with the insulation being air or cast-resin encapsulation. Some systems provide insulated bars only. The main advantages of LV busbar distribution are the reduced space, and the standard tap-off facility to add additional outgoing circuits later (via fused switches).

Control alarm and communication cables

15.31 There are many types of alarm and communications system in a healthcare facility. This section identifies some of the more common wiring systems used for such circuits. Since the mid-1980s, many communication and alarm systems have moved to digital networks and data highways. As such systems have expanded and their relative speed and bandwidths increased, many data highways are being used to carry a multitude of systems ranging from information technology systems, BEMS, nurse call, blood bank alarms, security and fire alarm signals. Since the mid-1990s, some of the communication and alarm systems have moved to wireless systems.

15.32 This Scottish Health Technical Memorandum is only concerned with fixed wiring. However, designers and stakeholders should consider the effects of wireless systems and electromagnetic compatibility (see Section 11). The use of any wireless systems in clinical risk Category 3 and above areas should be the subject of a risk assessment. Although the wireless signals may not have any common frequency or side-frequency with electro-biomedical equipment etc, the clinical risk may be high.

Control communication and non-fire-alarm cables

15.33 Designers should liaise with system suppliers before selecting the type of cabling used for general communication and alarm systems.

15.34 The distribution and installation of alarm and communication systems should follow (as far as practical) the general route of containment used for power systems, provided a suitable segregation distance (100mm to 300mm depending on voltage screening bands) is maintained.

Information technology cables

15.35 The construction and type of cable used for IT systems fall outside the scope of this Scottish Health Technical Memorandum. Designers should liaise with the IT staff at an early stage to coordinate the containment routing for such systems. IT containments should be in separate vertical risers to any other building services containment route. Horizontal containment used for IT should be at least 300mm to 600mm from other building services containment, subject to the voltage band of any distributed power cabling system. The IT distribution strategy and separation distance are exclusive of any maintenance access requirements that should also be considered.

Fire alarm cables

15.36 Cables used for any part of a fire alarm system should be an enhanced grade cable as defined by BS5839-1: 2002.

15.37 All fire alarm cables should also satisfy the CWZ rating of BS6387:1994; that is, the cable should be able to withstand water and impact and be subjected to a temperature of 950°C for three hours.

15.38 Cable systems may be derogated from their respective mechanical cable impact requirements of BS6387: 1994 by installing enhanced-grade fire alarm cable in a continuous containment, which then satisfies the impact requirement of BS6387: 1994.

16. Final circuits

16.1 This section deals with final circuits and point-of-use connections of the PEI that present best-practice configurations for final circuits, UPS and IPS for the emergency protection of final outlets, circuits and equipment. The configurations are presented generally in order of resilience from low to high. The selection of a particular configuration will be dependent on the specific factors of each individual design. The selected configuration should be based on a risk analysis to determine the appropriate level of resilience.

16.2 The configurations presented in this section should not be taken as being definitive, prescriptive, or restrictive of innovation. They are intended as a guide to best practice (see Figure 41).

Uninterruptible power supplies

Standards

16.3 UPS systems should be to, but not be limited to, the following design and manufacturing standards:

- BS EN 62040-1-1: 2003. ‘Uninterruptible power systems (UPS). General and safety requirements for UPS used in operator access areas’;
- BS EN 62040-2: 2006. ‘Uninterruptible power systems (UPS). Electromagnetic compatibility (EMC) requirements’;
- BS EN 60146, IEC 60146. ‘Semiconductor convertors. General requirements and line commutated convertors’;
- BS EN 60439-2, IEC 60439-2. ‘LV switchgear and control gear assemblies’;
- VDE 0510-2 paragraph 6.5, Ripple current for battery charging systems.

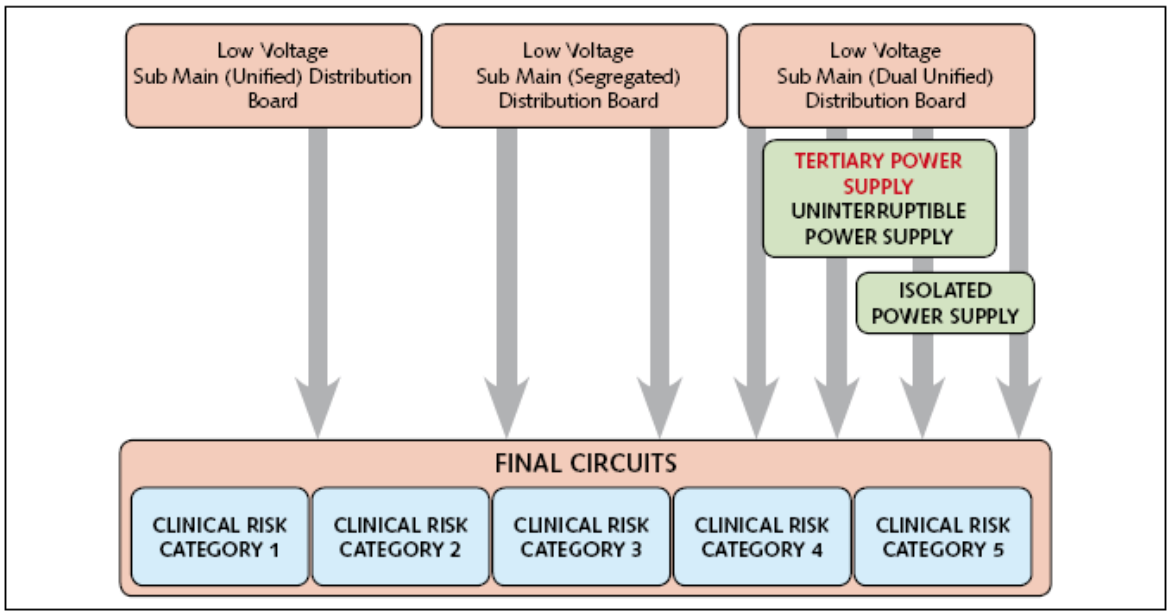

Figure 41: Final circuit connectivity

Rating

16.4 UPS system ratings range from 250VA up to several hundred kVA; the small units may be single-phase units used to support a single circuit, and the larger UPS systems may be single- or three-phase units for supporting a complete department.

16.5 Central UPS systems may be considered where the need covers several small distributed areas. Where centralised UPS systems are considered, a diesel rotary UPS (DRUPS) may provide an economic solution. The location of DRUPSs should be based on the same environmental criteria used for the standby generators and/or CHP plant.

16.6 Other types of rotary UPS, which use the stored energy of a flywheel under full torque connected to a motor, may also be used. The autonomy of these UPS devices is essentially time-based and largely independent from the actual load. These so-called “silent rotary UPSs” currently have high kVA ratings and are more suited to a centralised system.

UPS environment

16.7 Designers should consider the local space of the UPS, in terms of its access for maintenance and heat generated. Depending on the UPS type, single or double conversion, a UPS will radiate about 3% to 8% of its input power, which will need to be vented. Ideally, the ventilation should be natural. The environmental conditions should control the room space to the limits recommended by the battery manufacture.

UPS description and configurations

16.8 A UPS consists of three principal parts: a rectifier, a battery unit and an inverter. The rectifier converts the ac power supply (single- or three-phase) to a dc

supply. The rectifier output maintains the battery in a fully-charged condition. The inverter reconverts the rectifier output (or battery output) to a synthetic sinusoidal waveform output (again either single- or three-phase according to the input). The UPS should include a static bypass, a manual internal bypass and an external bypass; all three bypass switches should be installed. The static bypass will electronically divert the normal supply from the rectifier inverter line through the static switch whenever a fault in the UPS conversion occurs. The static bypass operates at such a high speed that it is considered as a no-break supply switch.

16.9 Single-conversion UPS units are configured so that the supply is normally via the static switch and, on loss of supply or when the supply quality falls, the static switch instantaneously connects the battery output to the load. The battery is held fully charged by a trickle charger supplied from the normal supply. The battery autonomy (see Section 10) of single-conversion UPSs working offline is typically up to 15 minutes.

16.10 Double-conversion UPS units are configured so that the supply is normally via the rectifier and inverter line and, on loss of supply (or poor supply quality), the battery output supplies the load via the inverter. The static switch will also bypass the rectifier inverter if the UPS circuit develops a fault. The battery is held fully charged by a trickle charger supplied from the normal supply. The battery autonomy (see Section 10) of double-conversion UPSs working online is typically up to 1 hour. The battery autonomy should be assessed to ensure that adequate power can be provided to allow the medical therapies to be concluded safely (within the area of concern). Usually 1 hour will facilitate the closure of any patient in an operating theatre. However, on the most complex of surgeries or medical therapies, periods of up to three hours may be required. Designers and stakeholders should liaise with surgical staff to understand the most appropriate cost-effective strategy.

16.11 The rectifier and bypass may have a common supply connection. The ideal connection should provide separate connections for the rectifier and bypass line (see Figure 42a/b).

UPS fault condition design

16.12 UPS protective devices should be capable of clearing downstream circuit faults in similar fashion to other distribution boards. UPS output-circuit protective devices should discriminate from upstream devices. Designers should consider the effect of overload and short-circuit fault condition. Short-circuits in the UPS load are isolated either by a downstream protective device, or by the insulated-gate bipolar transistor (IGBT) control circuit of the inverter. UPS units may tolerate overloads of 125% for 10 minutes, 150% for 1 minute, or 200% for 100 milliseconds (depending on the manufacturer's selected internal protective device). The actual overload characteristics vary from manufacturer to manufacturer. Designers should verify the coordination of fault conditions when selecting the UPS type.

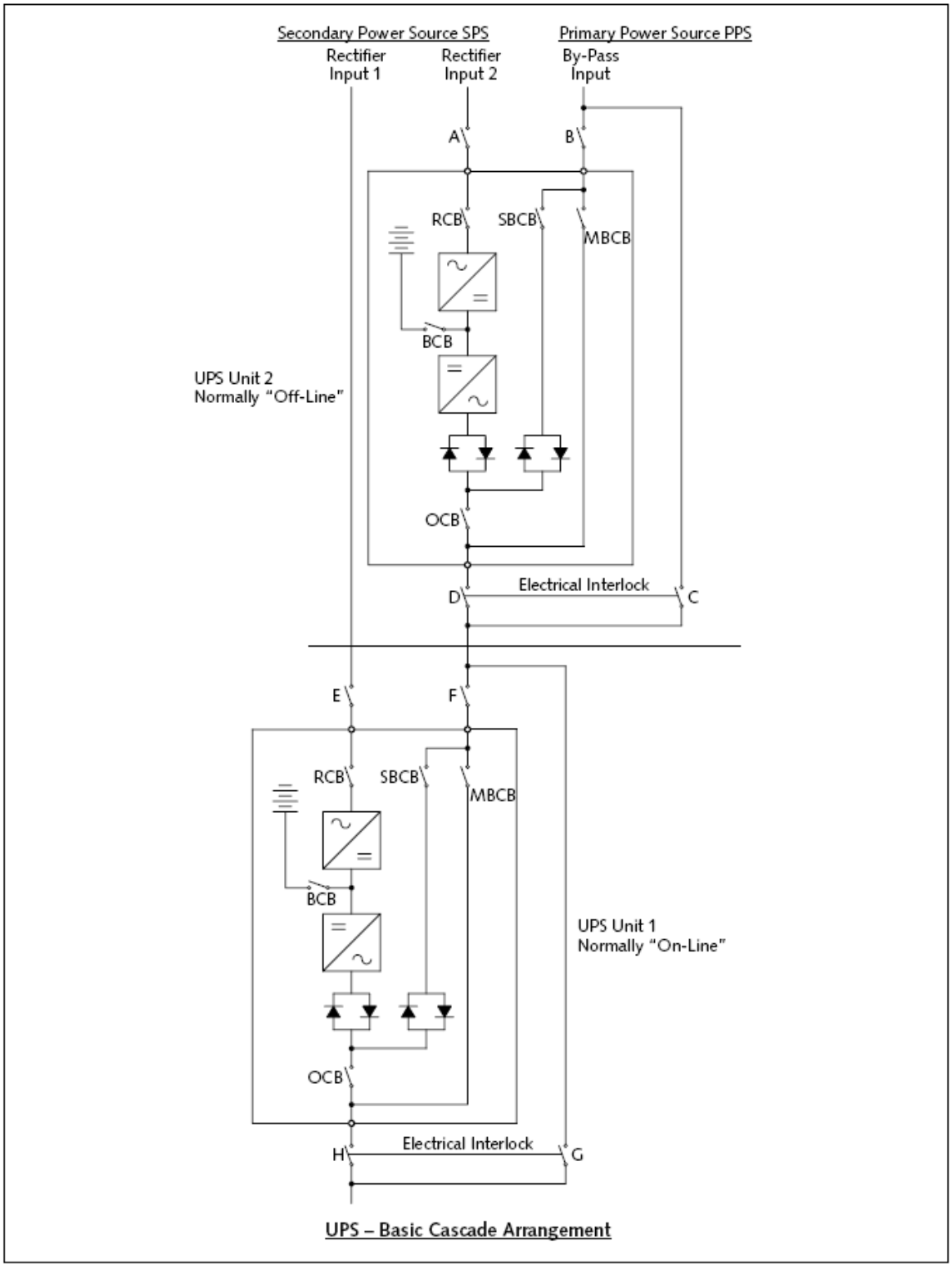

Figure 42a: UPS resilient arrangements

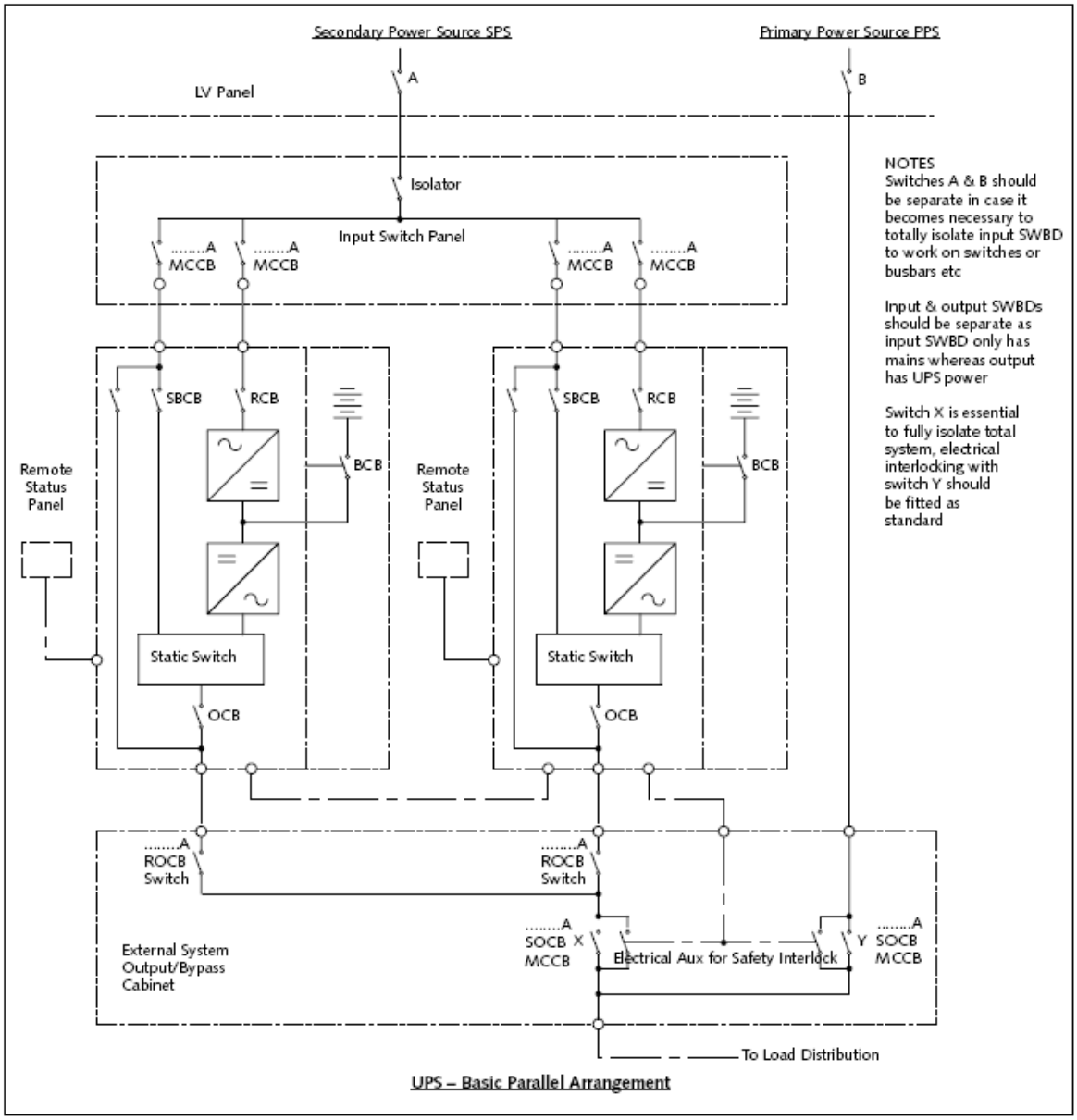

Figure 42b: UPS resilient arrangements

16.13 Designers need to consider carefully the protection systems used by the UPS. The UPS sub-circuit protective devices should provide adequate discrimination with the inverter/static switch protection. If the inverter/static switch protection operates before the sub-circuit protection, the UPS may shut down. Clearly, this would then isolate all the sub-circuits and not just the faulty circuit.

16.14 With three-phase UPS units, designers may wish to consider the use of a zig-zag transformer on the UPS bypass lines. Such transformers provide a local earth point, may help to ensure that an adequate fault current is developed, and assist in harmonic control.

16.15 Where the UPS is supported by the secondary power supply, a transformer with a double-wound secondary may assist with the limiting of the initial acceptance load as the harmonic currents have been reduced.

UPS power quality

16.16 UPS systems are a significant non-linear supply. The rectification stage provides a pulsed ripple dc circuit, and the inversion stage provides a synthetic sinusoidal ac circuit. Thought should be given to UPS units which use IGBTs and to the duration and value of any inrush currents.

16.17 The output of the rectifier will be a ripple dc voltage. The ripple effect is normally smoothed by the use of IGBT devices. However, the IGBT circuitry will reflect a harmonic current into the supply line. The level of harmonic currents should be controlled such that the net harmonic current reflected to the DNO connection is in accordance with the Energy Networks Association's Engineering Recommendations G.5/4. See also paragraphs 5.11–5.17.

UPS resilience

16.18 UPS units can be grouped as multiple units connected either in cascade (redundant) or in parallel (see Figure 42a/b). Either arrangement provides N+1 resilience, as described in paragraphs 6.8–6.30. UPSs connected in cascade provide a "redundant" arrangement. With redundant UPS arrangements, each UPS should be able fully to support the full load, that is, be 100% rated. The output of the first cascade-connected UPS should supply the bypass of the second UPS. UPS units connected in parallel are normally all online, but a standby unit (in parallel) may be provided. UPS units connected in parallel may be rated at a percentage of the full load, provided that when one unit is not available, the remaining units can provide the full load. The common point of coupling for parallel UPS units should be downstream of the external bypass of each unit.

16.19 The selected arrangement for UPS resilience should ensure that the internal and external bypass switches provide a safe maintenance strategy.

Inverter units

16.20 The inverter units considered in this Scottish Health Technical Memorandum relate to central battery units and stand-alone units used for theatre operating lamps. Inverters used as a self-contained power pack for emergency escape lighting and signage are excluded, as they do not connect to the fixed wiring. However, designers should be mindful of such units when assessing the overall electromagnetic characteristics of the wiring system (see Section 11).

Central battery units

16.21 The wiring used in central battery units should be of an enhanced grade as defined by BS5839-1: 2002.

16.22 Central battery inverter units should be directly connected to the secondary power supply and be so arranged that the output can energise all connected emergency escape lighting and signage within five seconds as required by BS5266.

16.23 Central battery inverter units should be constructed with maintenance bypass switches. The switch should isolate the battery charging unit and the batteries from the output, but maintain a normal supply to the output. Note: if there were to be an outage of the primary supply during the maintenance of a central battery inverter unit, there would be no output supply until the secondary power supply was available. This period of circa 15 seconds is beyond the 5-second requirement of BS5266. See paragraphs 10.14–10.16 for details of the battery capacity relating to central battery inverter units.

Rectifier units for theatre operating lamps

16.24 Each separate operating theatre should have its own rectifier battery unit, external to the theatre, exclusively for the operating lamp(s).

16.25 See paragraphs 10.14–10.16 for details of the battery capacity relating to inverter units for theatre operating lamps.

Isolated power supplies (IPS)

16.26 Medical IT systems are IT electrical systems having specified requirements for medical applications. Medical IT systems are commonly termed “isolated power systems”, and have monitored circuits. A medical IT system should comply with the following standards:

- IEC 60364-7-710;
- BS 7671 Special Guidance Note 7, Chapter 10;
- BS EN 61558-2;
- BS EN 61557-8.

16.27 It is a basic requirement that an IPS system should be able to sustain power on its sub-circuits during and following a first earth fault on the system. This requirement differentiates an IPS from a UPS: the IPS maintains power when an earth fault occurs on the transformer output circuits, while a UPS maintains power output when its source of supply is interrupted. Therefore, these systems may be used to full advantage to complement each other in critical medical locations to improve patient safety.

16.28 For the purpose of this Scottish Health Technical Memorandum it may be assumed that any electro-medical equipment used in either a Group 1 or Group 2 location (as defined in the above standards) should be compliant with the requirements of BS EN 60601-1, IEC 60601-1 (as required by the Medicines and Healthcare products Regulatory Agency, MHRA).

16.29 In medical locations, the distribution strategy should be designed to facilitate the automatic changeover from the primary distribution network to the SPS (standby generator feeding essential circuits) when and if the primary supply voltage drops by more than 10%. The LV distribution circuitry, up to the sub-distribution board used to connect the IPS and UPS systems, should be deemed an essential circuit.

16.30 The medical IT system provides a monitored, isolated, floating power supply, which will sustain the first single earth fault. Consequently, IPS systems do not require any overload protection on isolating transformer input or output circuits. An advance warning of potential faults on the medical IT system, which includes the final sub-circuitry, is raised by the monitoring of insulation, transformer overcurrent and temperature. The medical staff can unplug medical equipment from the affected circuit and replace or reconnect to a healthy circuit. To enable the transfer of equipment in this manner, sockets at patient locations should be from two interleaved IPS systems. Automatic earth fault location systems (EDS) may be used to advantage in interleaved IPS systems areas and especially in wards, to provide rapid, detailed earth fault location information to clinical staff at the staff base. Generally this should be in the form of a simple text message, which for example would state “IPS 1 Earth (Insulation) Fault, ITU bed 4, left side”. In addition to the requirements of IEC 60364-7-710 for these locations and BS EN 61557-8 (insulation monitor standards), insulation monitors installed in IPS systems should be capable of correct function (that is, no nuisance alarms) when dc levels (of either polarity) are present on the monitored medical IT systems. Furthermore, insulation monitors should be able to function correctly in systems with capacitive filters such as MRI installations.

16.31 The construction and design of the IPS units should provide adequate access for maintenance. This is especially important in “multiple channel” IPS panels, where it should be possible to isolate safely and maintain each individual IPS channel, without detriment to the operation of the other IPS channels. Where the multi-channel IPS panels also include EDS systems, each channel should be suitable for full EDS function either simultaneously with other IPS channels, or independently, when other IPS channels are isolated for maintenance.

16.32 The installation of IPS systems, together with additional equipotential bonding and other measures described in the standards/guidance referred to above, are necessary to ensure the safety of patients and medical staff in medical locations. However, the increased use of electrical equipment for the purpose of life support and/or complex surgery used in special medical locations requires enhanced reliability and safety of the electrical installation in hospitals to ensure the security of supplies and to minimise incidents of microshock.

16.33 The earth leakage current from the secondary winding of the isolation transformer, when measured in no load condition and in single earth fault condition, should not exceed 0.5 mA. It is essential that this requirement for leakage currents is specified as an additional requirement to IEC 61558-2-15. As it stands, IEC 61558-2-15 specifies these leakage currents to a limit of 3.5 mA; however, there are moves in hand to modify IEC 61558-2-15 to reduce the leakage currents specified to 0.5 mA. This requirement enhances the safety applications of the transformer and brings it in line with BS EN 60601-1, IEC 60601-1.

IPS environment

16.34 Designers should consider the local space of the IPS in terms of its access for maintenance and heat generated. The IPS unit should be located on the same floor and just outside the medical department clinical risk category area it

serves. Where this is not practical, derogation may be given to locating the equipment on the floor immediately above or below, or within 30 m on the same floor as the clinical risk category area. The IPS unit includes an isolating transformer, typically 3.5kVA–10kVA radiating about 2–5% of its output power as heat, which should be ventilated. Ideally the ventilation should be natural, unless the forced ventilation power is derived from a standby generator.

IPS communication

16.35 Each IPS system will have audible and visual alarm indication of any first fault in accordance with the requirements of BS EN 61557-8 and IEC 60364-7-710 insulation monitoring devices. Remote indication, where required, will be at the nurse/management station for the medical area covered by the IPS system. Connecting the remote alarm indication to a networked BEMS communication system and terminals within the estates office will have added advantages.

Resilience

16.36 IEC 60364-7-710 and BS 7671 require Group 2 areas to have at least two separate socket-outlet sub-circuits at each patient treatment location (for example bedhead or theatre pendant). This applies to Group 1 areas also. This can be achieved from a single IPS unit with an integral single-phase distribution board. The resilience would be further enhanced if the IPS had dual 100%-rated isolation transformers serving different integral distribution boards. Such arrangements would provide an N+1 resilient IPS isolation transformer as defined in paragraphs 6.8–6.14.

16.37 IEC 60364-7-710 and BS 7671 require luminaires and life support equipment used in Group 2 (or occasionally Group 1) locations which need power supply within 0.5 seconds or less, to be restored within 0.5 seconds of a supply failure and other equipment to be restored within 15 seconds. To achieve the safety requirements, IPS units serving life-support equipment should be connected to a UPS supply which has a derived power supply, supported by the standby generator. However, other equipment may not require the same level of UPS/generator support. In order to ensure that the appropriate support is always available to cover a range of treatment options, any IPS used should be supported by UPS and standby generators. This arrangement will provide greater flexibility in any future remodelling of the clinical risk category 4 and 5 areas.

16.38 Figure 43 shows an IPS arrangement suitable for Group 1 or Group 2 Locations. Figure 38 shows the earthing arrangement for a typical theatre. (Other IPS arrangements that satisfy the requirements of IEC 60364-7-710 and BS7671 may also be possible.)

The patient environment

16.39 Figure 44 relates to the patient treatment location, where all sockets associated with medical equipment should be connected to the IPS and any other socket (or fixed equipment) connected to the TN-S supply with an RCD/RCBO

protective device. Although the figure relates essentially to a theatre location, it should be reasonably clear how the zone would be modified (at the patient head) when used to illustrate an area such as a high-dependency unit (HDU).

16.40 Theatre operating lamps do not require an isolated power supply and should not be connected to IPS circuits.

16.41 In Figure 44 the dark grey area represents the theatre table/bed, while the light grey shows the patient treatment area (exclusion zone). Any exposed or extraneous conductive parts within the exclusion zone, or that could be reached from within the exclusion zone, should be connected to the ERB with an impedance less than 0.1 Ω. The theatre table (or bed) could be moved as illustrated, in which case the exclusion zone would also move. Therefore, any exposed or extraneous conductive parts within the outer boundary (above) should be bonded to the ERB with impedance less than 0.1 Ω. All exposed or extraneous conductive parts within the theatre (or ward) should be bonded as described above. Theatre operating lamps, pendants, beams, equipment gantries etc should be considered as extraneous metalwork and therefore should be bonded to the ERB (see Figure 38).

IPS low-power circuits

16.42 This section refers to sockets in Group 1 or 2 areas as defined by IEC 60364-7-710 (the IEE Guidance Note No 7) and mortuary post-mortem rooms.

16.43 Activity Database (ADB), the Department of Health's 'Health Building Notes' (HBNs) and Scottish Health Planning Notes (SHPNs) provide advice on the number of sockets. The number of sockets at the patient location of clinical risk Category 4 and 5 areas will be significantly large. IEC 60364-7-710 recommends that each patient location has two IPS socket circuits and one TN-S circuit. Final circuits of an IPS system may have up to 24 sockets per circuit.

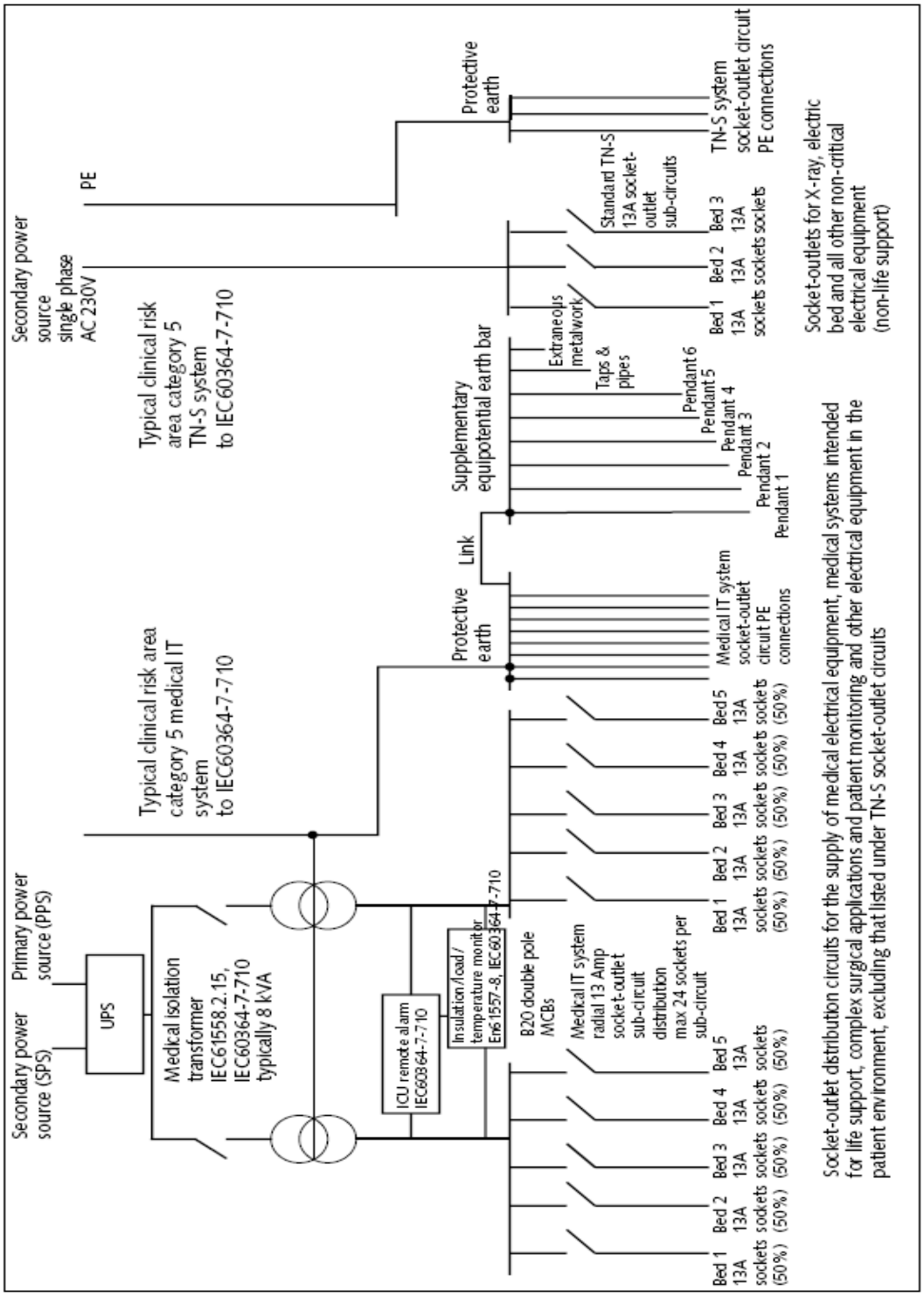

Figure 43: IPS/UPS high-security supply arrangements

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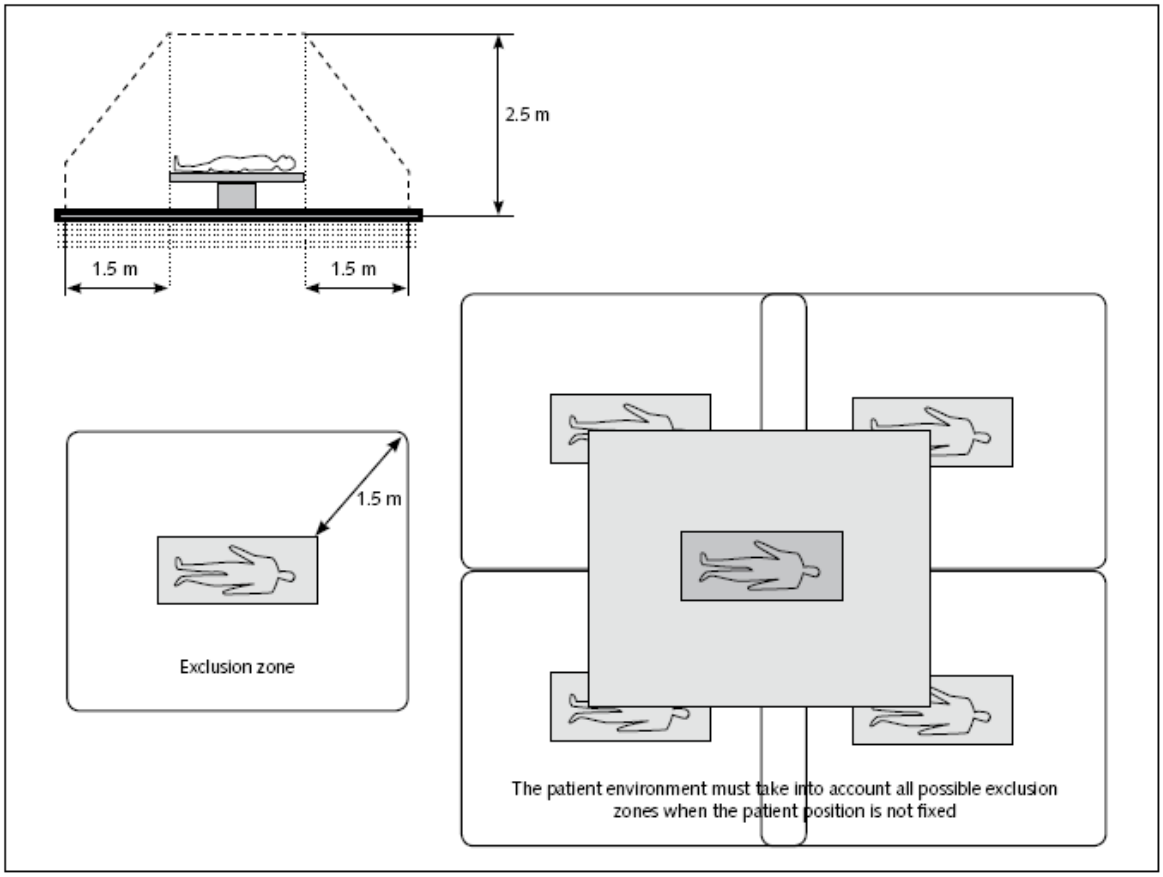

Figure 44: The patient environment

16.44 Socket-outlets in clinical risk category 4 and 5 areas and connected to the medical IT system (IPS circuits) will be connected in a radial format. The protective device for such circuits should be a 20A MCB with a Type B characteristic. Socket-outlets within clinical risk category 4 and 5 areas not connected to the medical IT supply should be protected by an RCD/RCBO protective device. The RCD/RCBO may be incorporated within the distribution board. The RCD/RCBO will be 30 mA and Type A or B characteristic.

16.45 Sockets-outlets in clinical risk category 4 and 5 areas, and connected to the medical IT system (IPS circuits) may be supplied as unswitched items to prevent accidental switch-off. Where such sockets are supplied as switched items, the switch will be double-pole. A means of identifying individual medical IT circuits should be provided at each socket-outlet. Medical IT socket-outlets should be blue in colour to distinguish them from any TN-S earthed socket within the same vicinity.

16.46 Initial concepts and remodelling of clinical departments will always require an understanding of the intended use of each medical location prior to designing the IPS-UPS configuration.

16.47 Some of the sockets in these areas will be earthed as part of the TN-S system, while others are part of a medical IT system. Sockets earthed by the medical IT method will be connected via the IPS distribution board.

General low-power circuits

16.48 In general, socket-outlets (as defined by BS7671) will conform to BS1363 or IEC harmonised standards and be connected to a ring or radial circuit. The protective device for a single-phase socket circuit should be rated no higher than 32A for a ring circuit and 20A for a radial circuit.

16.49 All sockets should be suitable for the local environment. While this may appear obvious, it ensures that suitable precautions (IP ratings) are made for sockets in kitchens, laboratories, plantrooms and general circulation spaces. Metal-finished sockets should be installed within a clinical risk Category 3 area and above in order to limit the effect of electromagnetic interference and the increased mechanical protection.

16.50 Socket-outlets and switches, regardless of the location, should be installed at a distance of at least 0.2m horizontally (centre to centre) from any medical gas outlets. This requirement is specified in BS EN ISO 11197: 2004.

Socket-outlets/connection units

16.51 Designers should assess the maximum number of socket-outlets on a final circuit by calculation of the minimum disconnection times given in BS7671, and the likely simultaneous connected power on the circuit. Designers should consider the distribution strategy and risk ownership when determining whether the socket-outlet circuit should be supported by the SPS. However, for some areas in clinical risk categories 1, 2 or 3, stakeholders may wish to have a different approach. In such areas, consideration can be given to socket-outlets connected to the SPS where the area has standby lighting of Grade B or above. In such cases, designers and stakeholders should be mindful of the implications for the capacity of the essential SPS.

16.52 Socket-outlets (in any location) connected to the essential SPS should be positively identifiable from any non-essential sockets in the same area.

Sockets for special locations

16.53 There may be areas that require special electrical installations, providing safety measures for specific purposes. In general, post-mortem rooms will have medical IT circuits having an earth fault trip for enhanced safety in a wet environment. However, other rooms within the mortuary should be supplied with final circuits protected by RCD/ RCBO protective devices. Consideration may be given to the provision of a PELV system within post-mortem rooms.

16.54 Other wet areas, such as hydrotherapy pools, will require all final circuits to be equally protected by RCD/RCBO protective devices. See the IEE Regulations BS7671 for more details.

16.55 Healthcare premises include engineering workshops for mechanical, electrical and biomedical repairs. The maintenance of electrical equipment and biomedical equipment may require testing with the supply connected, that is, working live. Great care for such working arrangements must be observed for

compliance with the Electricity at Work Regulations (regulation 14) and HSE guidelines etc.

16.56 Designers should consider providing a special test room or test bay within the engineering workshops and biomedical workshops. The low-power circuits within the test room and/or test bay should be from an isolating transformer, providing an earth-free environment. These circuits should be very clearly identified, and labels should be provided to alert the occupier to the earth-free environment. The circuits within this area should be protected by a 20A MCB Type A or B, and require a monitoring system.

Sockets for operating theatre suites

16.57 The patient environment of an operating theatre is a clinical risk Category 5, and hence the sockets may be served from a UPS or IPS circuit. Consideration may be given to connecting the full theatre suite from a UPS supported by the SPS standby generator, or just the SPS standby generator. Other socket-outlets within the operating theatre should be connected to the TN-S wiring system and have an RCBO or RCD with a 30 mA trip.

Socket for mobile X-ray units

16.58 Mobile X-ray units supplied since the mid-1980s do not present any real disturbance to the electrical distribution. However, designers should enquire whether any provision should be made for mobile X-ray units which derive their high ionisation voltage by inductive means, and provide dedicated sockets circuits accordingly.

Spark-proof sockets

16.59 The use of anaesthetic gases with a very low flash point has virtually been eliminated from UK NHS hospitals (see College of Anaesthetic Consultants and the Medicines and Healthcare products Regulatory Agency). However, an assessment by enquiry should evaluate the likelihood of such anaesthetic gases being used, and provide mercury-operated switched sockets (and light switches) accordingly.

Number of outlets per final circuit

16.60 Designers need to consider the potential earth leakage current that may flow on the protective conductor under normal conditions, which should be minimal. For clinical risk categories 4 and 5, the earth leakage current is regulated by cable leakage capacitance, the design of the IPS isolating transformer and associated medical equipment. In other clinical risk areas, the potential earth leakage current will be determined by the medical equipment (assumed to be compliant with BS EN 60601-1, IEC 60601-1), other equipment loads, and cable leakage capacitance.

16.61 The steady-state earth leakage current expected on a TN-S final-circuit protective conductor should not exceed 50% of the sensing element of any

RCD or RCBO used as the protective device on the circuit. Designers may therefore wish to consider this statement when designing final circuits as ring mains or radial circuits.

Fixed equipment

16.62 Large fixed equipment such as lifts, compressors, air-handling units, laundries, engineering workshops and radiographic imaging equipment is addressed here. Such items of plant include heavy inductive loads, which may cause disturbances to the distribution network.

16.63 Where the electrical supplies are for high-inductive motors, “soft-start” or “inverter speed drives” should be used. All such inductive loads should have local power factor correction and harmonic filtering. Dedicated earth cables should be provided between the MCC and LV switchpanel ERB, or the main earthing terminal (MET) at the transformer.

16.64 Where the electrical supplies are for radiographic imaging diagnostic and treatment facilities, designers and stakeholders should liaise with the equipment manufacturer/provider and MEIGaN before designing the electrical services to these areas. Dedicated sub-main circuits should be used for these areas. However, the use of dedicated earth cables between the radiography sub-main switchboard and the LV switchpanel ERB or the MET at the transformer is strongly encouraged.

16.65 Designers may wish to consider using a dedicated transformer for the sub-main supplies to large fixed equipment. There are strong positive advantages of such an infrastructure strategy, particularly where the fixed equipment has a very high inductive load, such as vapour compression chillers or radiography departments.

Supplies to external buildings

16.66 Some healthcare premises have small annexes used as stores and/or plantrooms not intended to be occupied for long periods. The standard of electrical installation for these buildings should be the same as for the main healthcare building. Electrical installation standards should reflect the nature of the stores, which may contain medical gases or flammable material. In such cases the electrical equipment, including containments, cabling, luminaires and accessories, may require to be intrinsically safe.

Temporary supplies

16.67 Designs that comply with the guidance given in this Scottish Health Technical Memorandum should avoid the need of temporary supplies. Where they are needed, the electrical standards should be as high as for the permanent supply. Derogation may be given on the containment requirement, when a clear understanding of the intended temporary period has been given.

16.68 Designers' attention is drawn to the application to connect (see paragraphs 3.60–3.62). The site engineer will reserve the right not to connect a temporary installation where the installation does not comply with the guidance given in the Scottish Health Technical Memorandums and local electrical safety rules.

Connections for mobile trailer units

16.69 Where mobile Treatment Centre (TC) units (for example MRI scanners), or similar units, are connected to the electrical distribution of the healthcare facility, it is important to maintain a high degree of electrical safety. This will include suitable protection to any cables and switchgear that might be more readily accessible to unauthorised persons. Suitable solid earthing between the healthcare premises building earth and the mobile unit should be provided.

16.70 Stakeholders should ensure that the internal electrical systems of any mobile TC unit used on healthcare premises could not compromise the safety of patients and/or the electrical system of the healthcare premises.

16.71 The mobile unit should be earthed as a TN-S system, and where the clinical risks are of Category 4 or 5, a suitable IPS system (with medical IT earthing) should be used (see MEIGaN and IEE Guidance Note 7).

16.72 Designers and stakeholders should ensure that the final supply/connection cable to any mobile unit includes a monitored earth as described in BS4444.

General lighting

16.73 The design of the lighting systems and lighting levels are outside the scope of this Scottish Health Technical Memorandum.

16.74 Lighting circuits used should be wired as a radial circuit with a maximum protective device rating of 10A.

16.75 In any room of clinical risk Category 3 and above, at least two lighting circuits should be provided.

16.76 Lighting circuits within the patient environment should be supported by the standby generator to ensure that Grade A standby lighting is achieved. Consideration may be given to connecting such lighting circuits to a UPS. Connecting lighting circuits to any IPS circuit is not encouraged by this Scottish Health Technical Memorandum.

Theatre operating lamps

16.77 All fixed theatre operating lamps, including the main unit and any satellite units, should be connected to a battery inverter unit providing 3-hour autonomy. The connection of the theatre operating lamp (including its battery inverter) to the output of any IPS circuit is not encouraged by this Scottish Health Technical Memorandum. However, any exposed conductive part of the operating lamp

should be bonded to the ERB.

Examination lamps lighting

16.78 Final circuits used for any fixed examination lamps located within a clinical risk Category 4 or 5 area should be protected by RCD/RCBO protective devices. The connection of the examination lamp to the output of any IPS circuit is not encouraged by this Scottish Health Technical Memorandum. However, any exposed conductive part of the examination lamp should be bonded to the ERB.

Emergency escape lighting

16.79 The emergency escape lighting circuits should be designed in accordance with BS5266 and BS EN 1838. This Scottish Health Technical Memorandum considers emergency escape lighting to consist only of escape-route emergency lighting. Emergency lighting circuits should be so arranged as to provide escape-route lighting throughout the healthcare facility. Where the facility has muster points for progressive horizontal evacuation (as defined in the Firecode series), at least two circuits should be provided. Emergency lighting emergency power should be derived from integral battery packs (tertiary power). Consideration can be given to central emergency battery units, but the additional fire-rated cabling cost may make this uneconomic.

Standby lighting

16.80 This Scottish Health Technical Memorandum considers standby lighting as a secondary form of emergency lighting (defined by BS5266 and BS EN 1838). All areas that require standby lighting should also have emergency lighting.

16.81 Standby lighting will derive its power from the SPS. There are two grades of standby lighting: Grade A and Grade B. Grade B standby lighting provides lighting at a reduced level compared to the normal lighting level. Standby lighting to Grade B is best provided by an increased number of emergency light fittings with integral tertiary power battery packs. Grade A standby lighting provides lighting at the same level as normal lighting. Standby lighting to Grade A is best provided by the SPS standby plant.

16.82 Clinical risk Category 3 areas should be provided with Grade B standby lighting, and clinical risk Category 4 and 5 areas with Grade A standby lighting.

16.83 Designers and stakeholders may wish to consider the implication of any additional circuitry required to provide a mixed standby-lighting facility. Consideration may be given to all lighting circuits being connected to the SPS.

16.84 Designers should be mindful that operating theatres, which by definition are clinical risk Category 5, should have an independent tertiary power source (battery inverter unit) for the theatre operating lamp(s) and satellite lamps. The battery autonomy should be at least three hours. In addition to the inverter unit, the electrical distribution supply to the theatre operating lamp(s) should be

derived from the secondary emergency power source (SPS).

Fire alarm, security circuits and critical alarms

16.85 Designers should provide an independent tertiary power source (battery inverter unit) for the fire alarm system. The battery autonomy should be compliant with the requirements of BS5839-1: 2002. The fire alarm systems should be connected to the SPS, where appropriate to the distribution strategy. Consideration may be given to connecting any fire-door detents to the SPS.

16.86 See paragraphs 10.11–10.16 for details of battery inverter capacity.

16.87 All cables associated with the fire alarm system should be of an enhanced grade as defined by BS5839-1: 2002, and should be installed as a Category 3 cable as defined by BS7671.

16.88 Cables used for security and other alarm systems should be installed as per the manufacturers' requirements.

16.89 Designers should provide an independent tertiary power source (battery inverter unit) for the central head-end of a security system. The system suppliers should specify the battery autonomy. Designers and stakeholders should liaise with all staff, especially security staff, when determining which, if any, security detection and alarm component parts are supported by the SPS. As a minimum, if there is a pharmacy on site with controlled and/or dangerous drugs, the security system should be connected to the standby generators.

16.90 Designers should provide an independent tertiary power source (battery inverter unit) to any blood-bank alarm system. The system suppliers should specify the battery autonomy.

BEMS communication and control wiring systems

16.91 Designers should provide an independent tertiary power source (battery inverter unit) for the central head-end of any system used for these facilities. BEMS outstations should have an integral battery unit to maintain internal software parameters. The BEMS equipment etc should at least operate in the fail-safe position. More critical plant and service (controlled through the BEMS) should be connected to the SPS standby emergency generator.

17. Validation and commissioning

17.1 This section describes the recommended level of validation and commissioning required for all new and modified fixed wiring systems. The section does not provide a fully comprehensive scope of works, but gives a general overview. Designers and stakeholders may wish to consider acceptance of standard equipment factory or type test certificate items, rather than repeat the test after installation, which in certain circumstances may be difficult to perform.

17.2 Procurement of projects, which includes electrical installations (and others), should include adequate time and organisation to perform the required validation and commissioning programme for any works associated with the fixed wiring of the site. Clearly, for the range of fixed wiring schemes within healthcare premises, it is not possible to provide a general rule of thumb. Design teams should consult with the contractor and planners when allocating resources to the validation and commissioning process. Inappropriate validation and commissioning may lead to failure of the fixed wiring system.

17.3 The CIBSE Commissioning Manual (CCM), which contains very useful data and commissioning techniques for building services in the construction industry, provides valuable guidance in general commissioning strategies. The CCM also describes the design considerations for the construction industry in a similar manner to Section 3.

Validation of specific plant

Generators and CHP plant

17.4 Generating plant, including wind turbines, PV cells and CHP, should be tested as a complete system, including the actual equipment control panel and functionality of the controls. Plant should be tested in accordance with the relevant British Standards; see:

- BS5514;
- BS4999;
- BSEN 60034-2;
- BS5000-50: 1982, LEC 60681-1:1980; and
- BS7698.

Factory testing

17.5 The manufacturer should conduct a full set of tests as described for site and dynamic tests below. For verification of dynamic load tests, a reactive and resistive load bank should be used. The project engineer should witness all factory testing. The generator should be located in an environment similar to

that of the main site during any factory test.

Site testing

17.6 Before any dynamic tests are carried out on a new engine, the following procedures and static tests should be carried out: all generator lubrication and cooling circulation systems should be fully filtered; after descaling the circulation, systems should be sealed; the oil circulation systems should be filtered; and the filters should be replaced after all tests have been completed and prior to handover. Checks on the engine crankshaft deflection (at the bearings) should be made and recorded for operational maintenance records. Verification of the stator insulation resistance with the manufacturer's type test records should be made. The ratio of the one-minute reading and ten-minute reading (Polarisation Index PI) should be at least 2. The installation resistance of all control circuits should be measured. Verification of the contract documents with installed plant should be made, with all appropriate indications, including fault and control indication lamps and alarms.

Dynamic tests

17.7 The dynamic tests on site should include the following witnessed observations:

- lubricating oil pressure and pressure trip;
- lubricating oil and jacket water bypass automatic valves opening during engine warm- up including a series of test starts and checks, as follows:
  - the ability to start up within the specified time;
  - overspeed trip;
  - speed variation within specified limits;
  - voltage regulation and open-circuit characteristic;
  - electrical trips of generator by overcurrent, reverse power protection relays at minimum plug settings with generator below 25% FL (or primary injection);
  - a full-load run of not less than four hours, followed by a one-hour, 10% overload test and full-load protection trip – the test full load should be obtained by either a ballast load bank, or synchronised to the normal supply;
  - fuel-oil inlet pressure;
  - fuel-oil injector settings;
  - temperature rise of jacket cooling water;
  - temperature rise of lubricating oil;
  - temperature rise of charge air across turbocharger, if fitted;
  - temperature of exhaust gases at each cylinder head;
  - 240V stator winding heater disconnects when circuit breaker closes;

- ambient conditions;
- noise acoustic levels, engine/background;
- verification of the generator voltage rise.

Voltage regulation

17.8 The generator terminal voltage should be verified to be within ±2.5% from no load to 110% load conditions. The voltage regulation should be checked with the applied load varied up and down in the range from no load to 110% load several times, hence simulating actual conditions. The generator terminal voltage on starting should not overshoot the nominal terminal voltage by more than 15%, and return to within 3% of the rated voltage within 0.15 seconds. The generator terminal voltage should not vary by more than 15% following a step load increase from no load to 60% load, and then return to within 3% of the rated voltage within 0.5 seconds.

Multiple generators

17.9 It should be verified that multiple generators, running in parallel (whether with the PES supply or not, G.59/1 regulation), share the connected load in equal proportions. The connected load should be varied and a measure of each generator terminal voltage made. The generator engine speeds should also be equal. Excessive differences in generator field currents may lead to the generators drifting out of synchronisation.

Parallel operation with the PES

17.10 Where generators are intended to operate in parallel with the PES, tests to verify that the generator speed varies in conjunction with any change in the PES frequency should be made. When the supply frequency varies, the generator's fuel governor should modulate similarly and adjust the fuel input accordingly. The governor speed characteristic over a speed range of 100%–105% should be at synchronous speed, given a load change from full load to no load respectively. From no load to 110%, the governor should be stable and sensitive, and should respond to prevent overspeed excursions reaching 110%. If a speed of 110% is reached, the governor overspeed protection should close the engine fuel rack, cutting off the fuel supply to the engine.

Power factor correction

17.11 Any installed power factor correction (PFC) units connected to any part of the generator-supplied network should be able to be isolated when the generator is supplying the load. Verification of this control should be demonstrated at commissioning. Where the PFC units continue to be connected across the generator output, a reduced field excitation current may result, making the generator output become unstable. PFC units may be fitted with enhanced modulation control such that the PFC does not produce a leading power factor while the generators are connected to any part of the network.

Operational tests

17.12 After the generator has been fully tested as identified above, an assessment of the actual fuel consumption should be made, and checks to verify that there is adequate fuel storage (on site) for 200 hours of continuous full-load operation. The manufacturer should hand over all test records and insurance certificates, which should be held in the building logbook and operational maintenance manuals. The generator should be run against the building load, and verification of all phase failure and control devices established. Where the generator is arranged to synchronise with other generators, this should be demonstrated within the required time, voltage and frequency tolerances. Where the generator is designed to operate in parallel with the DNO connection, verification of the G.59/1 relay should be established. The commissioning and operational testing of generators will require the DNO's engineer to witness and authorise.

Uninterruptible power supplies

17.13 The uninterruptible power supply (UPS) should provide a no-break supply rated to the load equipment for the required endurance period. The equipment should continue to function normally when the normal supply is disconnected. The battery endurance capacity in ampère-hours should be verified under load conditions.

17.14 Typical commissioning tasks should include:

- the supply (a UPS) should include a test to verify that the supply changeover occurs within 0.5 seconds;
- verifications to ensure that the UPS synthetic sinusoidal output is within specification tolerance of the normal mains sinusoidal ac waveform;
- verification of the total harmonic distortion (THD) should be within the tolerance given in the design specification;
- the UPS should be operated at a load greater than 50% on battery duty to establish the true battery autonomy.

Environment

17.15 The commissioning of the environment systems of the UPS room should be coordinated with all parties to establish that design conditions have been satisfied. Deviations from the design conditions may be best achieved by changes to the ventilation system, rather than replacing a UPS. This part of commissioning is essential to protect the operational life of the batteries.

Indications and alarms

17.16 All local and remote indications and associated alarm combinations for normal use or failure in operation should be demonstrated and recorded.

Isolated power supplies

17.17 IPSs should be commissioned and validated in accordance with the requirements of IEC 60364- 7-710 and manufacturers' recommendations.

17.18 Designs should ensure that the IPS integral distribution board has the correct protective devices and is correctly labelled.

17.19 Verification of alarm indicators, local and remote, should be demonstrated.

17.20 Measurements of all individual circuit insulation resistances should be made as part of the general testing and commissioning stage carried out by the electrical installations contractor and as required by the IEE Regulations. The results should be compared with the reading indicated on the insulation monitoring device (IMD). The IMD should be tested by decreasing the circuit insulation resistance to prove the alarm system.

17.21 The leakage current of the isolation transformer should be tested when the transformer is energised and with the secondary open circuit. The value should be <0.5 mA.

17.22 Where the IPS is connected to a primary supply and secondary supply (generator), a test should verify that the supply changeover (at the point of common coupling) occurs within 0.5 seconds or 15 seconds (depending on the actual circuit intention). This test will require the input of the main electrical contractor and IPS contractor.

Fixed wiring distribution, switchgear and protection

17.23 The fixed wiring system should be verified and commissioned in accordance with BS7671.

17.24 All testing, verification and commissioning will only be undertaken by suitably competent personnel (that is, having obtained a qualification compatible with the City and Guilds Certificate C&G 2391; see Scottish Health Technical Memorandum 06-02).

17.25 The recommended initial test and verification for the fixed wiring systems is given in the IEE Guidance Note No 3 'Inspection and Testing' Sections 1 to 3 inclusive.

17.26 Verification and commissioning of the fixed wiring system should demonstrate that the earthing systems employed comply with the TN-S system as defined in BS7671. The only exception to such earthing methods will be any IT earthing systems associated with the ISS employed in patient environment Groups 1&2.

17.27 Verification and commissioning should demonstrate that a consistent voltage rise (phase rotation) is employed throughout the electrical infrastructure, including the connection to the PES and any secondary or tertiary power sources.

Records to be kept

17.28 All tests and inspections should be recorded. A collection of sample record sheets covering the more common elements of the fixed wiring is provided in Appendix 2. Designers may wish to adopt other forms put forward by manufacturers or from software design programs. These will be accepted if they cover the minimum information provided on the sample forms.

17.29 The records should include all test certificates relating to electrical test and pressure test as appropriate. Records for all (off-site) manufactured items demonstrating conformity to the European Community legislation (CE marking) should be provided.

17.30 As appropriate, a comprehensive operational maintenance manual for all plant and accessories, including protection and switchgear items, should be provided at project handover or during the validation and commissioning period. The operational maintenance manual should describe how the design satisfies the design strategy and should indicate the intended mode of operation. The operational and maintenance manual should include a section to describe any action required to change the distribution for power supplied from the PES, and/or generator-supplied power.

17.31 The operational maintenance manual should include a full single-line diagram to show all points of isolation (with room name/number references).

As-installed drawings

17.32 The following list provides a minimum acceptable level for the as-installed drawings. Project contract documentation should be written and agreed with the healthcare organisation, and should clearly indicate which drawings are relevant to the particular project and any additional drawings that may be required:

- HV network – layout and single-line schematic to cover the whole site:
  - the drawings should include substation and equipment references;
- HV switching and transformer schedule to cover the whole site on one drawing:
  - comprehensive equipment details with CT and VT relay ratings settings etc;
- principal earthing drawing – layout and single-line schematic to cover the whole site on one drawing:
  - the layout drawings should use the site general arrangement as a background and show all main earthing points, regardless of being an HV earth, LV earth, generator earth or form the lightning protection systems;
  - the schematic drawing should clearly show the interconnectivity of all earthing systems, and the measured resistances of each earth electrode;

- LV main distribution – layout and single-line schematic – one drawing per substation:
  - the layout drawings should use the building general arrangement as background. The layout drawing should show all containment sizes;
  - the schematic drawing should indicate all cable sizes, protective device rating and setting, switchgear and fault levels at switchboards;
- LV sub-main distribution – layout and single line schematic per switchroom:
  - the layout drawings should use the building general arrangement as background. The layout drawing should show all containment sizes;
  - the schematic drawing should indicate all cable sizes, protective device ratings and settings, switchgear and fault levels at switchboards;
- LV final circuit distribution – layout of lighting and small power and single line schematic per distribution board:
  - the layout drawings should use the building general arrangement as background. The layout drawing should show all containment sizes;
  - the schematic drawing should indicate all cable sizes, protective device ratings and settings, switchgear and fault levels at distribution boards;
- general arrangement drawings of 1:20:
  - all substation HV rooms;
  - all substation transformer rooms;
  - all substation LV rooms;
  - all generator house/enclosures;
  - all rooms with CHP or other alternative power sources;
  - all LV main distribution switchrooms or rooms with LV distribution equipment;
  - all LV sub-distribution switchrooms;
  - all electrical risers;
  - typical cross-section ceiling voids showing principal routes and areas of high service density;
- system and control wiring:
  - where the project includes any associated electrical services (for example fire alarms, nurse-call systems), layout drawings (using the building general arrangement drawing as a background) to show the location of any associated devices and a single-line schematic of the system should be provided, including any associated panel wiring diagrams.

Building logbook

17.33 The building logbook is now a standard requirement for all new buildings throughout the construction industry, and is referenced in the Building

Regulations. The items identified throughout Section17 fulfil the requirements of the building logbook. Where the capital project relates to only part of the site or adaptations of existing electrical circuits, the existing building logbook should be updated.

17.34 The purpose of the building logbook is to provide a single collection of all relevant information relating to the architecture and building services at the site. The information should facilitate a source of all data to enable modifications to any part of the building services, and to operate the plant and services in an energy-efficient way homogeneous to the design intent.

17.35 The CIBSE Technical Memorandum TM31 ‘Building Logbook’ provides a validated guide template for small businesses. The CIBSE Building Logbook, CD-ROM, Logbook Template Standard (LBTS) or Logbook Template Customisable (LBTC) may prove more useful when the project relates to a new build. The CD-ROMs contain electronic templates. LBTSs are the standard templates, which may or may not dovetail into the project, while LBTC contains customisable templates that may be user-adjusted to suit the specific job.

17.36 The building logbook will fulfil some of the designer’s duties for compliance with the CDM Regulations.

Appendix 1: Maximum interruption times to the primary supply

Clinical Risk Category	Service	IEC 60364-7-710 Group	Maximum Electrical Supply Interruptions Times (Seconds)		
			< 0 to 0.5 >	< 0.5 seconds to 15 seconds >	< 15 to 10800 >
5	Medical Equipment with IPS	2	←--------→	←——————→	
	General Medical Equipment	0–1		←——————→	
	General Electrical Circuits	0	C	←——————→	
	Fixed Medical Lighting and Escape Lighting	0	←——→		
	General Lighting	0		←——A——→	
	Mechanical Services	0			←——→
4	Medical Equipment with IPS	2	←--------→	←——————→	
	General Medical Equipment	0–1		←——————→	
	General Electrical Circuits	0	C		←——→
	Fixed Medical Lighting and Escape Lighting	0	←——→		
	General Lighting	0		←——A——→	
	Mechanical Services	0			←——→
3	Medical Equipment with IPS	0–1			←——→
	General Medical Equipment	0			←——→
	General Electrical Circuits	0	C		←----------→
	Fixed Medical Lighting and Escape Lighting	0	←——→		
	General Lighting	0			←——B——→
	Mechanical Services	0			←----------→
2	Medical Equipment with IPS	0			
	General Medical Equipment	0			←----------→
	General Electrical Circuits	0	C		
	Fixed Medical Lighting and Escape Lighting	0	←——→		
	General Lighting	0			←——B——→
	Mechanical Services	0			
1	Medical Equipment with IPS	0			
	General Medical Equipment	0			
	General Electrical Circuits	0	C		
	Fixed Medical Lighting and Escape Lighting	0	←——→		
	General Lighting	0			←-----B-----→
	Mechanical Services	0			

NOTES

A Standby Lighting Grade A (Lighting provided to the same, or nearly the same, lighting levels, achieved at normal electrical supply)

B Standby Lighting Grade B (Lighting provided at a reduced lighting level, 33%, of that achieved at normal electrical supply)

C Battery Inverter Unit provided for items such as fire alarms, security, computer network servers, and local computer systems as appropriate.
When the alternative power source has been connected, it should remain connected until the primary power source has been restored and stabilised.
Tertiary power sources (UPS) will be required for periods less than 0.5 seconds (refer to Chapter 14)
Secondary power sources (generators) will be required for periods greater than 0.5 seconds (refer to Chapter 8)

←——→ Indicates that an electrical supply must be available within the specified timeband

←----------→ Indicates that an electrical supply must be available where equipment requires

Figure 45: Maximum interruption times – primary supply

Appendix 2: Sample test record sheets

Plant Item Fixed Panels and Switchboards Inspection			Completed	
Identification/Location			Incomplete	
Contractor			PC Address File	
Manufacturer				
Serial Number				
Witness Print Name and Sign			Date	Sheet 1 of
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
1	Check switchboard for damage or incomplete work			
2	Check all labels warning symbols, switchboard circuit identification labels are correct			
3	Check switch is fixed and mounted correctly			
4	Check switchboard protective earth conductor are connected to the main earth terminal (MET)			
5	Check termination lugs and bolts for tightness			
6	Check VT & CT compartment assembled correctly			
7	Check shutter linkage and the locking facilities			
8	Rack all devices into service position Note: all shutters should have a smooth movement			
9	Check all busbar joints with torque spanner and inspection contact spaces Bolt size Specified torque setting			
10	Isolate VT, remove fuselinks of Voltmeter and CTs Measure (i) IR py/Sy (ii) IR CT Sy (iii) IR busbar and circuit bar phases			
11	Measure total conductance of HV busbar phases along the switchboard by ohmmeter measurement a) between adjoin cubicle busbar phase spouts (BS) b) between circuit spouts (CS) and cable box (BX) Note: Estimate Resistance from 1.0 m of conductor Between Ph1 Ph2 Ph3 Res Spouts BS1 and 2 μΩs BS2 and 3 μΩs BS3 and 4 μΩs 1CS and 1 BX μΩs 2CS and 2 BX μΩs 3CS and 3 BX μΩs 4CS and 4 BX μΩs			

Figure 46: Test sheet – fixed panels

Plant Item HV Pressure Test Switchboards Identification/Location Contractor Manufacturer Serial Number			Completed Incomplete PC Address File	
Witness Print Name and Sign			Date	Sheet 1 of
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
1	Before HV test ensure all covers and fittings are replaced and secure			
2	Check components correctly assembled and fitted			
3	Check free operation of all switch movement etc			
4	Check all earthing facilities and switch positions			
5	Check (i) all instrument fuselinks removed (ii) VT isolated and CT fuselinks removed (iii) IR test busbar before and after pressure test MegΩ Values Ph1-Ph2/Ph2-Ph3/Ph3-Ph1 Ph1-N/Ph2-N/Ph3-N Ph1-E/Ph2-E/Ph3-N			
6	Adhere to the Electrical Safety Rules Health Technical Memorandum 06-02			
7	Pressure test busbars as 0.4 kV system @ 2 kV for one minute 11 kV system @2 kV for one minute Voltage ……. kV Humidity …..… % Temperature ….. °C Phase Ph1-Ph2/Ph2-PH3/Ph3-Ph1 Leakage Current Phase Ph1-N/Ph2-N/Ph3-N Leakage Current Phase Ph1-E/Ph2-E/Ph3-E Leakage Current			
8	Check IR of close, open and control circuits Note: HV Equipment should be energised as soon as practical after test, to ensure faults are checked			
9	Verify switch labels with circuits and record drawings			

Figure 47: Test sheet – HV switchgear pressure test

Plant Item Switchboard Devices Electrical Test Identification/Location Contractor Manufacturer Serial Number			Completed Incomplete PC Address File	
Witness Print Name and Sign			Date	Sheet 1 of
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
1	Ensure cubicle busbar/circuit shutter door mechanisms are locked shut, if board energised			
2	Carry out IR test between devices open contacts and when open, closed between phases and frame earth Values Ph1/Ph2/Ph3			
3	Pressure test busbars as 0.4 kV system @ 2 kV for one minute 11 kV system @ 2 kV for one minute Voltage …….. kV Humidity …..… % Temperature ..... °C Phase Ph1-Ph2/Ph2 -PH3/Ph3-Ph1 Leakage Current Phase Ph1-N/Ph2-N/Ph3-N Leakage Current Phase Ph1-E/Ph2-E/Ph3-E Leakage Current			
4	Rack devices into cubicle isolated position for the close open operational test			
5	Check local control, close and trip of device at the rated battery voltage, minimum of ten operations. Check the operation of the close and trip at 80% of the rated applied close battery voltage			
6	Check the trip mechanism at 50% of the rated applied trip battery voltage			
7	Check time of closing mechanism operating spring to recharge, at 80% of rated applied voltage			
8	Check operation of "auto-change" devices used for Emergency Generators and normal DNO supply as appropriate for the distribution strategy			

Figure 48: Test sheet – Switchboard devices electrical test

Plant Item Transformer Mechanical Test Identification/Location Contractor Manufacturer Serial Number			Completed Incomplete PC Address File	
Witness Print Name and Sign			Date	Sheet 1 of
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
1	Check drawing, general inspection for damage and completeness			
2	Check all components fitted to general arrangement			
3	Prove tightness of all fastenings			
4	Check all labelling to transformer schedule			
5	Check transformer correctly positioned in bay for cable box entries/ bushing connections			
6	Check colour of desiccant crystals (as supplied)			
7	State type of coolant in tank			
8	Check if transformers filled with oil/fluid to operating level yes/no			
9	Check for any coolant leaks			
10	Check cable box details agree with cable details and requirements			
11	Check location of loose CTs, if provided, and method of connection in cable box or to star point neutral			
12	Check position of transformer earth lug and connection to main earth system			

Figure 49: Test sheet – Transformer mechanical test

Plant Item Transformer Electrical Test Part A Identification/Location Contractor Manufacturer Serial Number			Completed Incomplete PC Address File	
Witness Print Name and Sign			Date	Sheet 1 of 2
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
1	Check IR of transformer cooling fan motors, and cable terminations (where appropriate)			
2	Check transformer cooling fan motor electrical function in local and remote modes			
3	Check transformer cooling fan motor overload/time by three-phase and single-phase injection			
4	Analyse the tank and Buchholz relay oil for clarity and resistance			
5	Take IR readings of HV and LV windings			
6	Check operation of all protection trips and alarms at initiating and control sections			
7	Check fan controls are operational			
8	Check cable box and bushing connections tight, oil tank free and secure			
9	Transformer enclosure locked and secure			
10	Check marshalling box wiring connections at termination blocks for tightness and correct labelling			
11	Check IR of control wiring using megger (i) Marshalling box control wiring (ii) Buchholz relay (if fitted) (iii) Temperature indicators Coolant Core			
12	Fill transformer with coolant to operational level with new oil complying with BS 148			
13	Check IR of Core insulation to earth before link is covered with coolant, during the fill operation			
14	Check IR when transformer filled with coolant HV LV PPh1–PPh2 / PPh2–PPh3 / PPh3–PPh1 / Sph1–Sph2 / Sph2–Sph3 / Sph3–Sph1 / Ph1–Ph1 / Ph2–Ph2 / Ph3–Ph3 / N–E / All Primary Phases to Earth All Secondary Phases to Earth			

Figure 50: Test sheet – Transformer electrical test part A

Plant Item Transformer Electrical Test Part B Identification/Location Contractor Manufacturer Serial Number			Completed Incomplete PC Address File	
Witness Print Name and Sign			Date	Sheet 2 of 2
Healthcare Premises Engineer				
Project Engineer				
No	Activity	Witness		Date
		Healthcare Premises Engineer	Project Engineer	
15	Winding ratios at each off-load tap position and the transformer vector group (i) apply 0.4 kV 3-phase ac to HV winding terminals and interconnected Ph1 HV to Ph1 LV (ii) Winding ratio HV Ph1–Ph2, Ph2–Ph3, Ph3–Ph1 LV Ph1–Ph2, Ph2–Ph3, Ph3–Ph1 Tap –10% –5% –2.5% 0% 2.5% 5% 10% (iii) Vector Group Ph1–Ph2 Ph2–Ph3 Ph3–Ph1 Ph1–Ph2 Ph2–Ph3 Ph3–Ph1 PPh2–Sph3 PPh3–Sph2			
16	Check trip/alarm supplies voltages (i) At circuit breaker (ii) At transformer (a) Buchholz (b) coolant temperature (c) Tank pressure (d) cooling fans running			
17	Check IR of Tap changer control pane (if fitted)			

Figure 51: Test sheet – Transformer electrical test Part B

Plant Item Secondary Injection Test (IDMT Relay) Identifications/Location Contractor Manufacturer Serial Number								Completed Incomplete PC Address File		
Witness Print Name and Sign								Date		Sheet 1 of
Healthcare Premises Engineer										
Project Engineer										
Manufacturer's Description Test								Setting for Test R	Y or N	R
1	General Inspection									
2	Check Contacts close at zero Tm time and follow through									
3	Check Flag operation									
4	Measure time to reset from contacts									
	Close at 1.0 Tm									
5	Check trip isolation contacts									
6	Set 100% Pm, check no creep at 1.0 Psm, and creep commences at/or before 1.25 Psm current values									
7	Check Plug bridge continuity, max Pm setting and with plug out									
8	Check relay, T shorts removed									
	CT ratio ……/…… type		Relay Controls					Relay Operating Times		
	Time/current characteristic at 100%		Pm	Tm	Psm	Amps		R	Y or N	R
	Pm and at applied setting			1.0	1.3					
					2					
			100%	0.5	2					
				1	4					
		Applied setting			2					
	Fag Setting	Final setting applied								
	Remarks									

Note: Settings for electronic IDMT relays are generally software set. Therefore the maintenance test of electronic IDMT relays may be reduced to a check that the commissioning settings have not been changed, or the network (protected by the IDMT relay) has not changed, which would require a re-commissioning of the IDMT relay. The manufacturer's data sheet should be used in all circumstances

Figure 52: Test sheet – Secondary injection IDMT relay

Plant Item Secondary Injection Test Instantaneous Relay Identification/Location Contractor Manufacturer Serial Number				Completed Incomplete PC Address File	
Witness Print Name and Sign				Date	Sheet 1 of
Healthcare Premises Engineer					
Project Engineer					
			Witness		Date
			Healthcare Premises Engineer	Project Engineer	
Test			R	Y or N	B
General Inspection Check Trip isolation contacts Check Flag operation Check CT shorts Plug bridge continuity (Inst o/c relays)					
R		Y or N		B	
Plug setting	Op Amps	Plug setting	Op Amps	Plug setting	Op Amps
Plug out		Plug out		Plug out	
With stabilising resistor series and CT in shunt		Stab resistor value Applied setting Operating volts Operating current	R	Y or N	B
Flag reset		Final setting applied			

Figure 53: Test sheet – secondary injection instantaneous relay

Description of Works													
Circuit Description	Over- current device Short circuit capacity kA		Wiring conductor		Test Results								
					Continuity			Insulation resistance		Polarity	Earth loop Impedance	Functional Testing	
	Type	Rating in A	Live mm^2	cpc mm^2	R1 + R2 Ω	R2 Ω	Ring	Live/ Live MΩ	Live/Earth MΩ		Zs Ω	RCD Time mS	Other
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Deviations from the Wiring Regulations and Special Notes													

Note the test sheet shown here is a much reduced format of the form provided by the IEE Regulations

Figure 54: Test sheet – LV final distribution board test results

LIGHTING COMMISSIONING DETAILS		
Location		
Building		
Areas Covered		
Relevant Distribution Board		
Relevant Controls		
Test Engineer		
Approved Engineer		
Test Date		
Test Commissioning	**Test Result**	**Follow Up Complete**
Groups of luminaires are assigned to the correct positions in grid switch or grid single circuit dimmer		
Emergency lighting complies with recommendations of BS 5266/BS 12464-1		
Luminaires and remote control gear are of the correct make and type		
Fixed luminaires have been installed at the correct orientation		
Fluorescent lamps have the correct phosphor		
Lamps are of the correct colour temperature (Rendering Index Ra **)		
All lamps are the correct wattage and voltage ratings		
Exterior floodlights have been aimed to drawing and according to terms of planning permission		
Horizontal illuminance on horizontal tasks(s) is at specified level		
Vertical illuminance on vertical tasks(s) is at specified level		
PIR detector systems are programmed and operate correctly		
Lighting levels associated with control signals have been chosen		

When commissioning lighting installations, grouping rooms with similar functions and lighting designs, for example toilet areas may reduce the number of repeated tests.

A more comprehensive lighting commissioning schedule is available from CIBSE

Figure 55: Lighting commissioning certificate

Appendix 3: Drawing symbols

The symbols below are all generic versions of the British Standard symbols. In some case where the device type is not specific to the figure in the Scottish Health Technical Memorandum text, a symbol representing more than one device type is indicated.

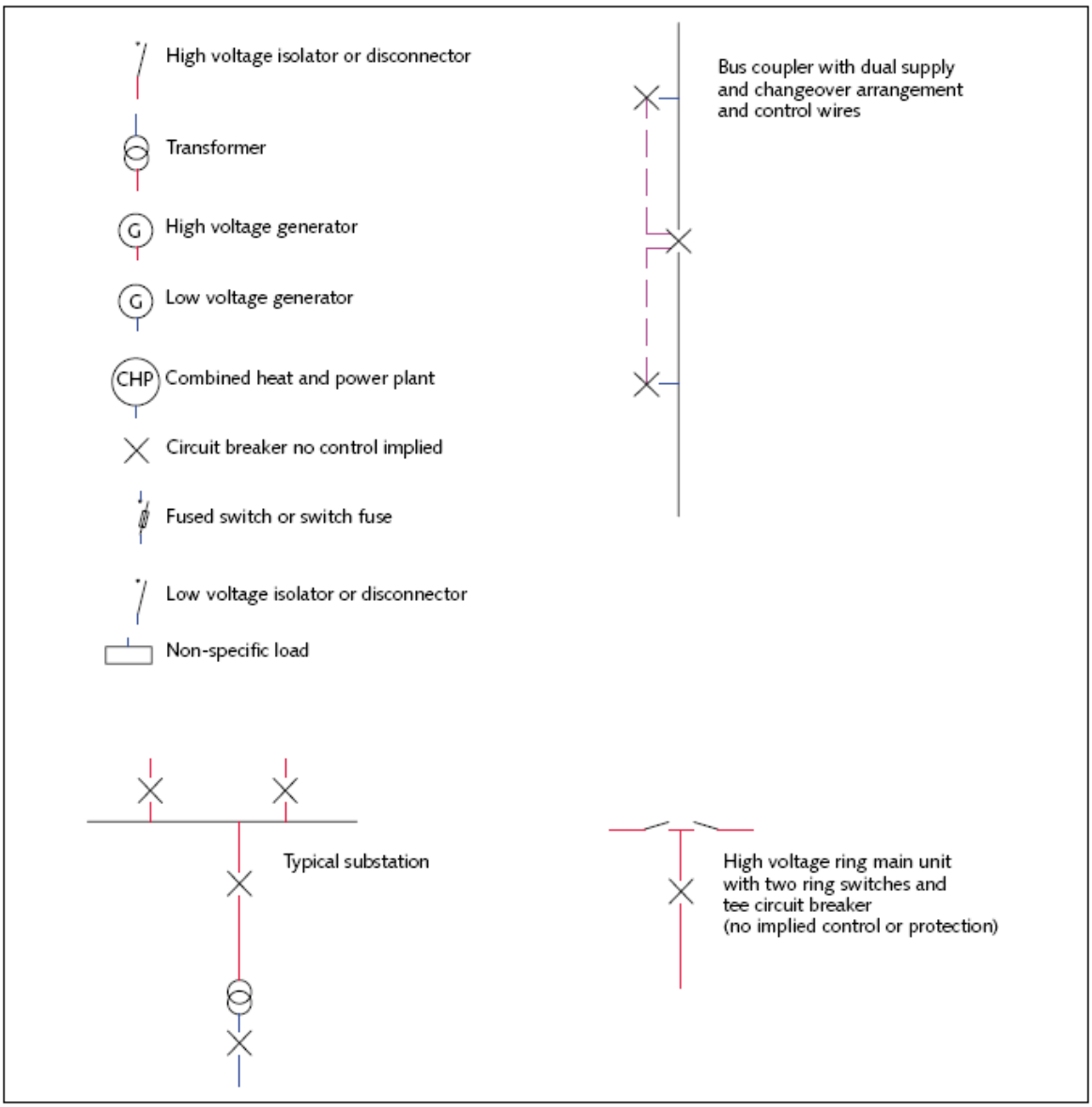

Figure 56: Drawing symbols used in this Scottish Health Technical Memorandum

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NHS Scotland Assure
Quality in the healthcare environment

NHS National Services Scotland

NSFG/2023/02/03

NHS Scotland Assure Strategy

2023 - 2026

A47168969

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Introduction

Our vision – the future we will create

To be the recognised national technical and clinical leaders in the healthcare environment for NHS Scotland.

Our purpose – how we will shape the future

To provide expertise and evidence-based advice that contributes to reducing risk, delivering a sustainable healthcare service, and improving the healthcare experience for Scotland.

Our role

NHS Scotland Assure has been designed with users to deliver a coordinated approach to the improvement of risk management and quality in the healthcare environment across NHS Scotland.

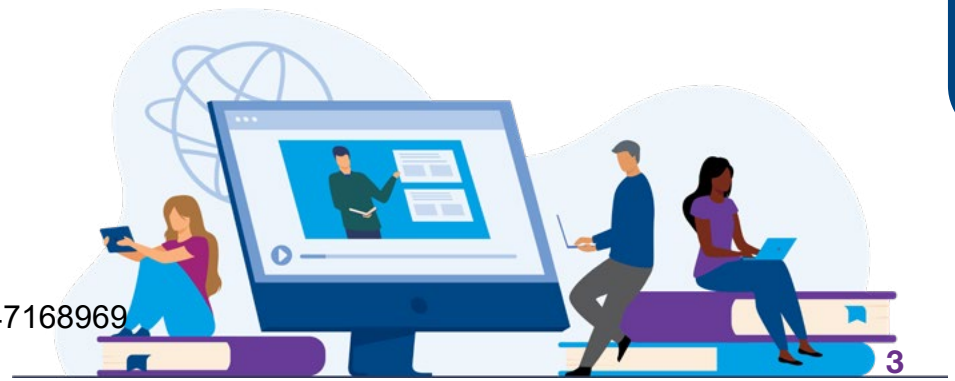
We underpin a transformation in the approach to promoting excellence, protecting patients from the risk of infection, and supporting better outcomes for the population.

We provide clinical and technical expertise to minimise risk and improve quality, practice and sustainability in the healthcare environment.

Established in 2021, NHS Scotland Assure has introduced new, and where appropriate enhanced existing services. We encompass services provided by Antimicrobial Resistance and Healthcare Associated Infection (ARHAI) Scotland and Health Facilities Scotland.

Our approach

Our strategic objectives and core themes inform our service delivery. We will continuously improve how we deliver our services. We will focus on quality to ensure our services are safe, efficient, effective and facilitate best practice. We will further integrate our services by collaborating with our stakeholders to ensure we meet their needs.



Our core themes

We will focus on five core themes over the next three years:

National leadership and strategy – we will have an overarching leadership role in NHS Scotland's work to manage environmental and clinical Infection Prevention and Control risk in the built environment, and we will influence the development of new policy.

Planned life cycle support – we will collaborate with health boards to ensure the best healthcare environment and services for patients and staff.

Capacity and capability – we will support the development of workforce requirements across Scotland as it relates to the healthcare environment. We will collaborate in the national drive to develop a sustainable, skilled workforce.

Response – as well as our planned activities, we will work with stakeholders to respond to specific emerging issues or risks.

Intelligence and knowledge sharing - We will deliver a coordinated research portfolio to support the development of evidence-based guidance. We will coordinate national data sets and use this intelligence to support improved outcomes and decision making for the benefit of NHS Scotland.

Our strategic objectives

Service excellence

To deliver service excellence we will:

- support the delivery of a safer healthcare environment across multiple disciplines, ensuring that infection prevention and control is embedded in all stages of the healthcare build lifecycle
- use data and intelligence to inform stakeholders, empower staff and enable health boards to identify, monitor and manage built environment risk factors
- provide health boards with clear and streamlined services by aligning and integrating our service offerings and underpinning them with digital solutions
- identify and address gaps in practice by leading, producing, and commissioning quality research, guidance, and advice
- provide tailored national leadership and expertise in response to outbreaks and incidents, enabling and informing local capability and developing epidemiological and evidence-based intelligence.

Climate Sustainability

To deliver climate sustainability we will:

- embed climate sustainability in everything that we do. For more information read the NSS Environmental and Sustainability strategy.
- support NHS Scotland boards to reduce their greenhouse gas emissions and impact on the environment, adapt to climate change and better contribute to the UN Sustainable Development goals
- support NHS Scotland in its ambition to become a net zero and environmentally sustainable healthcare service as described in the NHS Scotland Strategy on Climate Emergency and Sustainability. For more information read the NHS Scotland strategy.
- provide expertise and advice to stakeholders, including evidence-based guidance for net zero healthcare environment.

Workforce sustainability

To deliver workforce sustainability we will:

- have a diverse, knowledgeable and skilled workforce
- work with stakeholders to create a sustainable and resilient workforce model by developing in-house, competent, qualified subject matter experts that meets their identified needs
- work with stakeholders to establish career pathways across multidisciplinary teams, and provide appropriate pathways for professional development
- support the development of NHS Scotland's workforce in collaboration with NHS Education for Scotland (NES), to ensure staff have the appropriate skills and knowledge for their role.

Financial sustainability

To deliver financial sustainability we will:

- deliver services in a financially sustainable way, using opportunities to work collaboratively
- support NHS Scotland to develop a financially sustainable healthcare environment
- develop a financial plan that supports improvement, innovation and collaboration
- build clear structures that reduce waste while increasing resilience
- put in place a National Services Scotland (NSS) wide asset register with clear lifecycle plans
- use innovative tools and techniques to present knowledge and information to stakeholders that will aid financially sustainable decision making.

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Collaboration and engagement

Collaboration is at the heart of our services. We do this through stakeholder networks and look for opportunities for new engagement.

We work with health boards, other public sector organisations, academia and the private sector to deliver our strategic objectives. We are committed to open and transparent working relationships with our stakeholders in line with NHS Scotland values. We recognise how important a supportive environment is to deliver services successfully.

NHS Scotland Assure is commissioned by the Scottish Government. We work closely with the Chief Nursing Officer and Health Finance Directorates. We advise on and contribute to policy as required. Our strategy is informed by the needs, priorities, and policy of Scottish Government.

NHS Scotland Assure has processes in place to respond to and prioritise requests from stakeholders. This ensures that new work is transparently managed in line with our capacity and aligned to our strategy.

Our services

Engineering and Assurance

We provide comprehensive, proactive and reactive engineering services to assist health boards gain assurance that their engineering services are safe for patients and staff. Our goal is to support health boards to reduce risks in the healthcare environment underpinned by industry-leading guidance, robust processes and procedures.

Research, Innovation and Intelligence

Research and innovation

The guidance and advice we produce helps ensure that patients, their carers, and those delivering healthcare are in an environment which is safe, effective and person centred. Research plays a pivotal part in supporting this as it ensures that guidance and advice are based on best practice and best evidence.

Intelligence

We support health boards to identify, monitor and manage their healthcare environment risks. Our data and intelligence supports informed decision-making and risk management.

Workforce Development

NHS Scotland has a diverse workforce in the healthcare environment with many experts in their field. In partnership with NHS Education for Scotland (NES) we provide opportunities for staff to develop their interdisciplinary awareness and knowledge. For more information read the NES Healthcare environment resources.

This supports an integrated workforce with the knowledge and skills needed to reduce risk and improve safety and quality in the healthcare environment.

ARHAI Scotland

We provide expert intelligence, support, advice, evidence based guidance, clinical assurance and clinical leadership to local and national government, health and care professionals, the public and other national bodies. Our aim is to protect the people of Scotland from the burden of infection and antimicrobial resistance (AMR). As the national organisation responsible for IPC and AMR, we liaise with other UK countries and international counterparts to develop and deliver Scotland's IPC and AMR programmes of work.

Find out more about ARHAI Scotland at www.nss.nhs.scot/media/3401/arhai-scotlands-operating-model-strategy.pdf

Facilities

We provide national support services for health boards including support and guidance for service improvement and innovation in healthcare facilities services. We support the planning of health board decontamination services and commission the national home oxygen service for patients. Our medical physics service supports the Scottish Breast Screening Programme with safety advice and training.

We support NHS National Services Scotland with all aspects of property management. This is to ensure the safety and compliance of our buildings and workspaces, delivering an environmentally sustainable and effective working environment for all our staff.

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Property and Capital Planning

We provide expert services covering the full range of property and capital planning activity. For capital build projects, we provide a range of construction and professional services frameworks, an advisory service, a design assessment and assurance service, and an end-to-end equipping service. For the existing estate, we provide a range of systems and processes, advice and guidance, and national survey programmes. We also provide a response service to significant building failure events. The Digital Estate service aims to improve the performance, effectiveness and efficiency of the existing NHS Scotland estate by adopting digital technologies. We also support health boards with operational Public Private Partnership, Non-Profit Distribution and Hub contracts.

These services improve quality, reduce risk, encourage shared learning, and provide a consistent best practice approach to property and capital planning.

For more information read the NHS Scotland Assure case study - NHS Scotland Assure Information Management System (AIMS) and the NHS Scotland Assure case study - equipping Badenoch and Strathspey Community Hospital.

Climate change, Sustainability and Environment

We provide advice and guidance to Scottish Government and health boards to support NHS Scotland's climate and environmental sustainability commitments.

How to engage with us

Find out more about us:

NHS Scotland Assure - nss.nhs.scot/browse/nhs-scotland-assure

ARHAI Scotland - Antimicrobial Resistance and Healthcare Associated Infection | National Services Scotland (nhs.scot)

Health Facilities - Health facilities | National Services Scotland (nhs.scot)

Email: nss.NHSScotlandAssure@nhs.scot

Ask us a question via our enquiry form:

https://www.nss.nhs.scot/nhs-scotland-assure/contact-assure/contact-nhs-scotland-assure

If you work in an NHS Scotland board, sign up to our Learning Network: https://forms.office.com/r/jhhSiqfS0j

Malcolm Wright OBE

Date of Birth: [redacted]

Awards:

Companionship of the Institute of Healthcare Management	November 2006
Honorary Fellowship of the Royal College of General Practitioners	November 2007
Honorary Doctorate, University of Paisley	November 2007
Officer of the Order of the British Empire (OBE)	January 2008
Fellow of the Royal Society of Arts	May 2011
Honorary Fellowship of the Royal College of Physicians of Edinburgh	October 2012
Winston Churchill Fellow	2017

Career Summary:

Chief Executive, NHS Scotland and Director General. Health and Social Care, Scottish Government	June 2019 - April 2020
Chief Executive, NHS Scotland and Director General. Health and Social Care, Scottish Government (Interim)	February 2019 - June 2019
Chief Executive, NHS Tayside	April 2018 - December 2018
Chief Executive, NHS Grampian	July 2015 - September 2018
Lead Chief Executive, 6 North of Scotland Health Boards	April 2017 - December 2018
Interim Chief Executive, NHS Grampian	December 2014 - July 2015
Chief Executive, NHS Education for Scotland	April 2004 - December 2014
Member of Governance and Improvement Support Team to NHS Lanarkshire	December 2013 - March 2014
Leader of Ministerial Support Team and Interim Chief Executive, NHS Western Isles	August 2006 - January 2007
Chief Executive, NHS Dumfries and Galloway	2001 - 2004
Chief Executive, Dumfries and Galloway Acute and Maternity Hospitals Trust	1999 - 2001
Chief Executive, Edinburgh Sick Children's NHS Trust	1994 - 1999
Unit General Manager Lothian Health Board.	1992 - 1994
Hospital Manager Hospital for Sick Children, Great Ormond Street, London.	1989 - 1992

Range of managerial positions following Lothian Health Board Administrative Training scheme 1975 – 1977 through to 1989

Qualifications and Personal Development:

- Diploma of the Institute of Health Services Management
- King's Fund Senior Management Programme, London
- Cranfield Director as Strategic Leader Programme
- Leadership at the Peak Programme – Center for Creative Leadership, Colorado Springs, USA, followed by four-week study tour of US Healthcare systems supervised by Professor Donald Light, Princeton University
- Windsor Leadership Trust – Consultation for Strategic Leaders and Experienced Strategic Leaders Programme
- Tavistock Institute - Group Relations Training – Two-week residential programme, two occasions Center for Creative Leadership, Colorado Springs, Leading Strategically Program
- National School for Government Top Management Programme, including work with Serious Organised Crime Agency, British Immigration Authority and international week in Mumbai, India
- Invited member of Health Foundation study tour to North America to examine Quality Improvement in Healthcare
- Winston Churchill Fellowship – study visits to Sydney, Australia and Christchurch, New Zealand to study management of bullying and harassment in healthcare workforces

Career History:

June 2019 - April 2020 Chief Executive NHS Scotland and Director General Health and Social Care

As below, appointed following full Civil Service recruitment process in open competition.

On 22/4/20 I commenced a period of sick leave following the recurrence of a previously diagnosed and treated medical condition and regrettably subsequently stepped down from my role in Government on medical advice.

February 2019 - June 2019 Chief Executive NHS Scotland and Director General Health and Social Care (Interim)

Accountable Officer for the Health and Social Care portfolio, reporting to the Permanent Secretary, acting as a core member of the Scottish Government Executive Team, supporting Scottish Ministers and providing strong values-based leadership to the Health and Social Care system in Scotland
(160,000 NHS staff leadership of the wider system and £14bn portfolio budget)

Appointed on an interim basis to succeed Paul Gray, with a focus on building a strong SG team, developing the corporate contribution of the Health portfolio in the Delivery of the National Performance Framework and aligning leadership and governance to deliver early and sustained improvements in priority areas including access, mental health, integration, primary care, public health, workforce and financial sustainability
In my early weeks I gave particular attention to the development of working relationships with colleagues, partners and stakeholders to create the conditions

for sustainable system change.

April 2018 – December 2018 Chief Executive, NHS Tayside (concurrent appointment)

Chief Officer and fully accountable directly to Scottish government for the turnaround of NHS Tayside following Scottish Government ministerial intervention.
(11,700 WTE staff and £850m turnover)

Appointed by Scottish ministers as Chief Executive, following level 5 ministerial intervention to stabilise and lead recovery of the Health Board, which had an in-year overspend of £12m and accumulated debt of £45m. Accountable officer for two teaching Health Boards concurrently.

April 2017 – December 2018 Lead Chief Executive, 6 North of Scotland Health Boards

- Appointed by Scottish Government to lead the implementation of the National Delivery Plan across Grampian, Highland, Tayside, Orkney, Shetland and Western Isles Health boards, covering 25% of NHS Scotland staff and 60% of land mass.
- Production of Regional Delivery Plan
- Established system of cross-Board collaborative leadership at multiple levels, resulting in multiple programmes of collaborative work
- Membership of National Delivery Board for Health and Social Care

July 2015 – September 2018 Chief Executive, NHS Grampian

Chief Officer and fully accountable to the NHS Board for the leadership, management, and development of NHS Grampian
(12,000 WTE, £1.1 billion turnover)

Successfully led the organisation to deliver significant improvements to performance including:

- Strong and visible leadership of a major Health system in Scotland
- Comprehensive actions and delivery against all recommendations in relation to 3 challenging external reports
- Introduced comprehensive systems of Leadership, Governance and Management
- Reforming, and building, Senior Leadership Team
- Improved cancer, outpatient, treatment time guarantees, diagnostic test performance.
- Developed and launched 3 new Integration Authorities to integrate Health and Social Care
- Delivered financial balance and a sustainable financial position for the Board.

Dec 2014 – June 2015 Interim Chief Executive, NHS Grampian

Chief Officer and fully accountable to the NHS Board for the leadership, management, and development of NHS Grampian
(12,000 WTE, £1.1 billion turnover)

Appointed by Scottish Government following resignation of Chair and Chief Executive, in the light of 3 highly critical external inspection reports from Healthcare Improvement Scotland and Royal College of Surgeons of England.
Seconded from NES for the period of appointment.

2004 – June 2015 Chief Executive, NHS Education for Scotland

Chief Officer and fully accountable to the NHS Board for the leadership, management, and development of NHS Education for Scotland (1150 WTE Staff, £430m turnover).

Achievements to date**:**

- Led and developed the organisation from a challenging beginning from its three predecessor bodies into a strong visible, confident national educational body supporting Scottish Ministers and the NHS and working in partnership with a wide range of UK national, regional and local organisations.

- Implemented systems of strong internal leadership and management including personal and organisational performance management, leading to comprehensive delivery of the corporate plan within financial resources.

- Led cross governmental and cross organisational work to develop and deliver education and training across Health and Social Care

- Demonstrated strong organisational leadership and contribution to workforce development for Health and Social Care integration and Public Services workforce reform. Lead role in the establishment of Public Services Collaborative Learning.

- Led the development of our organisation to support all staff groups, e.g. Allied Health Professionals, Healthcare Scientists and Administrative and Clerical Staff.

- Created and developed a culture of cross professional and cross public service partnership working with governments, statutory, professional, regulatory and third sector bodies.

- Developed new and extended roles for healthcare staff, e.g. non-medical endoscopists, anaesthetic practitioners and hospital at night practitioners.

- Successfully implemented fundamental changes to postgraduate medical education, ensuring delivery of high-quality training and service continuity in a high profile and politically sensitive context.

- Forged strong working partnerships with Scottish and UK bodies, leading to tangible benefits to the NHS, e.g. with the Scottish Funding Council leading to joint funding of programmes including remote and rural healthcare, clinical skills development and healthcare support workers.

- Successfully implemented the complex, sensitive and high profile £50m Dental Action Plan leading to a significant increase in dental students, vocational trainees, therapist nurses and the development of a network of Teach-and-Treat Centres throughout Scotland.

2006 to 2007 Interim Chief Executive of NHS Western Isles (5 months)
(appointment concurrent with NHS Education Chief Executive)

Chief Officer and fully accountable to Board for the recovery of the Board affairs (1,000 staff – turnover £60m)

Appointed by the Minister for Health and Community Care and the Chief Executive of NHS Scotland to lead a support team in the light of loss of public confidence in the Board's work.

Achievements:

- Established robust financial recovery plan ensuring a reduction of an estimated £1.8m overspend to £800k in 5 months;
- Effected key changes in senior personnel;
- Fundamentally reviewed and put in place revised arrangements for clinical, financial, corporate and staff governance;
- Established confidence of key partners including council, locally elected representatives and staff;
- Delivered strategic agreement and plan with council to establish a community health and social care partnership;
- Ensured continued delivery of key business at NHS Education;
- Received letter of commendation from Chief Executive of NHS Scotland.

2001 to 2004 Chief Executive, Dumfries and Galloway NHS Board

Chief Officer and fully accountable to the NHS Board for the leadership, management and development of NHS Dumfries and Galloway (4,300 staff, £200m turnover).

Key Achievements:

- Led and delivered major organisational change through the creation of a single integrated NHS system from three separate organisations with full support from internal and external stakeholders. This was formally established on 1 April 2003, one year in advance of other NHS systems;
- Successfully established new NHS Board underpinned by strong collaborative whole-system working across NHS Dumfries and Galloway and with our partners in the Council. The Board was commended by Audit Scotland for demonstrating “strong leadership”;
- Ensured delivery of waiting list targets and a balanced financial position from all three former health organisations and from new integrated NHS Board. Specifically identified £1m of new investment from general NHS funds into services on 1 April, 2003;
- Successfully managed winter pressures and delayed discharges;
- Ensured delivery of a range of tangible benefits for patients including:

- New PFI build of Maternity and Day Care Unit;
- Managed Clinical Network for Cardiac Services;
- Wide range of strategies developed with full user, carer, Local Authority and NHS involvement which were approved and implemented;
- Integrated maternity services.

- Initiated the Dumfries and Galloway Review of Public Sector Physical Assets;
- Developed strong partnership working with Local Authority, Scottish Enterprise and Police through community planning and the establishment of the Joint Public Sector Senior Management Team;
- Developed and implemented leadership strategy for NHS Dumfries and Galloway;
- Led review of forensic services in West of Scotland, and Initiated and led the development of ‘Better Health, Better Healthcare’ Strategy to streamline the delivery of patient care.

1999 to 2001 Chief Executive, Dumfries and Galloway Acute and Maternity Hospitals NHS Trust

Chief Officer of and fully accountable to the Trust Board for leadership, management, and development of the organisation (1,850 staff; turnover £50m).

Achievements:

- Delivered Trust financial and waiting list targets for financial year ending 31 March 2000 and ensured Acute Trust management of winter pressures in partnership with Health Board, Social Services and Primary Care Trust;
- Led acute services in the redesign of surgical and accident and emergency services in Stranraer to a successful outcome working in partnership with Health Board, Primary Care Trust, general practitioners and public;
- Ensured closure of PFI agreement leading to the development to re-provide Cresswell Maternity Hospital and provision of day case surgery unit;
- Led the Dumfries and Galloway contribution to the establishment of a managed clinical network in vascular services for the Solway Basin;
- Initiated and implemented telemedicine link between Stranraer and Dumfries.
- Drove new approach to public involvement with the establishment of the Public Board and the systematic embedding of public involvement at all levels of the Trust's activity from specialty level planning through to strategic priority setting;
- Played a leading role in the establishment and roll-out of integrated service directorates in partnership with the Chief Executive of the Primary Care Trust in maternity, cancer, child health, elderly, information technology and pharmacy. I led the maternity, cancer and information technology groups which produced tangible improvements to services as a result of this approach;
- Led the establishment of partnership within the Trust as the new way of working through the Trust Partnership Forum, staff representation at Trust Board and Management Team and the creation of a joint work programme of projects;
- Led the introduction of clinical governance resulting in tangible improvements to services;
- Initiated system of critical incident reporting;
- Devised and implemented a range of initiatives to pro-actively manage the culture of the Trust in line with critical leadership behaviours. I sought to personally model these behaviours in my own leadership of the Trust.

1994 – 1999 Chief Executive, Edinburgh Sick Children's NHS Trust

Chief Officer of and full accountability to the Trust Board for the leadership, management, and development of the organisation (1,200 staff; turnover £32m).

Achievements:

- Devised, led, and achieved, with and through colleagues, the most significant programme of service development since the Royal Hospital for Sick Children entered the NHS in 1948;
- Positioned the Trust as one of only two in Scotland providing comprehensive combined child health services and as one of the leading paediatric providers in the UK;
- Led the centralisation of all day case and in-patient paediatric services in Edinburgh to the Royal Hospital for Sick Children (day case surgery, orthopaedics, ENT, neurosurgery, infectious diseases, neuro trauma);
- Developed new services (ITU, ITU retrieval, gastro-enterology, ambulatory paediatrics, specialist nursing) with Health Board, GP and clinician support;

- Redesigned services in response to parental and GP feedback (eg child and family mental health, fast-track out-patients, school nursing day case surgery);
- Drove consistent achievement of waiting times below Government targets;
- Led strategy development including Trust Strategy, Quality Strategy, Risk Management Strategy and jointly led Trust Clinical Strategy;
- Delivered redeveloped and re-equipped Royal Hospital for Sick Children £17m capital programme;
- Directed devolved management arrangements and delivered year on year reduction in management costs;
- Developed innovative IM&T approach for Trust;
- Initiated South East Scotland approach to children's services;
- Achieved financial targets each year and increased Trust income from £26.5m to £32m in four years.

1992 – 1993 Unit General Manager, Edinburgh Child Health Unit

Responsible to Lothian Health Board for budget of £19m, rising to £25m, for establishment of organisationally combined children's services.

Achievements:

- Led successful application for NHS Trust Status, winning backing from staff in a highly sensitive external environment;
- Established the top management team, effective systems of management and sound financial control;
- Managed the building of the New Wing (£11m) to time, budget and quality standards following the success of the Public Appeal.

1989 – 1992 Hospital Manager, Hospital for Sick Children, Great Ormond Street, London

Responsible to General Manager for the day to day running of the Hospital for Sick Children.

Achievements:

- Managed hospital-wide operational services during major hospital redevelopment following Wishing Well Appeal. This required high profile leadership and a pro-active team-based approach to problem solving;
- Developed special interest and expertise in medico-legal issues.

1975 – 1989

Successfully fulfilled a range of managerial positions in hospital and health centre management with Lothian Health Board following completion of the two-year Administrative Training Scheme in 1977.

Other Appointments:

Member of the National Delivery Board for Health and Social Care	2017 – 2018
Member of Ministerial Strategic Health Group for Health and Social Care	2016 – 2018
Chair of the Standing Ministerial Children and Young People's Health Support Group (formerly Child Health Support Group)	2000 – 2018
Vice Chair – Royal Society for Public Health	2017 – 2018
Trustee of Royal Society for Public Health	2013 – 2018
Chair of Senior Remuneration Committee, Royal College of General Practitioners	2014 – 2018
Member of Scottish Leaders Forum Planning Group	2012 – 2015
Member of Goodison Group	2010 – 2015
Chair of Ministerial Review of Specialist Services for Children in Scotland	2006 – 2009
Member of Ministerial Early Years Task Force	2012 – 2015
Chair of Cross Government task force on building, parenting, and family capacity pre- and post-birth as part of Scottish Government Early Years Framework	2008 – 2010
Chair of Scottish Government Keep Well Programme Board	2010 – 2013
Chair of Institute of Healthcare Management (UK)	2010 – 2012
Chair of Institute of Healthcare Management, Scottish Division	2007 – 2011
Vice Chair of Institute of Healthcare Management (UK)	2008 – 2010
Member of the UK Review of the future of Midwifery (Midwifery 2020) and lead of the Workforce and Workload Workstream	2009 – 2010
Member of the Reference Group of the Scottish Government Review of Teacher Education in Scotland	2010 – 2011
Member of the Review of Reshaping Care for Older People and Lead of the Workforce Workstream	2009 – 2010
Member of Scottish Committee of Quality Assurance Agency	2006 – 2009
Member of GMC/PMETB Joint Committee on Foundation Training	2006 – 2007
Member of the Expert Reference Group reporting to Cabinet Committee for Children	2003 – 2006
Non-Executive Director, Scottish Enterprise Dumfries and Galloway	2002 - 2004

Personal:

Following my retirement in 2020, I worked to rebuild my physical health and strength. I enjoy the arts including classical music and opera, reading and travel. I am currently studying Art History and Spanish language, and I have particular interests in history, politics, literature and international affairs. Last, and by no means least, I am physically active with a training programme to support my hillwalking and skiing activities. I enjoy time with family including grandchildren.

Malcolm Wright
December 2023

NHS National Services Scotland

Scottish Health Technical Memorandum 03-01

Ventilation for healthcare premises
Part A – Design and validation

Health Facilities Scotland
Engineering and Environment

February 2014

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Acknowledgements

Health Facilities Scotland would like to thank the principal contributors and the Steering Group led by the Department of Health for their efforts in producing the HTM 03-01 Part A document.

HTM 03-01 Part A has been updated and amended by Health Facilities Scotland for use in NHSScotland as SHTM 03-01 Part A and the contribution from the National Heating & Ventilation Advisory Group is gratefully acknowledged.

Preface

About Scottish Health Technical Memoranda

Engineering Scottish Health Technical Memoranda (SHTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of Scottish Health Technical Memorandum guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle.

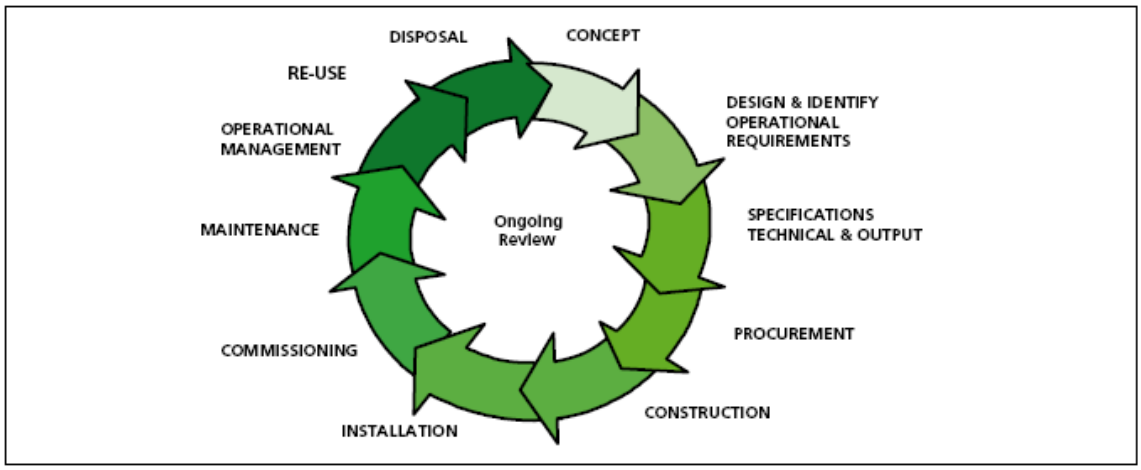
Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Engineering Scottish Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to repeat unnecessarily international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Scottish Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of eight subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.



Healthcare building lifecycle

Structure of the Scottish Health Technical Memorandum suite

The series of engineering-specific guidance contains a suite of eight core subjects:

Scottish Health Technical Memorandum 00: Policies and principles (applicable to all Scottish Health Technical Memoranda in this series).

Scottish Health Technical Memorandum 01: Decontamination.

Scottish Health Technical Memorandum 02: Medical gases.

Scottish Health Technical Memorandum 03: Heating and ventilation systems.

Scottish Health Technical Memorandum 04: Water systems.

Scottish Health Technical Memorandum 05: Reserved for future use.

Scottish Health Technical Memorandum 06: Electrical services.

Scottish Health Technical Memorandum 07: Environment and sustainability.

Scottish Health Technical Memorandum 08: Specialist services.

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Scottish Health Technical Memorandum 06-02 Part A will represent: Electrical Services – Electrical safety guidance for low voltage systems.

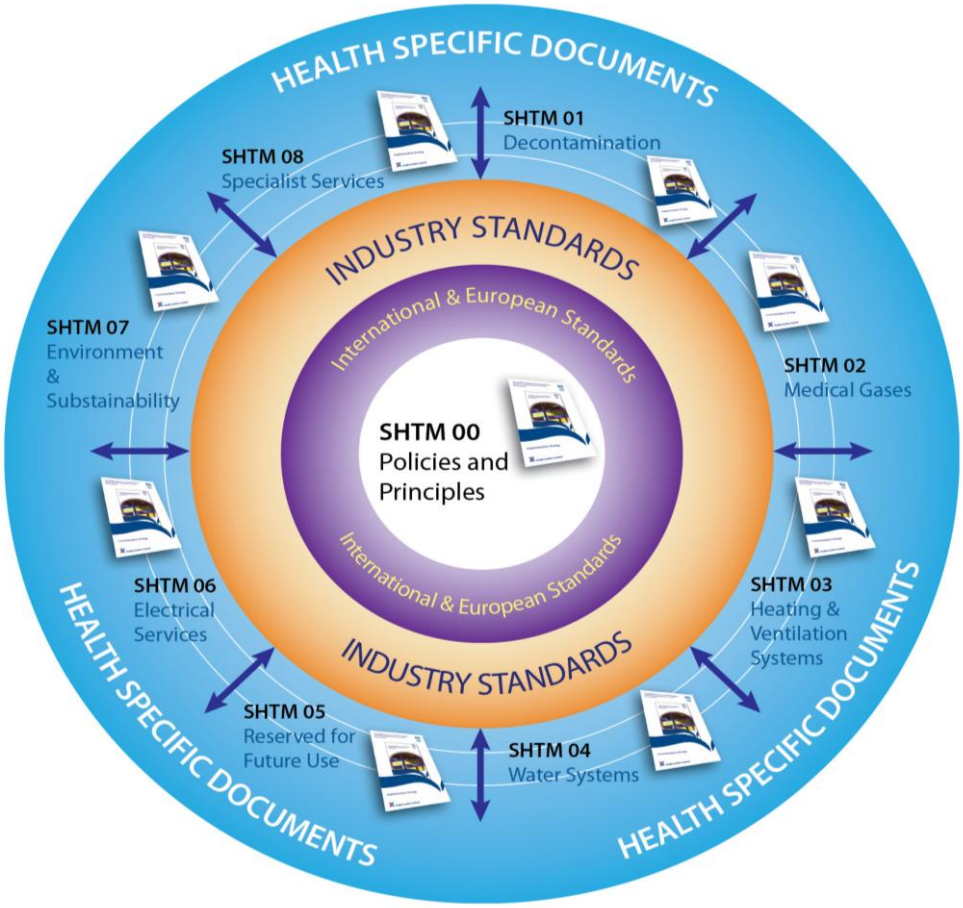
In a similar way Scottish Health Technical Memorandum 07-02 will simply represent:

Environment and Sustainability – EnCO_2de.

All Scottish Health Technical Memoranda are supported by the initial document Scottish Health Technical Memorandum 00 which embraces the management

and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.



Engineering guidance

1. Introduction

1.1 Ventilation is used extensively in healthcare premises or primary patient treatment in operating departments, high dependency units and isolation facilities. It is also installed to ensure compliance with quality assurance of processed items in pharmacy and sterile supply departments and to protect staff from harmful organisms and toxic substances, for example, in laboratories.

1.2 This edition of Scottish Health Technical Memorandum 03 'Ventilation in healthcare premises' is published in two sections. It is equally applicable to both new and existing sites. It gives comprehensive advice and guidance to healthcare management, design engineers, estate managers and operations managers on the legal requirements, design implications, maintenance and operation of general and specialised ventilation in all types of healthcare premises.

1.3 Current statutory legislation requires both 'management' and 'staff' to be aware of their collective responsibility.

1.4 'Ventilation' is also provided in healthcare premises for the comfort of the occupants of buildings. More specialised ventilation will also provide comfort but its prime function will be to control closely the environment and air movement of the space that it serves in order to contain, control and reduce hazards to patients and staff from airborne contaminants, dust and harmful micro-organisms.

1.5 Ventilation systems in themselves present little danger to patients or staff. However, they do possess the ability to transmit hazards arising from other sources to large numbers of people. The danger may not become apparent until many patients and staff have been affected.

1.6 The sophistication of ventilation systems in healthcare premises is increasing. Patients and staff have a right to expect that it will be designed, installed, operated and maintained to standards that will enable it to fulfil its desired functions reliably and safely.

1.7 The Health and Safety at Work etc Act 1974 (HSW Act 1974) is the core legislation that applies to ventilation installations and these installations are intended to prevent contamination, control closely the environment, dilute contaminants or contain hazards. Their very presence indicates that risks to health have been identified.

Statutory requirements

1.8 The Control of Substances Hazardous to Health (COSHH) regulations place upon management an obligation to ensure that suitable measures are in place to protect their staff and others affected by the work activity. These methods may include both safe systems of work and the provision of a specialised

ventilation system. In laboratories the requirements are often met by the provision of fume cupboards and safety cabinets.

1.9 The existing requirements to provide ventilation, implicit under HSW Act 1974 and COSHH, have been made explicit by the Management of Health and Safety at Work Regulations 1999, the Workplace (Health, Safety and Welfare) Regulations 1992 and the Provision and Use of Work Equipment Regulations 1998, all issued as a result of European Directives.

1.10 Where specialised ventilation plant is provided as part of the protection measures there is a statutory requirement that it be correctly designed, installed, commissioned, operated and maintained. The local exhaust ventilation (LEV) section of the COSHH regulations requires that the plant be inspected and tested at least every 14 months by an independent organisation and that management maintain comprehensive records of its performance, repair and maintenance.

1.11 Certain substances have Occupational Exposure Limits (OEL) set out in Guidance Note EH 40 published annually by the Health and Safety Executive. If special ventilation systems are provided in order to achieve these standards they will be subject to the COSHH regulations as above.

1.12 All ventilation systems should conform to the principles set out in the Approved Code of Practice and guidance document entitled “Legionnaires’ disease: the control of *Legionella* bacteria in water systems” (commonly known as ‘L8’) published by the Health and Safety Executive and Scottish Health Technical Memorandum SHTM 04-01: The control of *Legionella*, hygiene, “safe” hot water, cold water and drinking water systems.

1.13 Special ventilation plants installed in laboratories dealing with research, development or testing, whether involving drugs, animals or genetically modified organisms, may be subject to particular legislation with regard to their operation in addition to that mentioned above. Further information is given by the Health and Safety Executive Health Services Advisory Committee in:

- safe working and prevention of infection in clinical laboratories;
- safe working and prevention of infection in clinical laboratories: model rules for staff and visitors;
- safe working and prevention of infection in clinical laboratories in the mortuary and post-mortem room.

1.14 Plants installed in units manufacturing medicinal products to the standards set out in the current European Guide to Good Manufacturing Practice may also be subject to particular legislation with regard to their operation in addition to that mentioned above.

1.15 Records should be kept of equipment design and commissioning information. The Health and Safety Executive, Medicines Inspectorate and other interested bodies have a statutory right to inspect them at any time. All records should be kept for at least five years.

1.16 The fire regulations require that if ventilation ductwork penetrates the fabric of a building it should be designed and installed so as to contain the spread of fire. (for further information refer to Firecode Series SHTMs 81, 83 and 85)

1.17 Increased health risks to patients will occur if the more specialised ventilation systems installed to supply high quality air to operating departments do not achieve and maintain the required standards. The link between post-operative infection and theatre air quality has been well established. Plants serving conventional operating departments, for instance, will be required to ensure the separation of areas within the suite by maintaining a specific direction of air flow between rooms, even when doors are opened. They will also maintain the selected operating department environmental conditions regardless of changes in the outside air conditions or activities within the space. In addition ultra-clean operating ventilation systems that are designed to provide an effectively particle-free zone around the patient while the operation is in progress, have been shown to reduce significantly post-operative infection in patients undergoing deep wound surgery. Their use for other forms of surgery may well be required.

1.18 Ventilation systems that can be shown to be inappropriate, inadequate or ineffective and that give rise to proven failures can result in a civil suit by the patient against the operators.

1.19 If the plant has been installed to dilute, extract or contain harmful substances (the definition of which now includes microorganisms) its failure may expose people to unacceptable levels of hazard. Proven failures can give rise to a civil suit against the designers and operators by the individuals who have been affected. This would be in addition to the actions brought as a result of breaching the statutory requirements.

1.20 There is a statutory requirement to provide ventilation in all enclosed workspaces. It may be provided by either natural or mechanical means. The following are some of the factors that determine the ventilation requirements of a workspace:

- human habitation (minimum fresh air requirement);
- the activities of the department, that is, extraction of odours, aerosols, gases, vapours, fumes and dust – some of which may be toxic, infectious, corrosive, flammable, or otherwise hazardous (see Control of Substances Hazardous to Health (COSHH) regulations;
- dilution and control of airborne pathogenic material;
- thermal comfort;
- the removal of heat generated by equipment (e.g. catering, wash-up, sterilising areas, electrical switch rooms, uninterruptible power supply (UPS) cupboards and some laboratory areas);
- the reduction of the effects of solar heat gains where other forms of reducing the solar effect is not available or practical, i.e. solar blinds;
- the reduction of excessive moisture levels to prevent condensation (for

example Hydrotherapy pools);

- combustion requirements for fuel burning appliances (see BS5376, BS5410 and BS5440);
- 'make-up' supply air where local exhaust ventilation (LEV) etc., is installed.

Mechanical ventilation systems are expensive in terms of capital and running costs, and planning solutions should be sought which take advantage of natural ventilation either where the use of the area in question is not critical to airflow patterns or pressures, or where backup systems are available when natural ventilation cannot be achieved.

1.21 When new ventilation systems are accepted for use, full information as to their designed mode of operation together with recommended maintenance procedures should be provided as part of the handover procedure.

Requirement	Reason	Application
Statutory	Health and Safety at Work etc Act	Operating department Laboratories Pharmacy
	COSHH regulations	Areas containing identified biological or chemical hazards Areas containing oxygen displacing gases
	Local Exhaust Ventilation (LEV)	Enclosed work-spaces Workshops
Functional	Comfort	Situations where the quality of the environment for staff and patients is critical to their general performance and well-being
Clinical	Post-operative infection reduction	Operating suites used for general surgery, casualty, obstetrics/gynaecological and maternity procedures
	Reduction of deep wound sepsis	Ultra-clean operating suites for transplant, deep wound surgery, hip replacement, bone grafting and bone marrow transplant procedures
	Isolation from contact with bio hazards	Isolation units for patients who present a biological, chemical or radiation hazard to others. Isolation units for patients with a reduced immune system

Table 1: Reasons for providing ventilation

Functional overview – Terms in use

1.22 The terms 'ventilation' and 'air-conditioning' are often incorrectly used to describe the same equipment. A general explanation of the terms is given below.

Ventilation

1.23 Ventilation is a means of removing and replacing the air in a space. In its simplest form this may be achieved by opening windows and doors. Mechanical ventilation systems provide a more controllable method. Basic systems consist of a fan and either collection, (extraction) or distribution (supply) ductwork. More complex systems may include the ability to heat and filter the air passing through them. Ventilating equipment may be required in order to remove smells, dilute contaminants and ensure that a supply of 'fresh' air enters a space.

Air-conditioning and mechanical cooling

1.24 Air-conditioning is the ability to heat, cool, dehumidify and filter air. For full air-conditioning, humidification may also be provided. This means that the climate within a space being supplied by an air-conditioning plant can be maintained at a specific level regardless of changes in the outside air conditions or the activities within the space. Mechanical cooling may be provided where close control of 'comfort conditions' within a space is required but humidity control is not needed.

Special ventilation

1.25 In healthcare premises, certain activities will necessitate the provision of ventilation equipment with additional special features in order to achieve and maintain specific conditions. These may be needed in order to assist with the treatment of patients or maintain the health and safety of staff. The precise reason for providing special ventilation will depend upon the intended application. The list below indicates some of the more typical reasons:

- to remove, contain or dilute specific contaminants and fumes;
- to ensure the isolation of one space from another;
- to preserve a desired air flow path from a 'clean' to a 'less clean' area;
- to provide control of the cleanliness of a space;
- to provide 'close' control of temperature;
- to provide 'close' control of humidity.

1.26 The following departments will usually have specialised ventilation requirements, either for a single room or throughout a suite of rooms:

- operating department;
- laser surgery unit;
- intensive treatment unit;
- infectious diseases isolation unit;
- manufacturing pharmacy;
- specialised imaging, X-ray and scanning unit;

- pathology containment laboratories;
- mortuary and dissection suite;
- research laboratory;
- sterilising and disinfecting unit (SDU);
- endoscopy unit;
- renal dialysis suite;
- ultrasound facilities;
- audiology room.

1.27 Ventilation may be provided in a wide variety of ways. These will include:

- extensive purpose-built air-conditioning units housed in their own plant rooms;
- proprietary 'packaged' systems often sited outside on a roof or;
- wall-mounted electric fans located at the point of use.

1.28 A fixed volume of air may be supplied, often expressed in terms of the resulting number of air changes per hour (ac/h) within the space being ventilated. It may also be expressed in terms of litres/second/person. Alternatively the volume of air supplied may be varied in order to maintain a specific pressure relationship between the area supplied and other surrounding areas. In some situations a combination of both methods may be adopted.

1.29 Modern plants are fitted with the means to recover energy from the extract air where this can be justified without causing contamination of the incoming supply air.

1.30 Ultra-clean systems use the same basic plant and equipment as standard air-conditioning but are in addition fitted with a terminal device that supplies the air in a unidirectional manner to the working area. Their standard of filtration will be capable of delivering air with a very low particle count to the space that they serve.

Local exhaust ventilation

1.31 Local exhaust ventilation (LEV) is a term used to describe systems installed to prevent hazardous substances from entering the general atmosphere of the room in which they are being used. Their primary function is to protect staff from the effects of their work activity.

1.32 Simple LEV systems comprise a capture hood, extract ductwork and fan. These are used to contain industrial types of hazard such as fumes from welding processes, gas discharges from standby battery banks and dust from woodworking machinery. The vapour given off when large quantities of chemicals are decanted into ready-use containers and fumes from X-ray film processing units are further examples of chemical hazards often controlled by LEV systems.

1.33 In laboratories, pharmaceutical manufacturing facilities and operating suites, LEV systems usually take the form of semi-open fronted cabinets within which the hazardous substance is manipulated. These cabinets either have their own filtered air supply or are fed with air from the room. The air extracted from the cabinet is passed through a high-efficiency filter before being discharged either to the atmosphere or back into the room. Microbiological safety cabinets, laboratory fume cupboards, cytotoxic drug cabinets and fixed or mobile disinfection enclosures are all examples of this type of facility.

1.34 Mortuaries and dissection suites may have LEV systems incorporated within the dissection table, specimen bench and bone saw.

Management action

1.35 The guidance contained in this SHTM should be applied in full to new installations and major refurbishments of existing installations.

1.36 Ventilation will need to be provided:

- as a requirement for patient care;
- in order to fulfil a statutory duty.

1.37 In assessing the need for more specialised ventilation and the standards desired for patient care, managers will need to be guided by their medical colleagues and by information published by Health Facilities Scotland.

1.38 The statutory need for ventilation falls into two categories:

- in the first, the need for specialised ventilation and the standards to be adopted are clearly set out in specific pieces of legislation. An excellent example of this is the current legislation surrounding the manufacture of medicinal products in the European Community. The managers of the departments affected by this type of legislative requirement should be aware of their needs and be able to advise on the standards to be achieved;
- the second type of statutory requirement arises due to the interpretation of both the Health and Safety at Work etc Act and the Control of Substances Hazardous to Health (COSHH) regulations. The person tasked with conducting COSHH assessments will be able to advise as to the need for, and standard of, ventilation in each particular case.

Design and validation process

1.39 It is essential when undertaking the design of a specialised ventilation system that the project be considered as a whole. The process model set out below should ensure that all relevant factors are considered.

Step	Question	Design statement and information required	Comment
1	Why is the system required?	Healthcare applications Statutory elements Non-healthcare applications	
2	What is the required system performance?	Room air flow pattern Air change rate Differential pressures Air quality Room air condition Noise limits	
3	What are the constraints on the distribution system?	Location, Size, Materials Dampers, Access, Insulation Fire considerations Room terminals	
4	What are the minimum requirements for the AHU(s)?	Intake / Discharge positions *Legionella*, Health and Safety Access, Fire, Electrical safety Leaks, Insulation, Cleanliness Filtration, Drainage	
5	What control functions are required?	User control requirements Estates control functions Energy management Environmental conditions Control sequence logic Run, Set back, Off philosophy	
6	How will the system performance be validated?	Validation methodology Instruments used Design information required [*Design air flow rates* *Design air velocities* *Pressure differentials* *Noise levels* *Air quality* *Installation standard*]	
7	The system will only be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.		
8	Handover to client	Basic design information Commissioning results Validation report	

Table 2: Design and Validation process model

Use and function of typical equipment used in ventilation plant

1.40 Typical equipment used in ventilation systems is listed below together with a brief description of both function and use.

General

1.41 The equipment built into the ventilation system and its ductwork should be of a type that will neither cause nor sustain combustion. No materials that could sustain biological activity should be used in the construction or assembly of the system.

Air Intake

1.42 An uncontaminated air supply to the system is essential. In order to achieve this, the air intake will be positioned so that air discharged from extract systems or other dubious sources cannot be drawn in. Exhaust fumes from vehicles can present particular problems. The area surrounding the intake will need to be kept clean and free of vegetation and waste material in order to reduce the possibility of biohazards or fire. The intake itself will be protected by a louvre and mesh screen to prevent rainwater, vermin and insects etc from entering the system.

Damper

1.43 Several types may be fitted:

- automatic dampers fitted immediately behind the air intake and extract louvres. They will automatically close when the system is shut down in order to prevent an uncontrolled circulation of air;
- balancing dampers are fitted into each branch of the air distribution ductwork system so that the design air flow rate can be set during the commissioning process;
- where ductwork passes through a fire compartment wall, ceiling or floor a fire and/or smoke damper may be required;
- plant isolating dampers are fitted so that the main plant can be isolated from its air distribution duct system. They are manually operated and enable cleaning and maintenance of the air-conditioning equipment to be carried out.

Ducting

1.44 The means by which air is conveyed from the intake to its point of use. Ducting is usually constructed of galvanised steel and will normally be insulated to reduce noise and conserve energy. Ducts can also be formed in concrete, brickwork, stainless steel or plastic and may be rigid or flexible.

Fan

1.45 A series of rotating blades that move the air in the direction required. Fans are usually powered by electric motors either directly connected to them or driven through belts and pulleys. A fan may be arranged either to force air into or draw air from a ductwork system.

Attenuator / silencer

1.46 A device that will contain and absorb the noise emitted by a fan. They may be required to reduce disturbance caused by noise breaking out through the air intake and also noise transmitted along the ductwork to the conditioned space.

Filter

1.47 A filter consists of a labyrinth of fibrous material contained in a frame. It is designed to capture and hold particles being carried in the airstream. Because of the size range and number of particles that exist in air no filter can remove them all. The purpose of filtration is to reduce their number and size range to an acceptable level. Filters of progressively higher grades are fitted through the ventilation system:

- primary filters (coarse) are designed to collect the larger particles and are intended to keep the air-conditioning plant clean;
- secondary filters (fine) will remove the staining particles from air and keep the conditioned space visibly clean;
- high efficiency particulate air filters (HEPA/absolute) will remove virtually all particles from air. These may be required in order to reduce contamination in the working area either biologically or in terms of particle count.

Filters may be fitted to extract systems to protect energy recovery devices. They may also be fitted to remove biological, radiation or chemical hazards and if so, are often contained in a ‘safe change’ facility in order to protect those carrying out maintenance.

Activated carbon filters will reduce odours in extracted or recirculated air.

Heater battery / heater coils

1.48 A series of heater batteries or heating coils with or without fins through which steam or hot water is circulated. Heat is given up to the air passing over the battery thus increasing its temperature. Heating is usually carried out in stages, the final battery being controlled by the end user. Small batteries may be electric.

Humidifier

1.49 A device for increasing the humidity of air by adding moisture. For ventilation in healthcare premises this is normally achieved by releasing ‘clean’ steam into an air supply duct. The steam will be completely absorbed into the air, increasing its humidity. The level of humidity may be preset or controlled by the end user.

Cooler battery / cooling coil

1.50 A series of finned coils mounted in the air supply duct. Either chilled water or refrigerant is circulated through the coils causing heat to be removed from the air. This will reduce its temperature and may also condense moisture out of the

air. As free moisture in a duct can be a source of contamination the coil will be fitted with an eliminator and drainage system.

Eliminator

1.51 A device for catching and removing water droplets from an air stream. It may form part of a cooling coil or be a separate device.

Drainage system

1.52 A means of removing water from ductwork and disposing of it safely. Typically it will consist of a tray mounted in the duct to catch moisture, a glass water seal trap, continuously falling drainage pipework and an air break in the drain run to prevent waste water returning and contaminating the duct.

Access doors and observation ports

1.53 Doors and removable panels providing access for routine maintenance and cleaning. The doors should be fitted with glazed ports and suitable lighting provided so that the correct operation of devices such as cooling coils, humidifiers and filters can be easily observed without needing to switch off the plant.

Energy recovery

1.54 Many plants are fitted with the means to recover energy from the extract air without causing contamination of the incoming supply air. These devices will be fitted with a drainage system and may incorporate an eliminator. Several types of energy recovery systems are available.

1.55 Precise definitions of ventilation and air-conditioning terms are given in the Chartered Institution of Building Services Engineers (CIBSE) Guide B.

Typical plant

1.56 The layout of a typical plant that conforms to the requirements for healthcare applications is shown in Figure 1 overleaf. It contains most of the equipment described above.

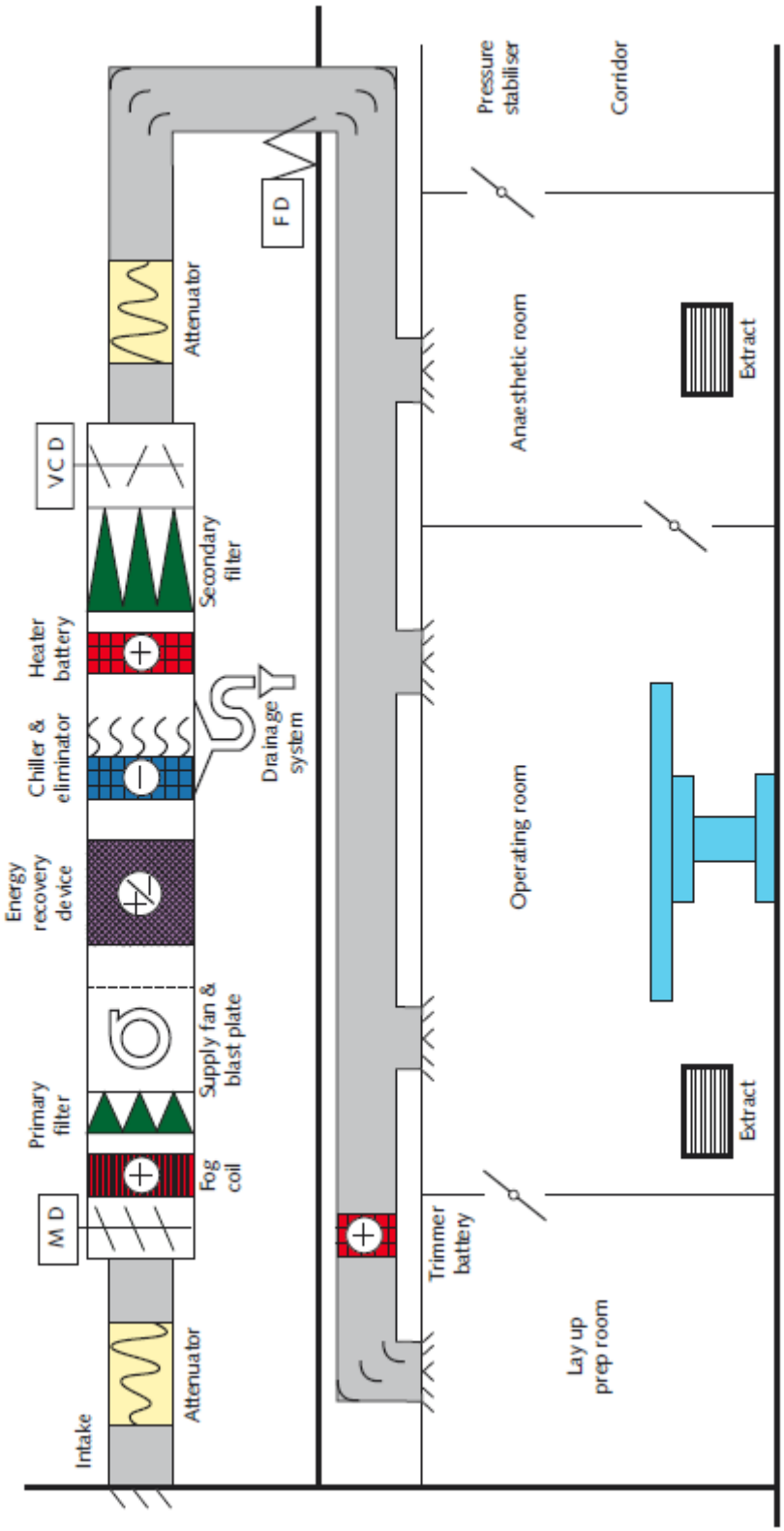


Figure 1: Design and Validation process model

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2. Provision of ventilation in healthcare buildings

2.1 It is acknowledged that planning constraints imposed by the building shape and/or functional relationships of specific areas will invariably result in some measure of deep planning thus reducing the opportunity for natural ventilation. However, ventilation costs can be minimised by ensuring that where practicable, core areas are reserved for rooms that have a functional requirement for mechanical ventilation. Examples are sanitary facilities, dirty utilities and those rooms where clinical or functional requirements have specific environmental needs; and where for reasons of privacy, absence of solar gain etc., windowless accommodation is acceptable. Other spaces appropriate to core areas are those that have only transient occupation and therefore require little or no mechanical ventilation, for example circulation and storage areas.

Natural ventilation

2.2 Natural ventilation is usually created by the effects of wind pressure. It will also occur if there is a temperature difference between the inside and the outside of the building. The thermo-convective effect frequently predominates when the wind speed is low and will be enhanced if there is a difference in height between inlet and outlet openings. Ventilation induced by wind pressures can induce high air change rates through a building provided air is allowed to move freely within the space from the windward to the leeward side.

2.3 As the motivating influences of natural ventilation are variable, it is almost impossible to maintain consistent flow rates and ensure that minimum ventilation rates will be achieved at all times. This variability is normally acceptable for general areas including office accommodation, general wards, staff areas, libraries rooms, dining rooms and similar areas which should, where possible, be provided with opening windows of a design that facilitates natural ventilation.

2.4 Current guidance restricts the amount windows can be opened for safety reasons and as many designs are top-hung, their ability to permit natural ventilation is limited. It may therefore be necessary to provide dedicated ventilation openings in the fabric of the building to allow a sufficient natural flow of air into and out of the space. Paragraph 2.20 also refers.

2.5 In all cases, excessive heat gain, indoor air quality requirements or external noise may limit or preclude the use of natural ventilation.

Extract ventilation systems

2.6 Separate extract ventilation will be required for sanitary facilities, lavage areas, dirty utilities and in rooms where odorous, but non-toxic fumes are likely, in order to ensure air movement into the space. 10 air changes per hour have been found necessary, particularly in geriatric and psychogeriatric accommodation. This will assist with infection control procedures. A single

fan/motor unit can be suitable for individual rooms, but multi-room systems should be provided with duty and standby fans or motors to meet this need.

2.7 Toilets should have an extract ventilation rate as set out in the building regulations. Where WC's are located in shower and bathroom spaces, the ventilation required for the WC will normally be adequate for the whole space.

Supply only ventilation

2.8 Mechanical supply ventilation will be required in areas where it is important to maintain a positive pressure in order to prevent the ingress of less clean air, e.g. in pharmacy aseptic suites, sterile supply packing rooms, operating theatres and their preparation rooms (air change rates are given in Table A1).

Supply and extract ventilation

2.9 Mechanical supply and extract ventilation should be provided in rooms where there is a need to control room pressure in relation to adjacent spaces. Intensive Care Units, (ICU), isolation suites and treatment areas are typical applications.

Mechanical or comfort cooling

2.10 Cooling is very expensive in terms of energy costs and should be provided only where necessary to maintain a comfortable environment for staff and patient, or to ensure satisfactory operation of equipment. The imaging department in particular may require cooling to offset the equipment load.

2.11 Calculations and thermal modelling should be undertaken to ensure that during the summertime, internal temperatures in patient areas do not exceed 28ºC (dry bulb) for more than 50 hours per year taking into account the level of design risk for the application.

2.12 Certain non-patient areas may also require cooling and will typically include some laboratories, central wash-up and other areas that are subject to high equipment heat gains.

2.13 Where deep planning of other continuously occupied spaces, for example offices, is unavoidable, there will also be occasions when acceptable levels of comfort can only be maintained by cooling. Planning solutions of this type however will be exceptional.

2.14 Refrigeration plant should be of sufficient capacity to offset heat gains and maintain areas at a temperature that does not exceed the external design shade temperatures by more than about 3ºC taking into account the level of design risk for the application.

Air-conditioning

2.15 Full air-conditioning is only required in a very small number of areas within healthcare buildings and due to the capital and running cost its inclusion should be kept to a minimum. Paragraphs 3.14 - 3.15 and 4.91 - 4.93 also refer.

2.16 Areas whose functions may warrant the installation of air-conditioning include operating departments, intensive therapy units, manufacturing pharmacies and areas with particularly sensitive equipment.

Specialised ventilation

2.17 Due to the nature and extent of activities carried out in healthcare buildings, there will be a need for a wide range of specialised ventilation systems. The types of system which are generally required in individual departments and typical arrangements are given in Section 7.

2.18 The activities within some departments will require the provision of local exhaust ventilation (LEV). This is a statutory requirement under COSHH wherever the escape of chemicals, toxic fumes, biological material or quantities of dust into the general area would present a hazard to the occupants.

Ventilation for general areas

2.19 Table A1 provides recommended air change rates, temperatures and pressures for general areas that require mechanical ventilation in healthcare buildings.

Use of natural ventilation

2.20 The air tightness of new buildings has improved to the point that infiltration through building leakage can no longer be relied upon to provide sufficient air-flow. Attention must therefore be given to the provision of purpose-made ventilation openings to achieve the necessary flow rates. The air entering the openings may need to be controlled by motorised dampers linked to temperature and / or occupancy sensors in the ventilated space.

2.21 Internal partitions, fire compartment walls and closed doorways can often impede the flow path, and when this happens, the process will be more dependent on single-sided ventilation. Nevertheless, even with this degree of compartmentation, acceptable ventilation may still be achieved without window openings that would prejudice safety, security or comfort.

2.22 Some types of window, for example, vertical sliding, can enhance single sided air change by temperature difference, and these will improve the overall rate of natural ventilation in protected or sheltered areas where the effect of wind pressure is likely to be minimal.

2.23 It is generally considered that natural cross-flow ventilation is able to give reasonable air distribution for a distance of up to 6 metres inwards from the external façade, provided that reasonably clear air paths are maintained. Beyond this distance in areas where clear air paths cannot be maintained and in areas where high minimum air change rates are specified, mechanical ventilation should be provided.

2.24 Further information can be found in SHTM 55 ‘Windows’, BS5925 ‘Code of practice for ventilation principles and designing for natural ventilation’ and

CIBSE Applications Manual AM10: 'Natural ventilation in non-domestic buildings'.

Mixed mode ventilation

2.25 This comprises an assisted form of natural ventilation. Fans are fitted in the purpose made damper-controlled ventilation openings. Alternatively a separate ventilation unit may be installed. In both cases the dampers and fans are controlled under the dictates of temperature and occupancy sensors to ensure a minimum air flow rate while taking advantage of natural ventilation effects when present.

2.26 Where natural or mixed mode ventilation is adopted with complex air paths, the designer should produce an air flow diagram in order to ensure correct provision of air transfer devices. CIBSE Applications Manual AM13: 'Mixed mode ventilation in non-domestic buildings' gives guidance.

Mechanical extract ventilation

2.27 General extract systems can vary in complexity from a single wall-mounted fan to a ducted air system with dual extract fans.

2.28 Replacement air is generally provided by a central supply system (as described below). Unless special precautions are taken, the latter may result in an unacceptable level of draughts occurring in winter, and possible risk of unacceptable levels of noise transmission.

2.29 If individual systems are used, the ventilation can be operated intermittently, provided it continues to run for at least 15 minutes after the room is vacated, as with light switch-operated fans in individual toilets.

2.30 If general exhaust systems are used; it is recommended that filtered and tempered replacement air is provided via a central supply plant to adjoining lobbies or corridors, to prevent the risk of discomfort caused by the ingress of cold air. Fire compartmentation requirements must be maintained.

2.31 Information on specialised extract systems is given in Section 7.

Mechanical supply systems

2.32 Where mechanical supply systems are required, the fresh air should be tempered and filtered before being delivered to the space, to avoid discomfort.

2.33 The air should be heated using a constant or variable temperature source, but generally only to the space air temperature. In most instances, the low-pressure hot water heating (LPHW) should offset any fabric loss, so that setback room temperatures can be maintained during unoccupied periods without the need for the ventilation system to operate.

Balanced ventilation

2.34 Balanced ventilation systems are merely a combination of a supply and extract systems of equal volume; and either a single space or a whole building may be considered to be balanced. A balanced system is necessary in instances where it is essential to maintain consistent air movement within an area, for example, treatment rooms.

Cascade ventilation

2.35 In operating departments it is normal practice to supply air to the operating room, and allow it to pass through less clean areas – corridors, utility rooms etc. (from where it is eventually extracted).

Recirculation systems

2.36 Due to the nature of the use of mechanical ventilation systems within healthcare buildings, there are few opportunities for the application of recirculation air systems. They are however normally used for HEPA filtered clean room applications where the extract air is significantly cleaner than the outside supply. Recirculation is also routinely used in the canopy section of Ultra Clean Operating theatre ventilation systems.

2.37 Where the designer is considering the installation of a recirculation air system, due account must be taken of:

- minimum fresh air supply volume required by the Building (Scotland) Regulations 2004 (currently 20%);
- prevention of contamination of supply air from vitiated air in extract systems;
- prevention of stratification occurring within plenum chambers and mixing boxes which may result in freezing of downstream coils;
- ensuring sufficient velocities through control dampers (ideally 5-6m/s) to provide suitable authority; and good shut-off;
- modulating control of mixing to provide optimum on-plant conditions;
- use of ‘free cooling’ by cycling the dampers to minimum fresh air when the enthalpy of the outside air is above that of the extract air under conditions when cooling is required.

Chilled beams

2.38 The use of chilled beams for the provision of heating, cooling and ventilation is increasingly common in healthcare premises. The use of Active Chilled Beams providing tempered filtered air to a heating / cooling device within the room can provide effective local control of environmental conditions.

2.39 Care should be taken in positioning chilled beams to ensure the avoidance of cold draughts particularly when used in the cooling mode. The control settings should ensure that the external elements of the beam are always above dewpoint.

2.40 Consideration should be given to the ease with which specific types of chilled beam units can be accessed for cleaning having regard to the need to control the infection risk. The impact of maintenance requirements on room availability should also be considered.

Split comfort air-conditioners

2.41 Split comfort air-conditioners, room conditioners or cassette units are used increasingly where there is a small local requirement for cooling for operational purposes. They can provide an effective economic solution to cooling needs, where a central refrigeration system is not practicable.

2.42 The units re-circulate room air so provision for a fresh air make up, either by natural or mechanical means, to the standard required by the Building (Scotland) Regulations must be provided.

2.43 The recirculation of room air presents problems with indoor air quality (IAQ) and may increase the risk of healthcare associated infection (HAI). Split units should not therefore be used in critical patient areas.

2.44 Split units may be used for single room applications or as multiple linked units that can independently provide either heating or cooling, all served by a single outdoor unit. These systems enable good temperature control of a number of rooms with maximum energy efficiency.

2.45 Whether single or multiple systems are used, it is essential that the designer gives due consideration to the source of electrical supply, location of the heat rejection unit, environmental effects to the refrigerant used and drainage provision for the cooling coil condensate.

2.46 The units will require routine maintenance for filter change and cleaning; they should therefore be installed in an accessible position.

Dilution ventilation and clean air flow paths

2.47 Dilution ventilation has in the past been used to control levels of hazardous substances in a space. This approach is no longer considered acceptable. The COSHH Regulations require that known hazardous substances should be substituted by safe alternatives. If this is not possible then they should be controlled at source by the use of closed systems such as anaesthetic gas scavenging units or exhaust protective enclosures such as fume cupboards.

2.48 The exposure of staff to casual spillages of substances such as medical gases in anaesthetic rooms should in the first instance be dealt with by establishing a clean airflow path. Air should be supplied at high level and extracted at low level directly behind the anaesthetic equipment position. The philosophy of establishing a clean air-flow path from the supply point; to the staff; on to the patient and out via a low level extract would also apply in recovery rooms and maternity delivery rooms including labour, delivery, recovery & post partum (LDRP) Rooms. A suitable air change rate will provide dilution ventilation as an additional safeguard; see Table A1, Table A2 and Note c.

2.49 In operating theatres the patient will be on a closed breathing circuit in a room with a high air change rate. Under these circumstances the dilution effect would be considered sufficient to control any casual exposure to anaesthetic gases.

Mechanical ventilation systems

System selection

2.50 Natural ventilation is always the preferred solution for a space, provided that the quantity and quality of air required, and the consistency of control of ventilation to suit the requirements of the space, are achievable with this method. If this is not the case, a mechanical ventilation system will be required.

Choice of central/local plant

2.51 Mechanical ventilation is expensive to operate, and as such, should be controlled to operate when the space being served requires to be ventilated. In addition, loads on refrigeration plant are rarely constant owing to changes in solar gain, occupancy and use of heat-generating equipment and lights, therefore control of temperature is critical.

2.53 If the ventilation loads throughout a department or building are in phase, or are not significant, a central plant with single zone control can be adopted. However, this is rarely the case, and elsewhere, the condition or quantity of supply air to different areas or zones of the building must be varied accordingly. This can be done by providing either individual plants to each zone, or separate zone terminal control. Where there is a high density of rooms with similar ventilation requirements in an area of a building or department, it is usually economical to combine them into a central system.

2.54 In large buildings, a choice between a single distribution system and multiple smaller systems may arise. Large distribution systems and their plant can have the advantage of lower operating costs, but require more space for vertical shafts and horizontal distribution. In general, very long runs of ducting should be avoided to prevent undue heat losses or gains, excessive leakage, and difficulties in balancing during commissioning. As the pressure losses in the long runs will be greater and a higher initial static pressure will be required, this will lead to a more expensive class of ductwork. Multiple smaller distribution systems may be more expensive in capital and operating costs but they avoid long runs, large ducts and vertical shafts, and this may reduce overall building costs. They also provide a more robust service as the failure of an individual system does not prevent the use of the rest of the building.

Zoning of the building

2.55 The efficiency and effectiveness of any ventilation or air-conditioning installation depends largely on the zoning and control of the installation. The factors to consider when determining the zoning of a ventilation system for a building or department are:

- periods of occupancy;

- fresh air/ventilation requirements;
- smoke control.

2.56 Where the ventilation system is not merely tempering the air, but also providing the heating and/or cooling requirements, the following additional factors will need to be considered:

- internal or peripheral location;
- orientation of windows;
- variation in internal loads;
- level of control required.

2.57 For single zone plant in staff areas, local control (with a run-on timer if required) is recommended, as this can be turned off when the space is not in use, thus saving both thermal and electrical energy. Most supply and extract systems, conversely, are required to operate continuously while the department is occupied, thus some form of time or use control is necessary.

2.58 The control of individual plant items is covered in Section 4, with examples of typical control strategies in Section 6. For control of particular specialised ventilation and air-conditioning systems refer to Section 7 of this document.

2.59 On very rare occasions a duplicate standby air handling plant may be justified. If installed it must be provided with a gas-tight damper at its junction with the supply distribution duct, so that no back-flow can occur. Standby plants can become sources of contamination if warm moist air is allowed to dwell within them. Their design and control system must ensure that this cannot happen.

Specific requirements for hospital departments

2.60 Specific requirements for individual spaces and departments are included in the Health Building Notes (HBNs) and Activity Database (ADB) A-Sheets, or Scottish Health Planning Notes (SHPNs).

3. Assessment of service requirement

Selection of design criteria

External design conditions

3.1 The most accurate data that is available for the summer and winter conditions at the site should be used. The Metrological office can supply data for the United Kingdom.

3.2 Healthcare mechanical ventilation systems will normally be 'full fresh air'.

3.3 Local adjustments such as for height above sea level, exposure factor, or other climate peculiarities, should be made as appropriate.

Internal design conditions

3.4 The design conditions selected within patient areas must strike a balance between the comfort requirements of staff and patients, who often have very different levels of clothing and activity.

3.5 Recommendations for the dry resultant temperature and humidity of individual spaces are shown on Activity Database (ADB) A-Sheets. Table A1 gives a summary.

Minimum fresh air requirements

3.6 For most applications involving human occupancy, the dilution of body odours is the critical factor in determining ventilation requirements. Where natural ventilation or mechanical full fresh-air systems are used, all ventilation air will be fresh.

3.7 Where odour dilution is the overriding factor, it is recommended that 10 litres/second/person should be taken as the minimum ventilation rate.

3.8 Smoking is not permitted in healthcare premises. If permitted for example in residential care, it will be confined to designated areas. It therefore follows that these areas will contain a high percentage of smokers so the ventilation rate would be at least 36 litres/second/person for these applications (CIBSE Guide A; Table 1.10 refers).

3.9 In non-standard applications such as laboratories, aseptic suites, operating departments, etc., the particular requirements for each area should be considered independently in order to determine the overriding minimum requirement for ventilation.

Limiting supply air conditions

3.10 For most applications in healthcare buildings, it is the temperature differential between the supply and room air, rather than the actual temperature of the

supply air which is the critical factor. The maximum recommended supply-to-room air temperature differential is:

summer cooling: - 7K

winter heating: + 10K

3.11 It is also necessary to keep supply air humidity below 70% during winter in order to minimise risks associated with condensation.

Air purity

3.12 In healthcare premises, the standard of filtration will depend on the activities within the occupied spaces. With the exception of special areas, (for example manufacturing pharmacies), the requirement for aerobiological needs is not stringent and filtration is only required to:

- maintain hygienic conditions for the health and welfare of occupants, or for processes such as food preparation;
- protect finishes, fabrics and furnishings; to reduce redecoration costs;
- protect equipment either within the supply air system; that is, to prevent blocking of coils, or in the space itself to prevent dust collection.

3.13 Given that almost all viable particles will originate from the occupants of a space and not from the incoming air, dilution is the more important factor aerobiologically. Therefore, for general areas a G4 filter will be suitable. More critical areas will require a F7 filter. HEPA filters will only be required in Ultra Clean systems.

Humidity control requirements

3.14 Providing humidification is expensive in terms of plant, running costs and maintenance, and therefore its use should be restricted to where it is necessary for physiological or operational reasons.

3.15 Humidification was originally required for some healthcare applications, e.g. operating theatres, in order to control the risk associated with the use of flammable anaesthetic gases. The use of such gases has now ceased. Humidification is therefore no longer required unless there is a very specific application requirement.

Maximum noise levels

3.16 Noise will be generated in an air distribution system by the fan, ductwork fittings, dampers and grilles. The specified maximum noise level will depend on the activities within the occupied spaces.

3.17 The overall noise levels should not exceed the values given in Scottish Health Technical Memorandum 08-01: ‘Acoustics’, although general requirements are given in Table 3.

3.18 Attenuation should be incorporated into the ductwork system or plant arrangement as necessary to reduce noise from fans and plant items in order to achieve the acceptable limits within the rooms at the design air flows.

3.19 Plant noise should not be greater than 80dB(A) within the plant room from the fans, coolers, heaters, humidifiers etc. when starting up or running, and should be reduced to lower noise levels where the plant is near to departments sensitive to noise.

3.20 Attention must be given to the reduction of tonal components. High tonal components from air diffusers etc. can seriously disturb concentration over longer periods even when the overall noise level is low. Broadband noise causes less annoyance. Reference should be made to SHTM 08-01: 'Acoustics'.

3.21 The designer requires knowledge of the total hospital layout and operational policies, to assign acceptance magnitudes to all the possible noise sources, in order to arrive at the correct rating.

Room	Overall noise level - NR	Ventilation plant commissioning - NR	Ventilation plant design - NR
Operating department	50 (55)	45	40
Ward areas	33	30	30
Sanitary facilities	45	40	35
Industrial areas	50	45	40
Circulation areas	50	45	40

Table 3: Interior noise level

3.22 In Table 3, above, the overall noise level takes account of all internal and external noise sources. The commissioning noise level is the level measured with a sound level meter in the unoccupied room, taking account of the external noise together with the noise generated by the ventilation system. When occupied and in use, this commissioning level will constitute a continuous background noise which will allow the overall noise level to be achieved. The ventilation plant design noise level is that generated by the plant alone with no other noise source being considered. The levels suggested make recognised allowance for the ingress of environmental noise that must be considered in the overall design, that is, in specifying the attenuation of walls, partitions, ceilings, etc.

3.23 The recommended criterion is measured as the "A" weighted sound pressure level expressed in decibels, which should not be exceeded for more than 10% of the time.

3.24 The designer must also consider noise escaping to the external environment and this must not be unacceptable to occupants of adjacent buildings.

Calculation of building loads

Air infiltration

3.25 Air infiltration occurs due to a complex combination of wind pressure, thermal effects, location relative to other features and the construction standard of the building. The infiltration rate is governed by the size and number of openings in the building envelope and the complexity of internal air paths.

3.26 CIBSE Guide A (2006) Section 4 provides information and formulae for the calculation of air infiltration and natural ventilation of buildings. In all cases the requirements of the appropriate section of the Building (Scotland) Regulations must be met.

Summertime temperatures

3.27 The calculation method for determining the summertime temperature is described CIBSE Guide A (2006) Section 5. However, it is very important to select the time of day and time of year of peak loadings for the calculations. These will be dependent on the orientation and proportion of solar to total heat gain. In establishing outside design values, the design risk having regard to the function and occupancy of the building should be considered.

3.28 Where calculations indicate that internal temperatures will frequently exceed the selected design external shade temperature by more than 3K for a period that exceeds the building design risk, methods of reducing temperature rise should be implemented. Options include: - reducing solar and casual gains, the use of chilled beams or ceilings, increasing ventilation rates or providing mechanical cooling. In some situations it may be possible to alter the thermal mass of the structure to 'move' the peak temperature event time so that it occurs outside of the occupancy period. Calculations and thermal modelling should be undertaken to ensure that during the summertime internal temperatures in patient areas do not exceed 28°C dry bulb for more than 50 hours per year. It has been found that there is a relationship between preferred indoor temperatures and mean outside temperature. Fig A2 in CIBSE Guide A indicates this relationship.

Peak heating load

3.29 Peak heating local calculations are necessary on all mechanical supply systems to establish the size of heater batteries and subsequently the central plant.

3.30 Where ventilation systems provide tempered air to spaces that have supplementary LPHW to offset the building fabric losses, the plant heating load should be calculated based on the external winter design temperature, the design internal air temperature, and the calculated total air volume (including a suitable allowance for leakage).

3.31 Where the ventilation system is the only means of heating a space, an increase in load equivalent to the calculated fabric heat losses from the space should be added to the ventilation load. A check of supply temperature difference should

be made. If it exceeds 10K the ventilation supply volume should be increased to suit.

Condensation risk

3.32 A check should be made to ensure that the selected air condition will not lead to surface condensation on low-temperature elements of the ventilated space.

3.33 Where there are local sources of moisture that would require excessive levels of ventilation to avoid condensation, the designer should consider the capture and removal of moisture at the source of the evaporation via an exhaust hood or similar device.

3.34 In intermittently heated buildings, it is necessary to consider the condensation risk at night setback conditions as well as during normal operation. Calculation methods for this assessment are given in CIBSE Guide A.

Peak cooling load

3.35 In addition to the base data of airflow rates and temperatures, when calculating cooling loads, the designer must take into account:

- solar cooling loads;
- surface conduction cooling loads;
- internal gain cooling loads;
- cooling loads due to high-level humidity control;
- method of control of internal conditions;
- fluctuations in internal temperatures.

3.36 When the peak internal loads have been assessed and a suitable allowance made for non-coincidence, the supply temperature can be calculated.

3.37 Once the lowest required supply temperature of the air handling unit has been established, and an allowance made for temperature rise through the fan and ductwork (usually 1K for low pressure systems), the off-plant enthalpy can be established from a psychrometric chart or table.

3.38 The cooling loads for all plants on the chilled water system should be calculated at each of the individual peak times in order to establish accurately the required (diversified) capacity of the chiller.

Annual energy consumption

3.39 Annual energy consumptions of heating-only ventilation systems are simple to calculate based on supply-to-external air temperature rise, and frequency of occurrence of external temperatures as given in CIBSE Guide A.

3.40 Minimum air volumes are usually fixed by the room loads or fresh air requirements. However, the designer may increase airflow to some rooms or

zones in order to balance loads, as detailed in the following paragraphs on "Calculation of plant requirements."

3.41 The method of zoning and control can significantly influence energy consumption.

3.42 The nature of air-conditioning operation, comprising cooling and reheating for humidity or zonal temperature control, makes prediction of energy consumption very complex. It is imperative that these calculations are performed to ensure optimum energy efficiency.

3.43 The concept of load and plant operation charts is outlined in the CIBSE Guide A. The method requires the designer to establish the minimum and maximum loads on all zones across the range of external temperatures between winter and summer design conditions. Once the load chart is complete, the plant chart converts the loads to supply temperatures, which are then superimposed on external air temperatures.

3.44 When all temperatures for all zones are plotted on the plant operation chart, set points and resetting schedules can be established. From this information, the outputs of individual heaters, coolers and humidifiers can be established at any given external temperature. When those loads are computed against annual frequency of occurrence of external temperatures as given in CIBSE Guide A, the annual energy consumption of individual elements, and thus the air-conditioning system, can be established.

3.45 In order to prevent surface condensation occurring, it is necessary to provide sufficient ventilation to maintain the maximum and ambient dew-point temperature below the lowest surface temperature, the coldest usually being the glazing. Paragraphs 3.33 and 3.34 also refer.

Calculation of plant requirements

Air supply volumes

3.46 The minimum air supply volume for a room is determined by the greatest of these three criteria:

- the minimum fresh-air requirement;
- the minimum supply volume for the room load as determined by the maximum heating or cooling supply temperature differential;
- the desired/required air change rate.

Plant sizing

3.47 Once the design airflow has been established the cross-sectional area of the air-handling unit can be calculated based on a maximum coil face velocity of 2.0 m/s.

3.48 In order to establish the length of the air-handling unit, it will be necessary to refer to manufacturers' literature, ensuring all necessary access panels and components are included as detailed in Section 4.

3.49 The fan duty should be calculated by adding the resistances of all elements that contribute to the pressure drop of the index circuit.

3.50 The main elements that must be considered are:

- inlet or discharge louvres;
- plant entry and discharge;
- attenuators;
- components within the air-handling unit;
- duct-mounted heaters and filters (including a dust allowance);
- ductwork distribution;
- ductwork fittings, including: fire dampers, volume control dampers, bends and sets, tees, changes of section;
- air terminal device;
- discharge velocity.

3.51 Where packaged air-handling units are installed, the fan pressure drop is usually quoted as external plant resistance, and thus the designer does not need to calculate the resistances of individual plant items. The designer should, however, ensure that an allowance has been made for filter clogging; and confirm whether the fan pressure quoted is fan total or static pressure.

3.52 Resistances of ductwork and fittings may be obtained from the CIBSE Guide A. However, the designer should exercise some care when using tabulated pressure loss information for fittings that are relatively close together.

3.53 Upon completion of the resistance calculation exercise, the designer should make allowances for calculation and construction tolerances as indicated in Table 4.

Criteria	Low pressure systems	Medium/high pressure systems
Volume flow rate margin for leaking and balancing requirements	+5%	+5%
Total pressure loss margin A. for increase in volume flow rate (above)	+5%	+5%
B. for uncertainties in calculation	+5%	+10%
Combined total pressure loss margin	+10%	+15%

Table 4: Typical fan volume and pressure margins

Plantroom size and location

3.54 The ventilation plant and associated equipment should be positioned to give maximum reduction of noise and vibration transmitted to sensitive departments; while at the same time, achieve an economic solution for the distribution of services.

3.55 It is not recommended that noise and vibration generating plant be housed either directly above or below sensitive areas (for example, operating or anaesthetic rooms) unless there is no alternative, in which case, additional care and attention must be given to the control measures.

3.56 The plant must also be located so that it is remote from possible sources of contamination, heat gains and adverse weather conditions. The design should ensure that wind speed and direction have a minimal effect on plant throughput.

3.57 Safe access to and around plant is essential to facilitate inspection, routine maintenance, repair and plant replacement.

Provision of primary services

3.58 Where more than one air-handling plant requires cooling, remote central cooling plants with piped chilled water are preferred. In the case of a single plant, a multi-stage direct-expansion cooling coil with refrigerant piped from an adjacent compressor/condensing plant could be considered. If this option is selected, a refrigerant gas detector mounted in the base of the duct and an alarm system audible to the end-user will also need to be provided (as dictated by COSHH Regulations).

3.59 Clean dry steam is preferred for humidification, provided that the boiler water treatment does not render the steam unusable for direct humidification.

3.60 If a suitable supply of steam cannot be obtained from the steam main, a steam generator should be provided locally, or a self-generating humidifier installed. Electric humidifiers require considerable electrical loads and if a gas supply can be derived, this would be preferable. The location of a local steam generator is critical if condensate is to drain back into it.

Inlet and discharge sizing and location

3.61 Air intakes and discharge points should preferably be located at high level, to minimise the risks of noise nuisance to surrounding buildings, contamination and vandalism.

3.62 Intakes and discharges should be designed and located so that wind speed and direction have a minimal effect on the plant throughput.

3.63 Helicopter landing pads in the vicinity of ventilation intakes and discharges can result in large short-term pressure changes. This can cause pressure surges in supply systems and reverse airflows in extracts. Exhaust fumes from the helicopter may also be drawn into intakes. For general information, refer to Health Building Note (HBN) 15-03 – Hospital helipads.

3.64 Intake points should also be situated away from cooling towers, boiler flues, vents from oil storage tanks, fume cupboards and other discharges of contaminated air, vapours and gases, and places where vehicle exhaust gases may be drawn in.

3.65 Where intakes have necessarily to be sited at or near ground level, the area around them should be paved or concreted to prevent soil or vegetation being drawn in. They should also be caged or located within a compound to prevent rubbish being left in the vicinity. The likely proximity of vehicle exhausts should also be taken into account when determining the protected area around the intake.

3.66 The discharge from an extract system must be located so that vitiated air cannot be drawn back into the supply air intake or any other fresh-air inlet. Ideally, the extract discharge will be located on a different face of the building from the supply intake(s). In any event, there must be a minimum separation of 4 metres between them, with the discharge mounted at a higher level than the intake.

3.67 Discharges from LEV systems should preferably be vertical and usually not less than 3m above roof level. They should not be fitted with a cowl that could cause the discharge to be deflected downwards.

3.68 Each intake and discharge point should be fitted with corrosion-resistant weatherproof louvres or cowls to protect the system from driving rain. Louvres should be sized based on a maximum face velocity of 2 m/s in order to prevent excessive noise generation and pressure loss.

3.69 The inside of the louvres should be fitted with a mesh of not less than 6mm and not more than 12mm to prevent leaves being drawn in and infestation by vermin.

3.70 The duct behind louvres should be self-draining. If this is not practicable, it should be tanked and provided with a drainage system.

3.71 Cleaning access must be provided either from the outside via hinged louvres or by access doors in the plenum behind the louvre. Where a common plenum is provided, cleaning access should be via a walk-in door.

Heat rejection devices

3.72 The design conditions given in Section 2 make no allowance for the elevated temperatures that can occur on the roof of buildings. Refrigeration condensers should, if practicable, be shaded from direct solar radiation, or the design adjusted to take account of the gain.

3.73 Air-cooled condensers must always be the first choice for heat rejection from any refrigeration plant. Evaporative cooling systems must not be used in healthcare premises.

3.74 Reference should be made to Scottish Health Technical Memorandum 04-01: 'The Control of *Legionella*, hygiene, 'Safe' hot water, cold water and drinking

water systems, Part A: Design, Installation and Testing, and Part B: Operational Management, published by Health Facilities Scotland, 2011.

4. Air handling unit design and specification guidance

General requirements

Location and access

4.1 Air-handling units should be located in an accessible area secured from unauthorised entry. Siting units in ceiling voids above occupied spaces is not appropriate.

4.2 Units located on roofs must have a safe means of access together with suitable precautions to prevent personnel or equipment falling or being blown off during maintenance activities.

4.3 Units located at ground level should be secured within a locked compound to prevent unauthorised access. Measures should be taken to exclude vehicles from the vicinity to ensure that exhaust fumes will not be drawn into intakes.

4.4 Units may have a working life of approximately 20 years. It can be anticipated that over this period there will be a need to access every element within the unit for deep cleaning. It is also quite possible that the main fan and individual heater and chiller batteries will need replacement. Suitably positioned service connection joints and adequate spacing should permit these items to be withdrawn without the need to dismantle other installed plant or equipment. Batteries significantly wider than 1 metre should be split to permit withdrawal from both sides.

4.5 It is essential that air-handling units are positioned so that all parts are easily and safely accessible for routine inspection and service. If a unit is located against a wall or backs onto another unit then access to all parts must be available from the front. Units greater than 1 metre wide should preferably have access from both sides or access doors large enough to permit the full and safe entry of maintenance personnel.

4.6 Water may be used during routine cleaning or spilt when maintenance is being undertaken. The area around the unit should be tanked to prevent water penetration to adjacent areas and adequately drained.

4.7 Fire precautions should be incorporated in accordance with Firecode. Guidance is available in BS5588: Part 9 and Sections 5 and 6 of this document.

4.8 Combustion equipment must not be located in a fire compartment that houses air-handling equipment.

Technical requirements

4.9 The basic technical requirements of the whole of the ventilation system should meet the relevant clauses of the Model Engineering Specification. It should be noted that the Specification contains a menu of clauses that cover a wide range

of applications, so it is important to select only those that are relevant to the specific application.

Note 1: At the time of writing, Model Engineering Specification C04 was listed for revision in order to bring it into line with the revised standards as set out in this Scottish Health Technical Memorandum. Where conflicts in specification arise, the Scottish Health Technical Memorandum takes precedence.

4.10 It is essential that the main plant/ductwork is located far enough above the floor to permit the correct installation of drainage systems for cooling coils, humidifiers and heat recovery systems. Easy access for maintenance of drainage systems and their associated pipework must be provided.

4.11 Organic materials or substances that can support the growth of microorganisms must not be used in the construction of the plant or its distribution system. The water fittings and materials directory lists suitable materials for sealants and gaskets.

4.12 The plant and its distribution system must not contain any material or substance that could cause or support combustion.

4.13 Plants should have a high standard of air-tightness. The double-skin method of construction with insulation sandwiched between two metal faces is recommended. The panels may be available in a variety of colours at no additional cost. This can aid identification by colour coding of units in a plant room (for example green for general ventilation; blue for theatres; red for laboratories and isolation facilities; grey for extract etc).

4.14 The inside of the plant should be as smooth as possible. Channels, rolled angles or formed sections that could trap or hold moisture should be kept to a minimum. If stiffeners are required, they should be fitted externally. If internal bracing has to be fitted it must be of a design that will not trap or hold moisture.

4.15 Airflow across air treatment components such as filters, heat exchangers and humidifiers will be influenced by the pattern of the approaching airstream. If unsatisfactory conditions are created, the performance of the component will be reduced.

4.16 Access to items that require routine service such as filters, frost batteries and chiller batteries should be via hinged doors. The doors should be large enough (for example 500mm minimum) to allow easy access. Items requiring infrequent access such as attenuators may be via bolted-on, lift-off panels. All doors and panels should be close-fitting and without leaks.

4.17 Care should be taken during installation to ensure that electrical and mechanical services are not installed in positions that will reduce or impede access.

4.18 It can be difficult to turn off AHUs in order to inspect filters and drainage trays. Viewing ports and internal illumination will therefore facilitate routine inspection of such items. Viewing ports should be at a convenient height so that temporary ladders are not required. Internal illumination should be provided by

fittings to at least IP55 rating. Fittings should be positioned so that they provide both illumination for inspection and task lighting. All of the lights in a unit should be operated by a single switch.

4.19 Access to AHUs and items in the distribution system such as filters or heater / chiller batteries should be via fixed ladders and platforms or pulpit-style moveable steps. The installation of distribution ductwork and other electrical or mechanical services should provide sufficient clearance to allow the pulpit steps to be easily wheeled into position.

AHU drainage system

4.20 All items of plant that could produce moisture must be provided with a drainage system. The system will comprise a drip tray, glass trap, air break and associated drainage pipework.

4.21 The drip-tray should be constructed of a corrosion-resistant material (stainless steel is preferred) and be so arranged that it will completely drain. To prevent 'pooling', it is essential that the drain connection should not have an upstand; and that a slope of approximately 1 in 20 in all directions should be incorporated to the drain outlet position. The tray must be completely accessible or, for smaller units, easily removable for inspection and cleaning.

4.22 Each drip tray should be provided with its own drain trap. The drain trap should be of the clear (borosilicate) glass type. This permits the colour of the water seal to be observed thus giving an early indication of corrosion, biological activity or contamination within the duct. The trap should have a means for filling and incorporate couplings to facilitate removal for cleaning. It should be located in an easily visible position where it will not be subject to casual knocks. The pipework connecting it to the drainage tray should have a continuous fall of not less that 1 in 20.

4.23 Traps fitted to plant located outside or in unheated plant rooms may need to be trace-heated in winter. The trace-heating must not raise the temperature of water in the trap above 5°C.

4.24 Water from each trap must discharge via a clear air gap of at least 15mm above the unrestricted spill-over level of either an open tundish connected to a foul drainage stack via a second trap, or a floor gully (or channel). A support should be provided to ensure that the air gap cannot be reduced. More than one drain trap may discharge into the tundish providing each has its own air break.

4.25 Drainage pipework may be thermoplastic, copper or stainless steel. Glass should not be used. The pipework should be a minimum diameter of 22mm and a fall of at least 1 in 60 in the direction of flow. It should be well supported and located so as not to inhibit access to the AHU.

Layout of air handling unit

4.26 The AHU should be arranged so that the majority of items are under positive pressure. Any item of plant requiring a drain should be on the positive pressure side of the fan. A recommended layout is given in schematic from in Figure 3.

4.27 A separate extract unit will generally be required for the area served by each supply unit.

4.28 An energy recovery system will normally be fitted between the supply and extract units.

Provision of dampers

4.29 Fire- or smoke-actuated dampers shall be provided at the locations required by Firecode. (See Paragraphs 5.17 - 5.21).

4.30 Motorised low-leakage shut-off dampers should be located immediately behind the intake and discharge of each supply and extract system respectively. They should be of the opposed-blade type, opening through a full 90° and must close automatically in the event of power failure or plant shutdown to prevent any reversal of the system airflow.

4.31 The quality of motorised dampers is critical. They should be rigid, with square connections fitted with end and edge seals of a flexible material and with minimal play in linkages. The leakage on shut-off should be less than 2%.

4.32 A manually operated isolating damper should be installed between the main AHU and its distribution system to enable the unit to be isolated when cleaning is in progress.

4.33 Good practice will require the fitting of a main volume control damper so that the design airflow rate can be set at commissioning. The damper should be lockable in any position. If it will also be used for plant isolation, it should be capable of being reset to give the design airflow without the need for re-measurement.

4.34 Internal plant isolating dampers or provision for the fitting of shut-off plates between items within a unit are not required.

Vibration

4.35 Vibration from a remote plantroom can be transmitted by the structure of the building, may be regenerated and may sometimes be magnified many times. Units should be selected to have the minimum vibration generation and installed on suitable anti-vibration mounts. Pipe and ductwork should incorporate anti-vibration couplings, preferably in two planes at right angles, as close to the vibration source as possible. Consideration should be given to the use of anti-vibration pipe hangers and supports.

Sequence of components

4.36 The following arrangement of plant components is typical although in many instances not all elements will be required:

- fresh air intake;
- motorised isolation damper;

- frost / fog coil;
- pre-filter;
- energy-recovery device;
- attenuator;
- fan;
- blast plate;
- attenuator;
- chiller battery;
- eliminator;
- heater battery;
- humidifier;
- final filter;
- isolation / volume control damper.

Note 2: Attenuators may be located in the intake and discharge duct if they are of a suitable type (See Paragraphs 4.159 - 4.162)

There may be instances where the above arrangement is not appropriate and the plant arrangement should be planned accordingly.

Fans

General requirements

4.37 The fan should be selected for good efficiency and minimum noise level, but the overriding factor should be the selection of a fan characteristic such that the air quantity is not greatly affected by system pressure changes due to filters becoming dirty or external wind effects.

Acceptable types

4.38 Fans can be of the axial, centrifugal, cross-flow, mixed-flow or propeller type, depending upon the requirements of the system.

4.39 Where used, centrifugal fans should preferably be of the backward-blade type. Alternatively, where noise levels are more critical and pressure requirements are lower, forward-curved blade fans are acceptable. For high-power applications, aerofoil-blade fans may be appropriate.

Selection

4.40 Generally, large ventilation systems will use centrifugal fans due to their efficiency, non-overloading characteristics, and developed pressures.

4.41 Forward curved centrifugal fans can overload if allowed to handle more air than they are designed for.

4.42 Alternatively, it may be appropriate to use mixed flow fans in high-pressure systems.

4.43 Axial flow or propeller fans are generally only used in local through-the-wall systems, or systems with very low pressure requirements.

4.44 Cross-flow fans have very low operating efficiencies, and thus their use is restricted to applications such as fan coil units.

Location and connection

4.45 Fans are normally positioned to 'blow through' the central plant so that the cooling coil and humidifier drains will be under positive pressure.

4.46 The fan performance figures given by manufacturers in their catalogue data are based on tests carried out under ideal conditions, which include long uniform ducts on the fan inlet/outlet. These standard test connections are unlikely to occur in practice, the designer should therefore ensure as far as is practical that the fan performance will not be significantly de-rated by the system. This objective can be approached by ensuring that the fan inlet flow conditions comprise uniform axial flow velocities with low levels of turbulence.

4.47 Where the outlet duct is larger than the fan discharge connections, there should be a gradual transition, with a following section of straight duct, having a length equivalent to three duct diameters.

4.48 The design of the fan intake connection must be carefully considered to avoid swirl in the airstream. When the air spins in the same direction as the impeller, the performance and power consumption of the fan are reduced. When the air spins in the opposite direction to the impeller the power consumption and noise will increase with hardly any pressure increase. Airstream swirl is usually induced by large variations across the fan intake caused by the air passing round a tight bend immediately before the intake.

4.49 Where a centrifugal fan is located with an open intake, the clear distance between the suction opening and the nearest wall should be not less than half the diameter of the inlet. If two fans with free inlets are positioned within the same chamber, their adjacent suction openings should be at least 1 diameter apart.

4.50 Airtight flexible joints should be provided at fan inlet and outlet connections. They should be equal in cross-section to the points of connection and be neither longer than 200mm nor shorter than 100mm.

4.51 For centrifugal fans, a diffuser screen / blast plate should be fitted immediately downstream of their discharge.

Supply fan drive arrangements

4.52 Where the fan drive is via a motor-driven belt and pulley, it should be external to the air stream. This arrangement has the following advantages:

- the fire risk is reduced;
- the drive is visible so it is simple to check that the belt is still there;
- particles shed from the drive belt are outside of the air stream;
- if the belt slips, the “burning rubber smell” is not transmitted down into occupied areas of the premises;
- noise generated by the motor and drive will not be transmitted along the ductwork;
- waste heat is excluded from the system;
- the drive may be through a vee or toothed belt and pulley. The latter have the advantage of eliminating belt squeal on start up and have a longer service life. They are particularly suitable where the fan drive motor is fitted with a soft start and should be located external to the air stream.

4.53 The drive train should be easily visible without the need to remove access covers. Protecting the drive train with a mesh guard is the preferred option. For weatherproof units designed to be located outside, the fan drive will be external to the duct but enclosed. It should be easily visible through a viewing port with internal illumination and access via a lockable hinged door.

4.54 For direct-coupled fan and motor units, the motor should be out of the air stream.

4.55 For induction drive ‘plug’ motor arrangements (where the motor is fitted within the fan and is integral to it) and in line axial fans with a pod motor; the fan / motor combination may be within the air stream provided the motor windings are protected from over temperature by a thermister and lockout relay.

Extract fan drive arrangements

4.56 The preferred method where the fan drive is via a motor driven belt and pulley arrangement will be to locate it external to the air stream.

4.57 The fan drive and motor may be located inside the duct within the air stream provided the motor windings are protected from over-temperature by a thermister and lockout. The drive train should be easily visible through a viewing port, have internal illumination and access via a lockable hinged door.

4.58 Where the system air is explosive, aggressive or has high moisture content, the extract fan motor must be located outside the air stream. This is generally achieved with axial fans by using a bifurcated unit.

Control

4.59 Fans in healthcare applications are normally either single or two-speed. Where there is a requirement for two-speed operation, this is generally via a local user control (for example, in a hood extract system to provide a boost facility) or via a time schedule for energy saving during unoccupied periods.

4.60 Normally only a single motor is required with a standby motor available for fitting as necessary or fitted but not belted. Twin, run and standby motors - with the standby being jockeyed around - are not required.

4.61 Where there is a specified requirement for standby fans, the system should incorporate an automatic changeover facility activated via an airflow sensor. Fault indication should be provided.

4.62 The control of fans in terms of start-up and run is increasingly being vested in computer software. Inverter-drive, variable-speed, soft-start systems are becoming a standard approach. It should be remembered that most healthcare applications require known amounts of air to be delivered while the system is in use. Constant volume systems that deliver specified air-change rates are therefore the norm. Duct- or room-pressure-controlled, variable-speed systems have a very limited application in healthcare.

4.63 It is necessary to ensure that - should the computer control system or its software develop a fault - then the fan can be switched to a direct-start, fixed-speed, manual operation. This is particularly important for critical care systems serving operating suites, high-dependency care units of any type, patient isolation facilities, laboratories and pharmaceutical production suites. Off-site software support is no substitute for the ability of on site staff to override the automatic control and keep the system operating in an emergency. Under these circumstances actions that may shorten the life of the plant are considered of secondary importance to that of preserving the health and safety of patients and staff.

Heater batteries / heater coils

General requirements

4.64 Frost batteries are installed to protect the downstream filters from low-temperature, high-humidity intake air conditions. As they handle unfiltered air they should be constructed of plain tubing without fins and be as near to the outside as possible to minimise condensation during cold weather. Access for cleaning will need to be provided to both sides of the coil.

4.65 Where steam coils are used for a frost battery, they may be constructed using spiral-finned copper tube. As they will be prone to fouling the tube layout and spacing should permit easy access for regular cleaning.

4.66 Main and branch heater-batteries should be constructed of solid-drawn copper-tube coils with copper fins, generally connected in parallel.

4.67 Where there is a wet heating system in the areas served, the main heater-battery should be sized for the ventilation requirements only, and not for the fabric loss.

4.68 Access for cleaning must be provided to both sides of all frost batteries and heater-batteries.

Acceptable types

4.69 Electric, water or steam heater-batteries may be considered. However, electric heater-batteries are expensive to operate and where there are alternatives, their use should be restricted to low-power use (for example trimming control).

4.70 Where steam-supplied heater-batteries are used, their control, venting and trapping systems should be designed so that a vacuum cannot occur within the coil. The condensate drainage arrangements should not allow pressure to build in the main resulting in a back-up of condensate in the coil.

Location

4.71 Where possible, wet-trimmer heater-batteries should be located in plant areas.

4.72 Where it is necessary to locate heater-batteries in false ceilings etc, consideration should be given to the use of electric heaters. If this is not practicable, drip-trays should be installed under both the battery and the control valve assembly to protect the ceiling. A moisture sensor and alarm should be fitted in the tray. In any event, to facilitate maintenance access, they should be located above corridors or other non-critical areas and never above patient occupied spaces.

4.73 Auxiliary fan coil units should not be installed in the ceiling above an occupied space. They should be accessible for routine maintenance and cleaning without the need to cause significant disruption to the operation of the department that they serve.

Control

4.74 LPHW frost coils should be controlled by an off-coil temperature sensor operating a motorised valve to provide a minimum plant “on temperature” of between 2°C and 5°C. The off-coil temperature of the frost coil is generally sensed by a serpentine thermostat downstream of the coil or upstream of the next plant item. This thermostat will shut the fan down if any part of the air stream is below the minimum set-point.

4.75 Steam-supplied frost coils should be fitted with an on/off control operated by a temperature sensor mounted upstream of the battery. These are normally set to open the control valve fully when the outside temperature drops to +1°C. This will ensure that there is no standing condensate in the base of the coil.

4.76 The main heater-battery should be controlled in the same manner under the dictates of either an off-coil temperature sensor, or a room temperature sensor, depending on the plant configuration and method of control. Trimmer heater-

batteries are generally controlled by one or more averaging temperature sensors within the room or rooms in the zone.

4.77 Heater-battery control valves should drive to a closed position on system shutdown or fan failure. The control system should then automatically set to provide frost protection.

Cooling coils

General requirements

4.78 Cooling coils will need to be decontaminated periodically. They must have good access both up and downstream. Hinged access doors with viewing ports and illumination inside the duct should be provided both sides of the coil.

4.79 An eliminator will be required downstream of all cooling coils. The eliminator may take the form of an extension of the coil fins or be a separate device. If a separate device it should be removable as a unit to permit cleaning of the coil face.

4.81 4.80 All cooling coils must be fitted with their own independent drainage system as specified above. A baffle or similar device must be provided in the drip tray to prevent air bypassing the coil. The tray should be large enough to capture the moisture from the eliminator, bends and headers. Where coils are greater than 1m high, intermediate drip-trays will be required.

4.82 Condensate traps manufactured from Borosilicate Glass will allow easy visual inspection and incorporate a self-cleaning smooth non-porous internal surface, complying with ISO 3585 and BS2589 Part 1.

Selection

4.83 Cooling coils supplied with chilled water are the preferred option. For small loads or where chilled water is not available, direct expansion coils may be used.

4.84 Care must be taken in selection to minimise electrolytic action resulting from condensation on the airside. Coils constructed from copper tubes with copper fins extended on the downstream side in the form of an eliminator and electro-tinned after manufacture are preferred. Aluminium fins should only be used if vinyl-coated.

4.85 All parts of the coil and its associated ductwork in contact with moisture must be manufactured from corrosion-resistant materials. Pressed steel coil headers, even if treated, have been shown to be prone to corrosion over time and should not be used. Steel mounting frames and casings present similar problems hence stainless steel is preferred.

Location

4.86 Microorganisms that multiply in moisture cannot be avoided when the coil is dehumidifying. However, locating the final filter downstream of the coils will reduce the risk of infection.

4.87 Cooling coils in AHUs should be located upstream of the final filter.

4.88 Where any cooling coil has to be located above a ceiling, drip-trays should be installed under both the coil and the control valve assembly to protect the ceiling. A moisture sensor and alarm should be fitted in the tray. To facilitate maintenance access, they should be located above corridors or other non-critical areas and never above patient occupied spaces.

Control

4.89 There are two basic methods of control for cooling coils:

- off-coil control – used in multi-zone systems or single-zone systems where close humidity control is required, to provide a constant maximum off-plant condition which satisfies the temperature and high humidity requirements of the zone with the highest load;
- sequential control – used in single-zone systems, or multi-zone systems with averaging sensors where close control is not required. A room or duct temperature sensor controls the cooling coil and heater battery in sequence to maintain constant room conditions.

4.90 The advantage of off-coil control is that accurate humidity control can be provided without relying on humidity sensors, which are prone to inaccuracy and drift. Off-coil control is however, expensive to operate in terms of energy consumption, due to the fact that there is no feedback of room loads, and thus at low loads and in systems where there are large zonal variations, significant over-cooling and reheating will occur.

4.91 On systems with two-speed operating, it is usual to isolate the cooling coil upon selection of low speed. In addition, on system shutdown, low airflow or fan failure, the cooling coil must be isolated.

Humidifiers

Design need

4.92 Humidification was originally required for some healthcare applications in order to control the risk associated with the use of flammable anaesthetic gases. The use of such gases has now ceased. Humidification is therefore no longer required unless there is a very specific application requirement.

4.93 Operating-theatre AHUs do not generally require humidifiers but provision for their retrofitting in terms of space provision and a capped drainage system should be provided.

4.94 Where humidification is required, it will be subject to the specific requirements set out below. These are intended to ensure that the unit will operate safely and not become a source of contamination.

General requirements

4.95 The most important requirement for a humidifier is to create complete mixing of the steam with the air. The manufacturers' instructions should be followed regarding minimum distances which should be allowed before bends or other components. This is particularly important with respect to a filter mounted downstream. If it becomes saturated by the humidifier, organisms can grow through the filter and be released into the duct. These may then be carried on the airstream into an occupied space.

4.96 The section of ductwork containing the humidifier may need to be periodically decontaminated. Hinged access doors with viewing ports and internal illumination should be provided. A label warning that the device emits live steam and should be isolated prior to opening should be affixed to the access door.

4.97 All parts of the humidifier and its associated ductwork in contact with moisture must be manufactured from corrosion-resistant materials. Stainless steel is preferred.

4.98 The electrodes of self-generating electrode-boiler type humidifiers should be stainless steel.

4.99 All humidifiers must be fitted with their own independent drainage systems as detailed in Paragraphs 4.20 - 4.25 or 4.72 and 4.87.

4.100 For self- and locally-generated steam humidifiers, the cleanliness of the water supply is essential for their safe operation. Provision should be made for draining down supply pipework and break tanks for periodic disinfection and cleaning during periods when they are not required in service.

4.101 The addition of treatment chemicals for continuous control of water quality for humidifier/air handling units should be avoided. Consideration could be given to installing a UV system to control microbiological growth. Given the limitations of UV systems, however, this will require filtration to high quality to ensure the effectiveness of exposure of organisms to the UV irradiation. As with all water treatment systems the unit should be of proven efficacy and incorporate UV monitors so that any loss of transmission can be detected.

Acceptable types

4.102 Only steam-injection manifold-type humidifiers are considered suitable for use in health building air-conditioning systems. Water humidifiers of any type should not be used.

4.103 Steam may be derived from the central steam supply provided that it does not contain any treatment carry-over, or generated locally either within or adjacent to the humidifier.

4.104 The introduction of steam should be by an appliance specially designed to discharge dry steam into the air-conditioning system without objectionable noise or carry-over of moisture.

4.105 During the design stage, consideration should be given to the proposed methods for the regular cleansing of the humidifier(s) and their components.

Selection

4.106 The number and length of steam-injection manifolds to be used is dependent on various factors such as duct cross-sectional area, air velocity, dry-bulb temperature and manifold design. Guidance from the manufacturer should be followed closely.

4.107 A mains steam humidifier can be noisy and will be difficult to control if it is operated at an excessive steam pressure. It should be sized for an operating pressure of approximately 1 bar. The pipework supplying it should be provided with a dirt pocket, pressure reducing valve and steam trap installed as close as practicable to the humidifier, so that the steam condition at entry is as dry as possible. A temperature switch on the condensate line (or equivalent design provision by the humidifier manufacturer) should be incorporated to prevent 'spitting' on start-up.

4.108 Most operational problems with mains steam humidifiers arise because of back-pressure in the condensate discharge line which will result in flooding into the duct. Unless the condensate from the device can be discharged and collected at atmospheric pressure, it should be discharged directly to drain.

4.109 A local steam generator, where used, must be fed with potable quality water. Additional water treatment to the standard set out above may be required. If the humidifier is unused for a period exceeding 48 hours, it must automatically drain its water content, including that contained in the supply pipework, right back to the running main and leave itself empty.

4.110 Some steam generators are of a type that requires regular cleaning and descaling. The design must allow for them to be installed such that they can be physically isolated from the air duct in order to prevent contamination of the supply by cleaning agents while this is taking place.

Location

4.111 Careful siting of the humidifier injection manifold is required to prevent the steam impinging onto the side(s) of the duct, condensing and generating excess moisture.

Control

4.112 Accurate humidity control can only be provided on single-zone systems, or multi-zone systems with zonal humidifiers. In the above systems, humidity sensors control the humidifier for low-level humidity control, and override the temperature controls to open the cooling coil valve for high-limit humidity control.

4.113 Multi-zone systems are more usually controlled by a minimum humidity sensor located in the supply duct(s) following the last heater-battery.

4.114 Overriding controls separate from the normal plant humidistat should be installed. Their purpose is to prevent excessive condensation in the conditioned space when starting up. A time delay should be incorporated into the humidifier control system such that the humidifier does not start until 30 minutes after the ventilation/plant start-up. In addition, a high-limit humidistat should be installed to limit the output of the humidifier so that the saturation in the duct does not exceed 70%. This humidistat is to control the added moisture. It is not necessary to install a de-humidifier to reduce the humidity of the incoming air if it already exceeds 70%. The humidifier control system should ensure that the humidifier is switched off when the fan is not running.

4.115 On systems with two-speed operating, it is usual to isolate the humidifier upon selection of low speed. In addition, on system shutdown, low airflow or fan failure, the humidifier should be isolated.

Filtration

General requirements

4.116 The purpose of filtration is to reduce the level of airborne contamination in an air stream. It is generally carried out in stages.

4.117 Filters must be securely housed and sealed in well-fitting frames that minimise air by pass. Air by pass significantly reduces filter efficiency, the higher the filter grade the greater the effect. Mounting frames should be designed so that the air flow pushes the filter into its housing to help minimise air bypass. Mounting frames that withdraw so that the filter can be changed without having to reach into the unit are preferred.

4.118 Neither the filter media, nor any material used in the construction of the filters, should be capable of sustaining combustion. The filter media should be such that particles of it do not detach and become carried away by the airflow.

4.119 Filters need to be readily accessible for replacement so a hinged access door should be provided. The upstream side of the filter should be visible for inspection through a viewing port with internal illumination.

4.120 All filters should be provided with a means of visually checking the differential pressure across them. Direct-reading dial-type gauges marked with clean and dirty sectors are preferred.

4.121 A complete spare set of filters must be provided at handover.

Definition of filter terms

4.122 Particulate air filters are divided into four categories:

- general ventilation filters grades G1 to G4;

- fine filters grades F5 to F9;
- high efficiency particulate filters (HEPA) graded H10 to H14;
- ultra-low particulate air filters (ULPA) graded U15 to U17.

4.123 General filters are graded in terms of their 'Synthetic dust weight 'Arrestance'. This represents the percentage of a test dust captured by a filter. 'Arrestance' provides a good indication of a filter's ability to remove the larger, heavier particles found in outdoor air. These are of a size to block finned batteries and large enough to settle out in the air distribution system.

BS EN 779 grade (Eurovent grade)	% Arrestance	Notes and typical healthcare application
G1 - (EU1)	< 65	Metal mesh grease filter
G2 - (EU2)	65 to < 80	Coarse primary filter
G3 - (EU3)	80 to < 90	Primary air intake; return air; energy recovery device protection
G4 - (EU4)	> 90	General purpose tempered air supply

Table 4: General Filters

4.124 Fine filters are graded in terms of their 'Atmospheric dust spot Efficiency'. This is a measure of the filter's ability to remove the very fine staining particles found in outdoor air. It will indicate how 'visibly' clean a filter will keep a ventilated space. The staining particles are approximately the same size as most common bacteria so it is also a rough measure of the filter's ability to remove microorganisms.

BS EN 779 grade (Eurovent grade)	% Efficiency	Notes and typical healthcare applications
F5 - (EU5)	40 to 60	General purpose panel / bag filter
F6 - (EU6)	60 to < 80	Basic grade bag filter
F7 - (EU7)	80 to < 90	Medium grade bag or pleated paper Conventional operating theatre supply air
F8 - (EU8)	90 to < 95	High grade bag or pleated paper
F9 - (EU9)	> 95	Basic HEPA filter – Level 8 clean rooms

Table 5: Fine Filters

4.125 High efficiency filters (HEPA and ULPA) are graded in terms of their ability to capture their 'Most Penetrating Particle Size' (MPPS). High-efficiency filters self-select the particle that they are least able to trap, hence the MPPS. They are then tested against that size of particle. These filters are designed to provide very high-efficiency filtration of particles in the sub-micron size range.

BS EN 1822 grade (Eurovent grade)	% Efficiency @ MPPS	Notes and typical healthcare application
H10 - (EU10)	85	Ultra-clean theatre terminal
H11 - (EU11)	95	
H12 - (EU12)	99.5	
H13 - (EU13)	99.95	
H14 - (EU14)	99.995	Pharmacy aseptic suite Category 3 room extract
U15 – U17	-	Not generally used in healthcare

Table 6: High Efficiency (HEPA) Particulate Filters

Selection primary filters

4.126 All filters should be of the dry type. Panel filters are cheap and disposable with relatively low dust-holding capacity. They are generally used as pre-filters to eliminate large particles that would otherwise clog or cause damage to the fan and finned heating and cooling batteries. Stainless steel frames that hold disposable pre-cut filter pads are preferred.

4.127 General ventilation supply plant should incorporate primary air filters of grade G3, sized for a maximum face velocity of 2.0 m/s. Additional coarse pre-filters may be justified where the intake air is exceptionally polluted. They are sometimes fitted as a temporary measure when building work is being carried out in the vicinity of the air intake.

Secondary filters

4.128 Where a higher standard of filtration is required, secondary bag or pleated paper panel filters would be used. Rigid frame filters incorporating pleated paper elements are preferred over bag filters for critical care applications such as operating theatres.

4.129 In urban or other areas of high atmospheric pollution, a higher standard of filtration may be justified to reduce the level of staining to internal finishes.

Extract air filters

4.130 Extract filtration will generally only be required where heat-recovery devices are installed. There are a very limited number of specialised applications (microbiological safety cabinets and similar LEV systems) where contaminated air is required to be filtered prior to discharge to atmosphere. If it is safe for staff to work in a room without wearing respiratory protective equipment, it is safe to discharge the room air to atmosphere without filtration.

Return-air filters

4.131 They are used to reduce the load on HEPA filters in recirculating applications such as Ultra Clean operating suite ventilation canopies and pharmacy aseptic suites.

High-efficiency filters – HEPA and ULPA

4.132 HEPA filters are expensive so their use should be kept to a minimum. Applications requiring HEPA filters include the air supply to aseptic suites in manufacturing pharmacies, the discharges from microbiological safety cabinets and isolation facilities.

4.133 If used, HEPA filters should be of the replaceable panel type with leak-proof seals. They should be installed in a manner that permits on-site validation of the filter and its housing. This may involve the release of a Dispersed Oil Particle (DOP) challenge smoke through an injection point upstream of the filter and a measurement of the DOP penetration across the downstream face. Alternatively a particle-counting method may be used.

4.134 HEPA filters are sometimes fitted in extract systems to capture hazardous substances or organisms. Design provision must be made for the subsequent safe handling of contaminated filters by maintenance staff. This may be achieved by:

- sealing the hazardous substance into the filter before it is removed;
- providing a system to fumigate the filter to kill any organisms;
- housing it in a ”safe change” unit that permits the filter to be ejected into a bag and sealed without staff having to come into direct contact with it.

4.135 In view of the costs and problems associated with placing HEPA filters in extracts, it is recommended that a full risk assessment be carried out at the design stage. This should include defining the true need for HEPA filters in an extract; validation of its performance at installation; the method of safely changing a contaminated filter; and its subsequent disposal.

4.136 ULPA filters are very expensive and are designed to remove particles below a size that are either surgically or aerobiologically significant. There would have to be exceptional circumstances in order to justify their use in healthcare ventilation systems.

Activated carbon filters

4.137 Activated carbon filters are able to remove gases and vapours from an air stream and are graded according to the range of substances they can remove. They are not normally fitted in air-conditioning supply systems.

4.138 They are occasionally fitted retrospectively because the main air intake has been poorly sited and is drawing in traffic fumes. Where used they must be protected by a particulate air filter.

4.139 Activated carbon filters are more commonly used in specialised fume extraction systems when the location of the discharge means that dilution cannot be relied upon to disperse noxious fumes.

Location

4.140 The primary filter should be positioned on the inlet side of the supply fan, downstream of the frost coil. The secondary filter, when fitted, should be on the positive-pressure side of the fan. This will prevent air being drawn into the system after the filter and capture any particles shed by items of equipment within the AHU.

4.141 The filter installation must be arranged to provide easy access to filter media for cleaning, removal or replacement, with side or front withdrawal as required.

Control

4.142 Differential-pressure transducers should be provided to monitor and alarm remotely on excessive filter pressure drop. In critical areas dirty-filter indication lights should be provided at the point-of-use.

Energy-recovery

General requirements

4.143 Energy recovery will normally be fitted to all healthcare ventilation systems. It may be omitted only where it would clearly be uneconomic. Where the economic case is marginal, space should be allowed for the retrofitting of an energy recovery system.

4.144 For systems in healthcare premises, a plate heat exchanger or 'run-around coil' system is suitable. Thermal wheels may be used providing they are fitted with a purge sector. The small amounts of air leakage across those devices are not considered significant. Other systems such as heat pumps or heat pipes are also suitable. Selection should be based on relative locations of the supply and extract units, ease of maintenance and practicality. Cleaning access will be required to both sides of any energy-recovery device.

4.145 The following are the minimum energy transfer efficiencies required for devices handling equal air volumes:

- run-around coil – 45%;
- plate heat exchanger – 50%;
- thermal wheel – 65%;
- any other energy-recovery device – 50%.

4.146 If a plate heat exchanger is chosen, the plates should be constructed of metal. Plastic should not be used for internal bypass dampers and drive gears.

4.147 Whichever energy-recovery device is chosen the extract side will need to be protected by a G3 filter and provided with a drainage system as described in Paragraphs 4.20 - 4.25, to remove condensate.

Location

4.148 Energy-recovery devices should be located downstream of the frost battery and pre-filter, prior to the cooling coil or main heater battery on the supply side.

Control

4.149 It is essential to consider the control of both the energy recovery device and the frost battery when assessing the economics of recovery, as all energy provided by the frost battery will directly reduce the heat exchange of the recovery device. To this end, the off-coil setting of the frost coil should be the minimum possible to protect the primary filter (for example +2°C).

4.150 The energy-recovery device should be controlled in sequence with the main heater battery, and should incorporate a control to prevent the transfer of unwanted heat when the air-on condition rises above the required plant set point.

4.151 In instances where the plant is cooling the air, it may be possible to remove heat from the supply air at high ambient conditions, under the dictates of enthalpy sensors in the intake and extract ducts.

Attenuation

General requirements

4.152 Noise will be generated in an air distribution system by the fan, plant items and airflow. The ductwork is a very effective transmitter of this noise hence there is generally a need to limit the noise transmission to meet the requirements of the building. This normally involves the provision of sound attenuation treatment as part of the overall ductwork system design.

4.153 A thorough assessment of the design should be made to assess the noise impact. This should take into account the following primary factors:

- fan- and plant-noise generation;
- air-flow generated noise in ductwork fittings and dampers;
- noise generated at grilles, diffusers and other terminals;
- noise break-in and break-out of ductwork;
- cross-talk and similar interference;
- the noise limitations for the building and surrounding areas;
- external noise generation.

4.154 A method of assessment of these factors and the sound attenuation requirements of ductwork systems is given in CIBSE Guide B.

4.155 The fan is usually the main source of system noise. The sound power that it generates varies as the square of the fan pressure, and thus to limit the fan noise level the system resistance should be kept as low as economically

possible. As a general rule the selected fan should operate close to its point of maximum efficiency to minimise its noise generation. Where there is disturbance to the airflow at the fan inlet, the manufacturer's stated fan noise levels should be increased by up to 5 dB(A). More precise guidance on this aspect may be available from the manufacturers.

4.156 Fans radiate noise through both the inlet and outlet connections and it may be necessary to provide attenuation to limit the noise from both of these connections. It is always preferable and more economic to control noise and vibration at source, or as close to source as possible. It should be noted that attenuators offer a resistance to airflow. The resistance must be included in the fan and ductwork calculations.

4.157 Provided care is taken in the design and construction of low-pressure systems to avoid significant noise generation in the ductwork, attenuation should only be needed to absorb fan noise.

4.158 Noise breakout from all equipment housed in the plantroom must be taken into consideration if control is to be satisfactory. Any ductwork within the plantroom after the silencer should be acoustically insulated to prevent noise break-in or the silencer relocated at the point of entry or exit of ductwork to and from the plant room.

4.159 There is no complete means of control over external noise generation from such as road traffic, aircraft, factory and community noise. Consideration must be given to this at the design and planning stage.

Acceptable types and location

4.160 The noise levels produced by ventilation and other plant should be reduced by either lining the inside of the duct with sound-absorbing material or fitting bespoke attenuator units.

4.161 In supply systems, sound-absorbing material should not be applied to the inside surface of a duct system downstream of the final filter, owing to the risk of mechanical damage and the subsequent dispersal of the media into the ventilation system.

4.162 In supply and extract systems, sound-absorbing material must not be applied to the inside of a duct within 1 metre of a fire damper. The material should be non-particle-shedding and fire-resistant (further guidance can be found in SHTM Firecode suite of documents). Where sound-absorbing material is applied in a section of duct that will be routinely exposed during maintenance activities it should be protected from mechanical damage.

4.163 Bespoke attenuator units with a sound-absorbing infill suitable for the quality of air being handled and protected by a perforated sheet metal casing are the preferred option for critical systems. Absorption of moisture, dirt and corrosive substances into the 'in-fill' and the release of fibrous particles into the airstream should be prevented by the use of a membrane. The membrane material should have a declared service life of at least 25 years. If these conditions can be met then the attenuator may be located in the supply ductwork downstream

of the final filter. When so located, cleaning access should be provided at both ends of the attenuator unit.

5. Air distribution system

Air distribution arrangements

Ductwork distribution systems

5.1 Ductwork systems for ventilating and air-conditioning applications are referred to by their velocity or pressure category, that is, as low, medium or high velocity (or pressure) systems. Heating & Ventilating Contractors Association (HVCA) limits are up to 10 m/s or 1,000 Pa; 20 m/s or 1,750 Pa: and 40 m/s or 3,250 Pa in the case of conventional low, medium and high pressure systems respectively. High-pressure systems are disappearing because of the constraints of the Building Regulations but existing systems may sometimes need to be altered or extended.

5.2 For normal applications in healthcare buildings, low velocity systems are recommended. The use of higher velocities than those recommended is not likely to be economical. Future trends are likely to be towards even lower optimum duct velocities; however, velocities below 2 m/s are unlikely to be justified.

5.3 The site will often dictate the main routing of ductwork systems, but in general, the design should seek to make the layout as symmetrical as possible; that is, the pressure loss in each branch should be as nearly equal as possible. This will aid regulation and may reduce the number and variety of duct fittings that are needed.

5.4 Main distribution ductwork should not be routed above sleeping areas. Where there is no alternative route, additional acoustic insulation will be required.

5.5 Where auxiliary cooling units, fans, filters or trimming devices are installed in the distribution system, they must be independently supported and fitted with a suitable drainage system where appropriate. If they are a source of vibration they should be linked to the distribution ductwork via flexible connections.

5.6 The fan of a Local Exhaust Ventilation (LEV) system provided under the COSHH Regulations should be located outside of the building so that all of the ductwork within the building is under negative pressure. Where the fan has to be within the building it should be located as close as practicable to the outside with an absolute minimum run of discharge ductwork within the building. The discharge ductwork within the building will be under positive pressure so it must not be penetrated by test holes or inspection hatches.

Ductwork materials and construction

5.7 The choice of duct material should take account of the nature of the air or gas being conveyed and the environment in which the duct will be placed.

5.8 Galvanised-sheet-steel is generally suitable and most economical for normal ventilating and air-conditioning applications. Its inherent mechanical strength

renders it resistant to casual damage both during the construction phase and throughout its service life when mechanical and electrical services around it are altered. It also readily withstands the impacts sustained when rotary equipment is used to for internal cleaning.

5.9 In instances where moisture levels and/or corrosive elements in the air being conveyed are very high, aluminium, stainless steel, PVC or GRP (glass-reinforced plastic) ducts should be used. Stainless or black steel are the only suitable materials for high-temperature ductwork.

5.10 In inherently wet areas, such as the base of fresh air inlet ducts and some extract systems, the ductwork may require draining to prevent a build-up of standing water. The layout of the drains should be as specified in Paragraphs 4.20 - 4.25.

5.11 Where builderwork plenum chambers or ducts are used, these may be constructed of various materials. However all such ducts must be rendered and sealed to prevent dust shedding. A greater allowance may need to be made for leakage.

5.12 Galvanised, black and stainless steel ductwork should be manufactured and installed to the current HVCA specification for sheet metal ductwork DW144, but excluding the use of bolt-through supports.

5.13 GRP and PVC ductwork should be manufactured and installed to the current HVCA specification for plastic ductwork DW154.

5.14 Where phenolic-board ductwork is considered, care should be taken to ensure that it is fabricated to a quality standard and installed strictly in accordance with the manufacturers' instructions. Its pressure rating and degree of support should be suitable for the application and ducts should be fitted with mechanical protection where required. Designers should be fully conversant with installation techniques and Installers should be experienced having received training in the techniques required and certified to this effect by the manufacturers. Due consideration should be given to the impact on ductwork pressures created by the closing of dampers. Phenolic-board ducting should not be installed in plant rooms or any other areas where it could be vulnerable to impact damage. Internal cleaning using mechanical (rotary) means is also liable to cause damage to the integrity of surfaces.

5.15 Flexible ductwork is unsuitable for air distribution in healthcare applications. It should only be used to make the final connection to a terminal (See Paragraphs 5.54 and 5.55).

5.16 The inside of the ductwork should be free from structural projections and as smooth as possible. Flanged, gasketed joints are preferred.

Fire aspects, damper types and locations

5.17 It is essential that all relevant fire aspects of ducting systems are agreed with the fire officer before the design is finalised.

5.18 Ductwork must be fire-stopped where it penetrates fire compartment walls, floors and enclosures, cavity barriers and sub-compartment walls or enclosures, and provided with weatherproof collars where roofs or external walls are penetrated.

5.19 Fire/smoke dampers shall be provided at the locations required by SHTM Firecode. The fire-damper mounting frame must be securely attached to the building fabric. Where a fire-damper is not mounted directly in a fire compartment wall, it must be correctly supported and the ductwork between it and the firewall must posses the same fire rating as the firewall that it penetrates. The fire-rated portion of ductwork must not be penetrated by test holes or inspection hatches. All fire/smoke dampers shall be capable of remote re-setting via the Building and Energy Management System (BEMS) or equivalent, after periodic testing procedures.

5.20 An access hatch shall be provided adjacent to each fire damper so that its correct operation can be directly observed.

5.21 Smoke-diverting dampers must be provided on recirculation air systems to divert automatically any smoke-contaminated return air to the outside of the building in the event of a fire; and arranged so that the normally open smoke-diverting damper on the return-air branch to the input unit closes and all the return air is exhausted through the extract fan. Guidance is available in SHTM 81 and BS5588: Part 9.

Duct sections

5.22 Ducting is generally available in rectangular, circular and flat oval sections, although other sections may be made for special situations.

5.23 Rectangular ducting is most common on low-pressure systems, for the following reasons:

- it can readily be adapted to fit into the space available;
- fittings are cheaper than those for circular or flat oval ductwork;
- it can readily be joined to such component items as heating and cooling coils, and filters.

5.24 When sizing ductwork, the designer should take into account:

- both installation and operating costs;
- space limitations imposed by the structure and other services;
- operating noise levels;
- requirements of regulation at the commissioning stage.

5.25 For overall economy and performance, the aspect ratio should be close to 1:1, since high aspect ratios increase the pressure loss, heat gains or losses and overall cost (for example, changing the aspect ratio from 1:1 to 1:4 can typically

increase the installed cost of the ductwork by 40% and add 25% to the heat gains or losses).

5.26 Rectangular ducting should not be the first choice for high pressure systems, and should be avoided in systems operating at high negative pressures, because the strengthening of the flat sides and the sealing requirements necessary to make rectangular ducts suitable for these high pressures are costly.

5.27 Circular ducting is preferable for high-pressure systems, and for systems operating at high negative pressures. In the case of the latter, additional stiffening rings may be necessary. Machine-formed spirally-wound ducting and a standard range of pressed and fabricated fittings can sometimes make circular ducting more economical, particularly in low pressure systems having a relatively low proportion of fittings.

5.28 Flat oval ducting provides an alternative to circular ducting, principally where there is a limitation on one of the dimensions in the space available for the duct run.

5.29 Other sections may be used, such as triangular sections to pass through roof trusses. Such sections present difficulties in the provision of fittings, and connections to standard plant items, and are likely to be more expensive than traditional sections.

Standard ductwork fittings

5.30 All fittings should conform to current HVCA specification DW144. Wherever possible, long radius bends, large radius main branches, not more than 45° angle sub-branches and long-taper transformations should be used.

5.31 Fittings should be arranged with vanes in sub-branches connected directly to grilles and diffusers, and turning vanes in square bends (when used). When vanes are used, additional cleaning access will be required.

5.32 The number of duct fittings should be kept to a minimum and there should be a conscious attempt to achieve some standardisation of types and sizes. Increasing the number and variety of fittings in a system can markedly raise its overall cost.

5.33 Bad design in relation to air flow can lead to vibration of flat duct surfaces, increases duct-generated noise and pressure loss, unpredictable behaviour in branch fittings and terminals, and adverse effects on the performance of installed plant items (such as trimmer batteries).

Branches

5.34 There are many designs of branches and junctions in use. The important features are that the flow should be divided (or combined) with the minimum interference and disturbance. Changes in duct sizes should not be made at the branch but a short distance downstream (or upstream). A good dividing branch

design cannot be effective if the flow entering the branch is not uniform across the section.

Changes of section

5.35 The expansion of a duct section should be formed with sides having a total included angle of no more than 30°, and preferably less than 20°. If the angle of expansion is greater, the flow is not likely to remain attached to the walls of the duct and large eddies will be formed with flow reversal at the walls. This leads not only to a high-pressure loss, but also to non-uniform velocity pattern at the outlet. Where there is insufficient space for a gentle expansion and a greater angle is necessary, internal splitters should be used.

5.36 A contraction in a duct section is less critical, but the total included angle of the taper should not exceed 40° (or 20° where the contraction is made on one side of the duct only)

5.37 The most economical way to change the section of a rectangular duct is to restrict the change of duct size to one side only. If the calculated reduction or increase to the side dimension is 50mm or less, it is usually not economical to change the size at the position. The minimum size of a rectangular duct should usually be 150mm x 100mm.

Other fittings

5.38 As a general rule, fittings should avoid abrupt changes in direction and also sharp edges that cause the flow to separate and form eddies, thus limiting pressure loss and causing noise generation. If the fitting leads to the flow preferentially attaching to one side of the outlet, then a significant length of straight downstream duct is necessary before the next branch or fitting; this length should be greater than five equivalent diameters.

Thermal insulation

5.39 Thermal insulation is applied to ductwork to reduce heat exchange, and to prevent condensation.

5.40 In a duct system, the air temperature changes can be significant, especially when passing through untreated space, and these have the effect of reducing the heating or cooling capacity of the air and of increasing the energy input to the system. The heat transmission to and from the surrounding space can be reduced by effective insulation of the ducts. Extract ductwork conveying air from which heat recovery will be derived should be thermally insulated to the same standard as with associated supply ventilation ductwork.

5.41 Condensation can arise in ductwork systems conveying cooled air and, apart from creating conditions conducive to corrosion of ductwork, condensation affects the heat and vapour-resisting properties of insulating materials themselves which may induce further condensation.

5.42 In normal circumstances, the insulation thickness for heat resistance is sufficient to prevent surface condensation, but in extreme conditions the

insulation thickness for vapour resistance may be greater than that for heat resistance. When cold ducts pass through areas of high dew-point, carefully selected vapour barriers should be applied externally to the insulation.

Noise generation within the ductwork

5.43 Noise is generated in ductwork at sharp edges, by tie rods, damper blades, duct obstructions and sharp bends etc. This air-flow-generated noise becomes an important factor if it is about the same or greater level than the upstream noise level. (Air-flow-generated noise is often referred to as “regenerated noise”).

5.44 The noise level generated by airflow in ductwork is very sensitive to the velocity. The sound power of this noise is approximately proportional to the sixth power of the velocity; that is, a doubling of the duct velocity will increase the sound power by a factor of 64. The duct velocities should therefore be kept as low as possible. In general, duct fittings that have lower pressure loss factors in similar flow conditions will generate less noise.

5.45 Ductwork serving quiet areas should not be routed through noisy areas where noise break-in can occur and increase the noise level in the ductwork.

5.46 Grille, register and louvre noise should be kept to the minimum by selecting types having low noise-producing characteristics, without high tonal noise, and should be fitted with acoustically treated external inlet and outlet louvres.

5.47 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where individual room confidentiality is required. They will normally be of the ‘through-the-ceiling, ‘up-and-over’ type and may include a fire damper if required.

Volume control damper locations

5.48 Manually operated balancing dampers are needed generally:

- in the main duct downstream of the fan;
- in branches of zone ducts;
- in sub-branch ducts serving four or more terminals;
- at terminals not covered by the previous item.

5.49 Dampers integral with terminals should only be used for final trimming of air volumes, otherwise noise and air distribution problems may ensue.

5.50 Dampers in rectangular ducts should be single-bladed when the longer side is up to 450mm but be of the opposed-blade multi-leaf type above this size. In circular ducts, iris-type dampers are recommended. Dampers must be accessible, incorporate a position indicator and means of locking in the commissioned position. Dampers should be located as far away as possible from adjacent branches or plant items.

Cleaning and access door locations

5.51 Cleaning and access doors are required to facilitate access to plant items and ductwork components for inspection, maintenance, cleaning and replacement, and must be of sufficient size to permit safe access for the required functions. Consideration should also be given to the number of doors to be provided. Older installations may be deficient in the provision of access doors and consideration will be necessary to have these incorporated in the course of any refurbishment in the accommodation served.

5.52 Recommended locations for access doors are given in the current HVCA specification DW144 and are generally provided to give access to:

- every regulating damper;
- every fire and motorised damper;
- filter (to facilitate filter withdrawal);
- both sides of cooling/heating coils;
- humidifiers;
- fans; and
- motors and impellers.

5.53 Care should be taken when siting access doors to ensure that no other services to be installed will prevent reasonable access.

Flexible ducting

5.54 Flexible ductwork may be used for final connections to grilles and diffusers provided it is constructed to meet the fire precautions recommended in BS8313. It must not pass through fire compartment walls, floors or enclosures of sub-compartment walls or enclosures, or through cavity barriers.

5.55 Flexible ducting will cause a significant frictional loss and may be difficult to clean and should never be used in lieu of a bend. Where installed it should take the most direct route and be as short as possible, never exceeding 1 metre in length.

Diffuser and grille selection and sizing

5.56 The effectiveness of all ventilation and air-conditioning systems depends on the methods by which air is introduced to, and vitiated air is removed from, the space. The usual results of poor air-terminal selection and/or positioning are: draughts, stagnation, poor air quality, large temperature gradients and excessive noise.

5.57 Air can be supplied to a space in a number of ways, although any device can be broadly placed into one of two categories: that producing a diffused supply, or that producing a perpendicular jet. Diffusers may be radial or linear, and normally utilise the Coanda effect (that is, adhesion of the air stream to an adjacent surface), to reduce the risk of excessive room-air movement. A

perpendicular jet is formed by discharging air through grilles, louvres or nozzles, which are generally adjustable.

5.58 Air-flow patterns produced by both types of terminal are dependent to a large extent on the presence of the Coanda effect.

5.59 Supply air terminals can be incorporated into any room surface, for example, floors, walls (high or low level), desktop etc.

5.60 As they operate on the jet principle, the use of sidewall and linear grilles is restricted to areas where air change rates are low, that is, less than 10 per hour. Perforated rectangular diffusers can provide acceptable conditions within the occupied zone at up to 15 air changes per hour. In areas where a higher air change rate is required, square or circular ceiling mounted diffusers should be used.

5.61 The performance of supply air terminal devices is provided, based on three criteria: throw, spread and drop.

- **throw** is defined as perpendicular or parallel distance from the terminal to the point at which the air velocity is 0.5 m/s isovel;
- **spread** is defined as the width of the 0.5 m/s isovel; and
- **drop** is defined as the vertical distance from the centre line of the terminal to the bottom edge of the 0.25 m/s isovel.

5.62 It is necessary to consider each of these parameters in both summer and winter conditions to ensure satisfactory operation of the air-terminal device, as warm jets behave very differently from cold jets.

5.63 A warm jet tends to rise until it attaches itself to a horizontal surface, while a cold jet falls. Care must be taken to ensure that this does not lead to unacceptable temperature gradients in winter or excessive air velocities in the occupied zone in summer.

5.64 In order to ensure satisfactory air movement within a space, it is necessary to consider interaction between air movement from adjacent terminals, and ceiling mounted fixtures (light fittings etc), as well as interaction between air movement and room surfaces.

5.65 If the supply and extract terminals are too close, short-circuiting may occur, while if they are too far apart, stagnant zones may be formed. Where two opposing air streams meet, the individual velocities must not be greater than 0.25 m/s.

5.66 Supply and extract grilles and diffusers should be fitted with opposed-blade dampers for fine balancing purposes.

5.67 Further guidance on the selection of grilles and diffusers is given in the CIBSE Guide B.

5.68 In operating theatres, the supply terminals must be able to produce a down-flow movement of air in the operating zone 1 metre above floor level. Ceiling mounted diffusers with fixed directional vanes that provide a downward turbulent airflow are the preferred option. Plenum boxes fitted with perforated screens to produce a parallel downward flow are also acceptable. Nozzles or jets of any type are not acceptable. Sidewall-mounted linear diffusers that utilise the Coanda effect to send air across the ceiling and 'drop' it into the operating zone are also not suitable. However linear ceiling mounted diffusers that provide a direct downward airflow around the operating zone may be used.

Transfer grille - size and location

5.69 Air-transfer grilles in walls, partitions or doors form an integral part of the building's air distribution system. Modern doorsets have very low leakage rates so cannot be relied upon to permit even quite small airflows. Failure to make adequate provision for air to move from room to room will result in excessive pressure differentials and 'door whistle'.

5.70 Transfer grilles are required in locations where there is a significant imbalance between the supply and extract rates in a room. They will relieve any pressure differentials that may affect the operation of the spaces and/or the ventilation system and permit airflow in a known direction. However, transfer grilles are vulnerable to damage and, in many instances, as long as the equivalent free area is provided, they can be substituted with undercut door.

5.71 Care needs to be taken to ensure that the positioning of transfer grilles does not interfere with the fire or smoke integrity of the building. In general, the air-transfer grilles should not be installed within fire-resisting boundaries, although if this is unavoidable, they should be fitted with fire- or smoke-dampers.

5.72 Where installed, transfer grilles should be of the non-vision type, sized for a maximum face velocity of 1.5 m/s.

5.73 In photographic dark rooms, lightproof transfer grilles will be required.

5.74 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where individual room confidentiality is required. (See also Paragraphs 5.43 - 5.47).

Pressure stabilisers - size and location

5.75 Pressure stabilisers are required in lieu of air-transfer grilles in areas where it is necessary to maintain pressure differentials between adjacent rooms to prevent reversal of airflows for example, in operating suites, isolation facilities and clean rooms. (See also Paragraphs 7.24 - 7.28).

5.76 Fire precautions for pressure stabilisers are the same as for transfer grilles. For sizing criteria, refer to Paragraph 7.23

5.77 Pressure stabilisers should be of the balanced-blade type, with the facility to make fine adjustment of the pressure setting. They should be silent in

operation and give a seal as tight as practicable when closed. The materials of construction and method of assembly should allow for cleaning and disinfection.

5.78 Pressure stabilisers should be installed in a visible location so that their operation can be readily observed.

5.79 Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where confidentiality is required. In these cases, the pressure stabiliser and cross-talk attenuator should be mounted in a short length of ductwork within the ceiling void.

5.80 Pressure stabilisers may need to be fitted with a stand-off baffle on their discharge side to prevent a sight line in situations where a laser will be used. Baffles may also be required to preserve privacy or prevent discharge air causing draughts or disturbing the air distribution pattern in the adjoining room. They are also useful in low-level locations to prevent the airflow path being obstructed by portable equipment.

6. Automatic controls

6.1 Various options for control of single and multi-zone air-conditioning systems are given in CIBSE Guide B.

General requirements

6.2 The basic requirements for an automatic control system are as follows:

- facilities to start, set-back and stop the plant;
- facilities to control the volumetric air-flow;
- facilities to control the system or room pressure;
- temperature control and indication;
- humidity control and indication;
- devices to monitor and indicate the plant's operating state;
- alarms to indicate plant failure, low air-flow, and filter state.

The control functions actually provided will depend on the purpose of the ventilation system.

6.3 There will also be a need to determine the control strategy in the event of a fire either within the zone being served or within an adjoining zone.

6.4 The designer should consider whether it is necessary for the supply and extract fans to be interlocked, either so that the supply fan will not operate unless air-flow is established within the extract system, or vice-versa depending on the required pressures within the rooms being served.

6.5 The sequence switching of units in order to prevent transient reverse airflows will be particularly important in laboratory and pharmacy areas that also contain fume cupboards, safety cabinets and other LEV systems.

6.6 Alarms should be provided to show 'filter fault' and 'low air-flow'. The "filter fault" alarm should be initiated by a predetermined increase of pressure differentials across the filter. The 'low air-flow' alarm should be initiated when the supply air quantity falls to 80% of the design value.

Objectives of control system

6.7 The primary objective of ventilation plant control system is to maintain the space served within the required environmental control limits, at the appropriate times, regardless of external conditions or internal loads and with the minimum energy consumption.

6.8 Often, it is not possible to predict accurately building load variation at the design stage, and thus optimum set points cannot be assessed. Information provided by monitoring the operation of the plant via a Building and Energy Management

System (BEMS) will enable optimum set points to be established and energy consumption reduced. Control of most systems will be via a BEMS. This will enable the operating conditions and control tolerances to be set and monitored. The BEMS may also be set to log the actual energy consumed by the system together with that recovered by the energy-recovery device. This will provide a useful check on overall operating efficiency and provide evidence that energy targets are being achieved.

6.9 BEMS incorporating self-adaptive control algorithms that automatically adjust the set-point to the suit the usage and load are preferred. The provision of movement sensors within the controlled space in order to determine the actual occupancy will facilitate this process.

6.10 The failure of specialised ventilation systems can have grave consequences for the delivery of healthcare. Control systems should therefore be simple, robust and reliable.

6.11 Computer-software-driven control systems are becoming the norm in building services. However, it should be remembered that healthcare ventilation systems need to be available to operate outside of normal working periods when software support is not available. Should the software fail, it will be left to site staff, who may have little knowledge of the control algorithms to restart the ventilation system. It is therefore essential to ensure that a simple means of re-starting critical systems in the event of a software failure is provided (see also Paragraphs 4.62 - 4.63)

Location of controls

6.12 Whether within the plant, duct or room, sensors should be located to provide accurate measurement of the condition of the air being monitored.

6.13 Sensors and control items such as control valves should be located close to the element being sensed or plant item being controlled, in order to minimise time lags within the system which may create over-shoot of conditions beyond the design envelope and result in additional energy consumption.

6.14 There are practical advantages in locating all control valves for an air-handling unit in a bank (at a convenient height) at one end of the unit. (This will not normally result in an undue additional control lag.)

6.15 Some applications require intermittent mechanical ventilation, frequently at a high air-change rate, (for example, in bathrooms and treatment rooms.) Local controls to facilitate this mode of operation should be placed in a prominent position to encourage economical use.

6.16 Local controls that enable the user to select more than one mode of operation should be clearly labelled to identify the particular mode selected. Where the system allows different room pressures to be selected then a direct-reading pressure gauge should be fitted within the eye line of the users to provide an independent confirmation of the resultant mode of operation. A clear

description of the selectable modes of operation should be mounted adjacent to the control switch.

Fire aspects

6.17 A fire control panel should be mounted at the entrance of the area that the ventilation serves. The panel should have restricted access for the fire officer and include independent on/off controls and indication of the supply and extract systems.

6.18 In certain critical care departments it is preferable to maintain the supply ventilation in case of a fire within the area. For example, in an operating department, while undergoing surgery, the patient cannot always be easily moved without significant risk. In the event of a fire in a staff or support area of the department, or adjoining zone, the continued supply of air to a theatre will maintain it at a positive pressure and protect the patient and staff from the effects of smoke. This will allow time for the patient to be stabilised so that he/she can be safely evacuated if necessary. A similar situation occurs for patients in ITU and other critical care units. In all of these cases the ventilation to the critical area should continue to operate unless the AHU starts to draw in smoke. For these departments, a notice should be affixed to the fire control panel drawing attention for the need to liaise with departmental staff before switching off fan units.

6.19 All supply AHUs should have a smoke sensor mounted in the main supply duct immediately downstream of the AHU. In the event of a fire in the AHU or smoke being drawn into the system from an outside source, it should cause the supply air fire damper to close and shut down the AHU.

Time switching

6.20 Facilities to start, set-back and stop the plant should be provided in the plantroom. Remote start and set-back control and indication, if required, should be provided at a manned staff location, for example, at the reception or staff base or, in theatres, within the Surgeon's Panel.

6.21 Many ventilation systems may be completely shut down when the area served is not in active use. Alternatively, where there is a need to maintain a background condition, the ventilation output can be reduced by "setting back" the system. This will significantly reduce energy consumption and extend the life of filters and other system components.

Start-up control

6.22 The plant's start control should contain a control logic that will start the plant in the sequence set out in the following algorithms, Figures 2 - 5

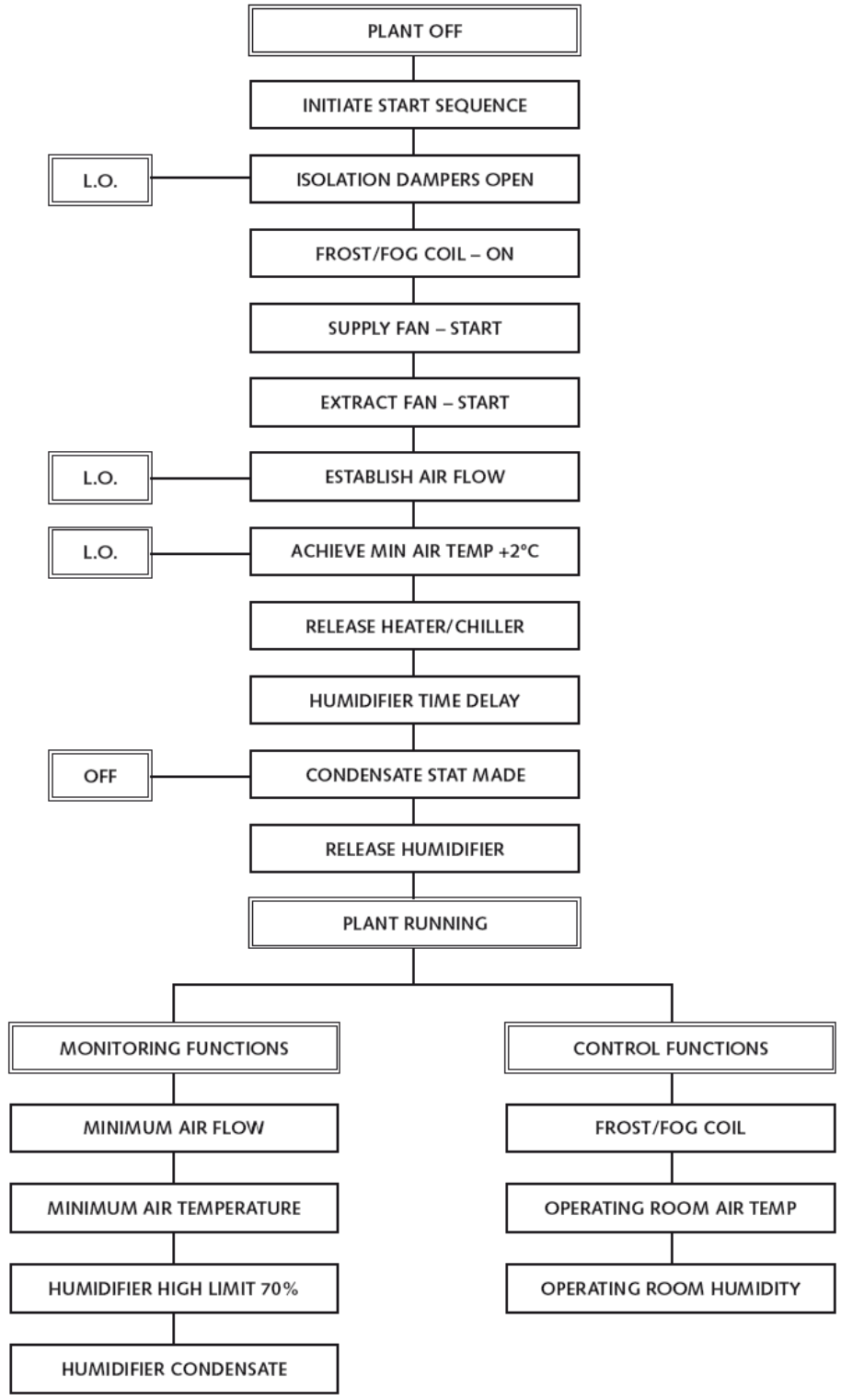


Figure 2: Typical plant control algorithm – normal start-up sequence

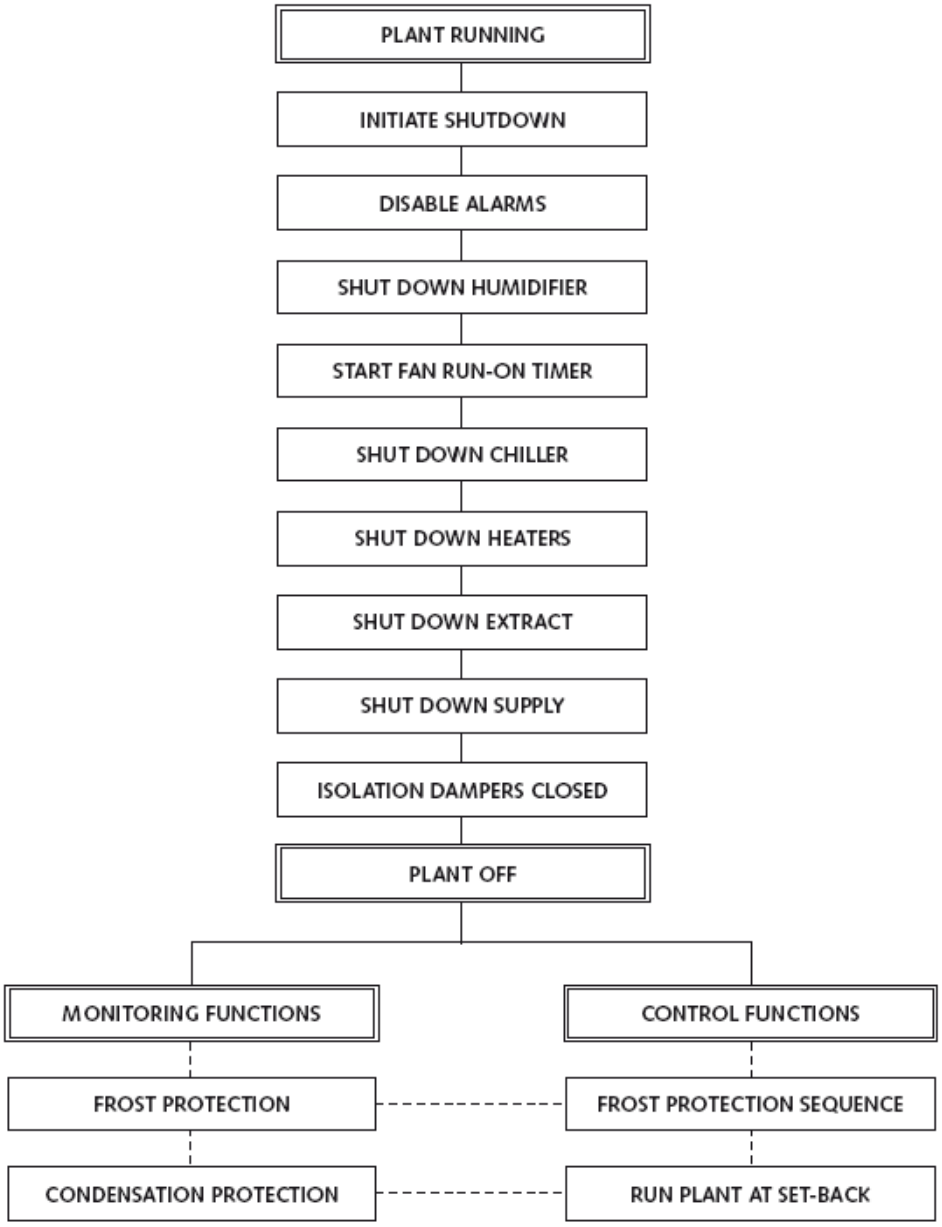


Figure 3: Plant control algorithm – normal shutdown sequence

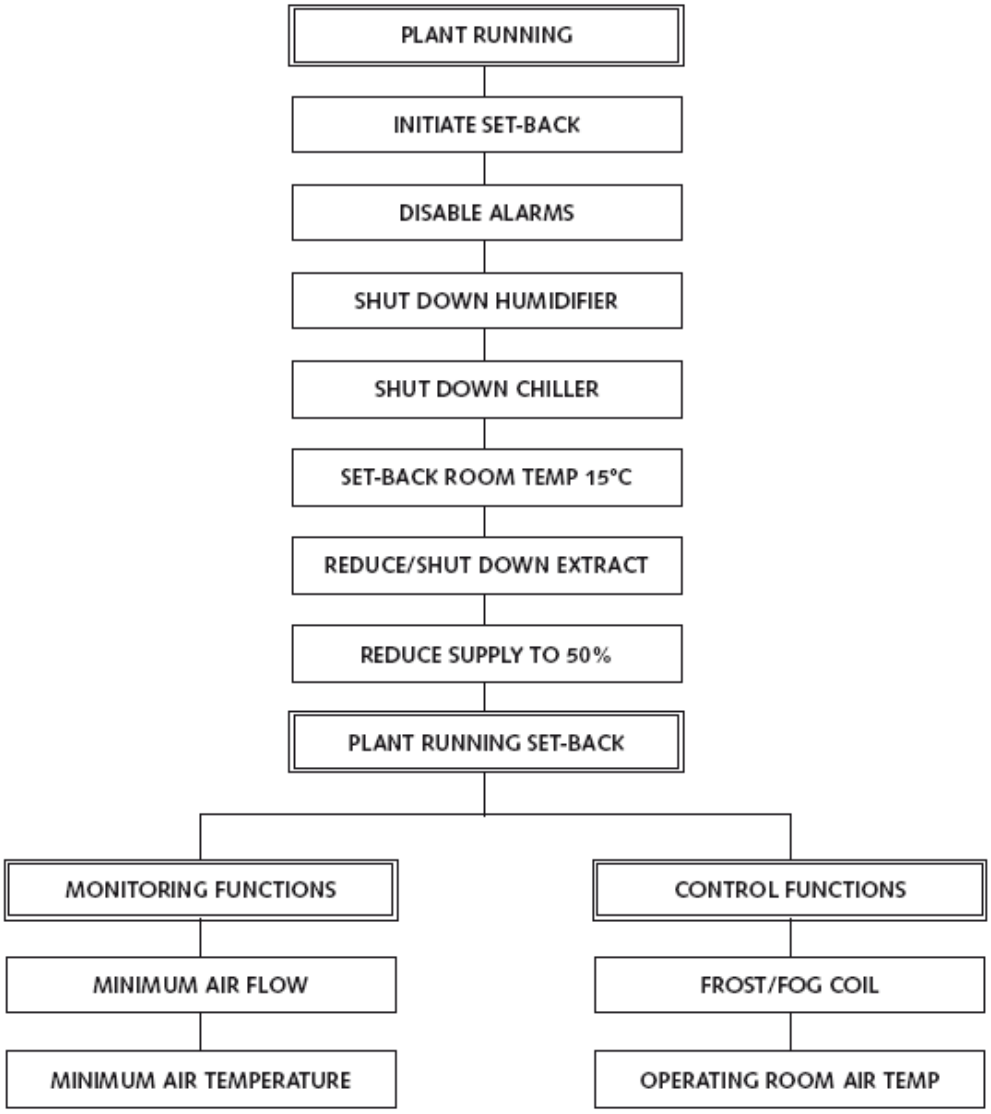


Figure 4: Plant control algorithm – set back sequence

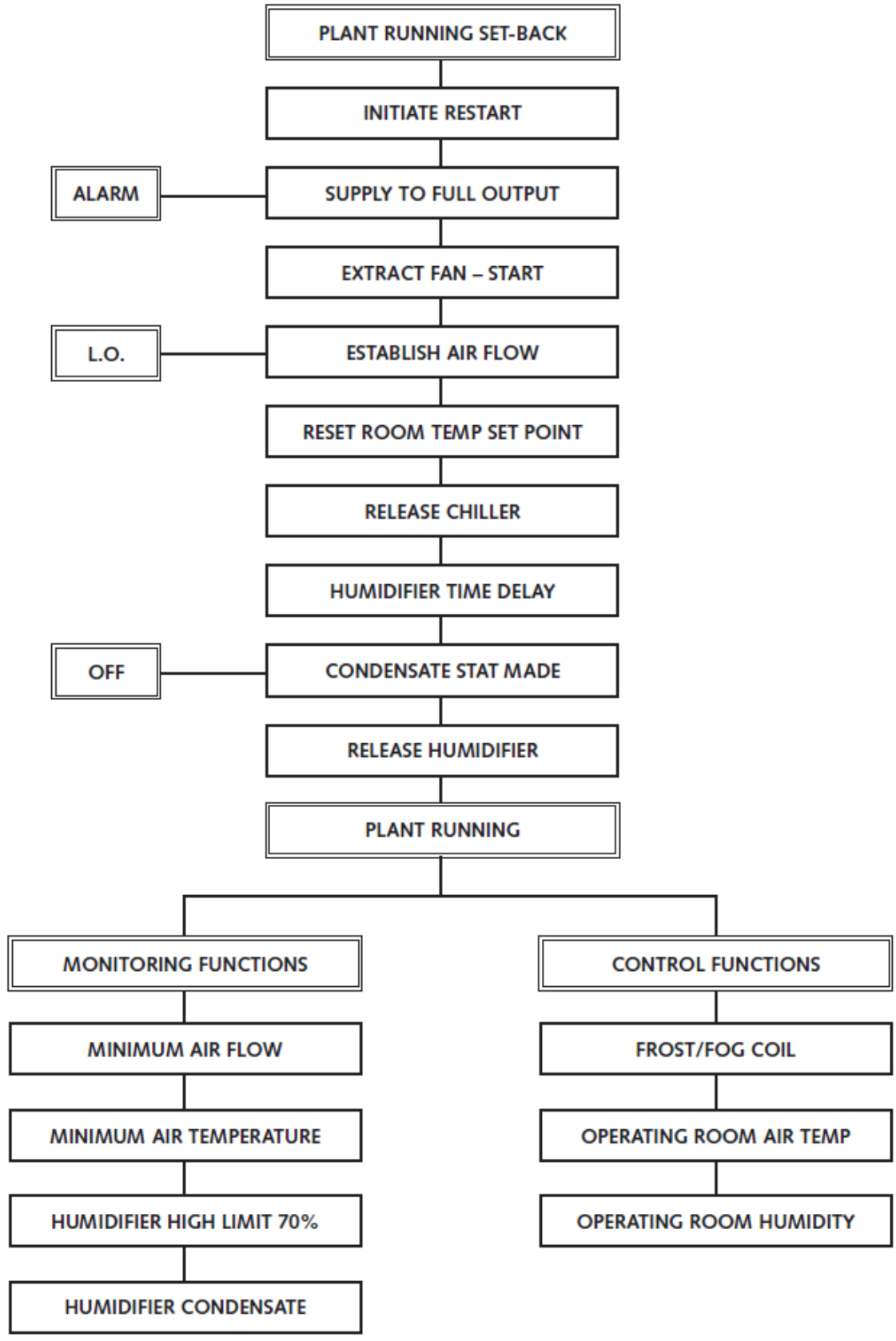


Figure 5: Plant control algorithm – restart from set-back

Set-back control

6.23 Where variable speed controls are installed, the setback facility for each plant should depress the control temperature to around 15°C; exclude any humidification and cooling from the system; and reduce the supply and extract air volumes to around 50%. The extract fan can also be turned off as long as the desired direction of air movement from clean to less clean will be maintained (See also Figures 2 - 5).

Use control

6.24 The installation of movement detectors allows for “use control” of ventilation systems. A simple control logic that reduces the system to a “set-back” condition if there has been no movement detected in the space for, say, 30 minutes and that switches the system “off” if no movement is detected for one hour is recommended for many applications, including operating suites.

6.25 A variation on this can be provided by linking ventilation controls to lighting. For example, in an operating theatre, the system may be off outside of working hours, could run at set-back when the general lighting was switched on and increase to full speed when the operating lamp is switched on. As with movement detection, a 30-minute run-on should be provided at each stage when the lights are turned off.

6.26 Either of the above control strategies may be refined by linking to the BEMS to provide a control logic related to normal working hours and associated ‘real-time’ movement within the zone being controlled. This should result in significant energy savings.

Environmental control

Temperature control methods and application

General

6.27 All control valves must fail safe, that is, close in the event of power or air-flow failure, with the exception of the fog/frost battery control valve, which should open upon power or airflow failure.

6.28 Control valves should be located in an accessible position. Isolation valves should be provided to enable the control valve to be removed for service without the need to drain-down the system.

6.29 Care should be taken to ensure that the installation of control valves and their associated pipework do not obstruct access to the AHU inspection doors and hatches.

Room temperature control

6.30 The limits for room temperature set point are generally between 16°C and 25°C depending on the particular application, and in some specialised instances (for

example, operating departments) are adjustable within a predetermined range by the user.

6.31 The selection of temperature set point for each room or zone may be by a control facility in the room / zone, or remotely at the control panel or BEMS. Where the control device is mounted within the room / zone and adjustable by the user, it should be marked either 'raise' and 'lower' or '+' and '-'. It should control within a specified temperature range to suit the user requirement with a control tolerance of ±1K. All other control set-points should be selectable either on the control panel or at the BEMS interface.

6.32 Where local control is provided, an indication of temperature will be required locally, or at a staff base (if appropriate), using an analogue or digital indicator. The indicator should be large enough to be read from the normal working position (for example, at the operating table in a theatre). This may be mounted in a supervisory or, 'surgeon's' control panel, with the signal repeated on the main system control panel or BEMS. It is important that this indicator displays the actual measured temperature and not the selected temperature.

6.33 Where the supply and extraction systems are designed for ventilation only and there is a wet heating system to provide background heating, care must be taken to avoid one system trying to heat the space while the other system is trying to cool the area.

Frost battery control

6.34 Steam-supplied frost batteries must be operated as on/off devices with their sensor mounted upstream of the battery. This will give 'open loop' control. A set point of +1°C is recommended.

6.35 Low pressure hot water (LPHW)-supplied frost batteries should be controlled using the proportional mode. Their sensor should be located downstream of the battery to give 'closed loop' control. A set point of between 2°C and 5°C is recommended.

6.36 If the temperature downstream of the frost battery, as sensed by a serpentine thermostat, falls below the required set point over any part of the coil, the plant must automatically shut down in order to prevent damage to the other batteries. The serpentine thermostat must not be in direct contact with the coil.

Off-plant control

6.37 The control logic must prevent the chiller and pre-heater being on at the same time.

Humidity control methods and application

6.38 In order to prevent excessive condensation when starting up from a total plant shut-down, a time delay should be incorporated into the control system such that the humidifier does not start until 30 minutes after the ventilation plant starts up.

6.39 Irrespective of the method of control, a high-limit humidistat should be installed to ensure that when the humidifier operates, the condition of the air in the duct does not exceed 70% saturated, particularly during plant start-up.

6.40 With certain types of steam humidifiers, it may be necessary to install a thermostat in the condensate line from the humidifier's steam supply, to ensure that the steam at the control valve is as dry as possible before it is injected into the air supply.

6.41 The humidifier and cooling-coil control must be interlocked so that they cannot be on at the same time.

6.42 The humidifier control system should ensure that it is switched off with the fan. It is preferable to design the control system so that the humidifier is isolated for an adequate time before the fan is turned off so as to purge humid air from the system.

6.43 All control valves must fail safe (that is, close in the event of power failure) and the humidifier must be interlocked with the low airflow switch.

Multi-zone control methods and application.

6.44 Close control of all air-conditioning parameters may be difficult to achieve with multi-zone systems, since each zone will in theory require a re-heater and humidifier to give total control of humidity if that is what is required. In reality such close control is rarely required in practice. It is therefore usual with multi-zone systems to provide control of zonal temperature only, with humidity control where fitted being based on average conditions within all zones, or minimum conditions within one zone.

6.45 Where there is a requirement for close control of air-conditioning parameters in a number of zones (e.g. an operating department) separate plants should be provided for each zone in order to avoid the need for expensive over-cooling and reheating of individual zones.

6.46 Most multi-zone systems within healthcare premises are controlled based on off-coil control within the central plant, with trimmer heater batteries on individual zones.

Alarms and indication

6.47 Supply and extract systems should include indicator lamps on the control panels to confirm the operational status of each system. Where the usage is on a regular daily pattern, time control with a user-operated timed manual over-ride should be provided.

6.48 Where a system is provided for a particular space, the indicator should be in, or immediately adjacent to, that space and local controls should be provided with labels clearly defining their function (eg. isolation suites.)

6.49 The 'plant failure' and 'low air-flow' alarms should be initiated by a paddle switch or other device located in the main air supply duct. This should operate when

the air quantity fails to reach or falls to around 80% of the design value and will give indication of fan failure, damper closed, access door left open, or any other eventuality that could cause a reduction of air quantity. Monitoring the current drawn by the fan motor is not a substitute for a sensing device that is directly affected by the air-flow.

6.50 The 'filter fault alarm' should be initiated by a predetermined increase of pressure differential across the filters, thereby indicating a dirty filter.

6.51 Direct-reading gauges or manometers should be installed across filters to give maintenance staff an indication of their condition.

6.52 Visual indication should be provided at a manned staff location (for example, the reception or staff base) and on the main control panel and BEMS to show 'plant failure' and 'low air flow'.

BEMS

6.53 Control of most systems will be via a Building Energy Management System (BEMS). This will enable the operating conditions and control tolerances to be set and monitored. The BEMS may also be set to log the actual energy consumed by the system and recovered by the energy recovery system. This will provide a useful check on the overall operating efficiency and provide evidence that energy targets are being achieved.

7. Specialised ventilation systems

7.1 This section contains design information for a range of healthcare ventilation applications.

7.2 The following departments will require a degree of specialised ventilation.

- the Operating department;
  - treatment rooms;
  - endoscopy, day case and minimum invasive suites;
  - cardiology and operative imaging suites;
  - conventional operating theatres;
  - Ultra-clean ventilation (UCV) operating theatres;
  - barn theatres;
  - recovery and ancillary areas.
- Obstetrics;
  - maternity theatres;
  - birthing rooms;
  - LDRP Rooms;
  - SCBU.
- critical areas and high-dependency units of any type;
- Isolation facilities;
  - infectious diseases units;
  - bone marrow and other transplant units;
  - chemotherapy and oncology units.
- Sterile Supply and Decontamination Units;
  - wash rooms;
  - inspection and packing rooms;
  - sterile pack stores.
- the Pharmacy departments;
  - aseptic suites;
  - extemporaneous preparation areas;
  - radio pharmacies.
- the Pathology department;
  - laboratories;
  - cat 3 and 4 rooms.

- the Mortuary and Post mortem suite;
  - mortuaries;
  - post-mortem rooms;
  - specimen stores.
- Hydrotherapy units;
- Burns units;
  - burns theatres;
  - treatment rooms;
  - isolation rooms;
  - tissue banks.
- Emerging specialties;
  - gene therapy units;
  - stem-cell laboratories.
- Infrastructure;
  - plant rooms housing combustion equipment;
  - welding facilities;
  - wood working workshops;
  - electric vehicle charging areas.

7.3 Design information for many of these applications is given in Appendix 1 Table A1, Appendix 2 and in the following Chapters within this section.

7.4 It is not possible within this existing document to give definitive guidance for every healthcare specific ventilation application. Additional detailed guidance may be issued in due course in the form of supplements.

General information

7.5 The section on operating theatres is the most extensive and contains much information that is common to other applications. Each theatre suite should have its own dedicated air-handling unit and extract fan. Where no specific guidance is given the principles set out below should be followed:

- the foregoing sections of the document contain general information on healthcare-specific aspects of ventilation system design and specification;
- a set of standard solutions for the design of general operating theatre suites to conform to past and new standards is given in new standard layouts Nos 1, 3, 5 and 7 and those for UCV theatres in new standard layouts Nos 2, 4, 6 and 8 within Appendix 3;
- the CIBSE Guides A & B contain basic information on ventilation design that can be applied to most applications;

- where a British or European standard exists that is specific to the application (for example, a clean room) it should be used as the basis of the design requirement;
- air should always move from clean to less-clean areas. A hierarchy of room cleanliness is given in Table A2;
- differential pressure will prevent contamination between areas when doors are closed. Information on air leakage through closed doors and hatches for a range of differential pressures is given in Table A3;
- the flow of air will prevent contamination between areas when doors are open. Information on air leakage through open doors and hatches for a range of differential pressures is given in Table A4;
- if anaesthetic gases are used, 15 air changes per hour will be required;
- a methodology for calculating a design solution for a non-standard suite of operating rooms is given in Appendix 4. This may be adapted as necessary to suit other less complex applications where air is required to cascade from clean to less clean areas.

7.6 The supply of air to a room has four main functions:

- to dilute airborne contamination;
- to control air movement within such that the transfer of airborne contaminants from less clean to cleaner areas is minimized;
- to control the temperature and if necessary the humidity of the space;
- to assist the removal of and dilute waste gases where used.

7.7 Because of the complexities of controlling air-movement patterns, much design effort will be required for this aspect. It is important that the design makes the best possible use of the air available, as excessive supply airflows for the control of air movement should not be used. The amount of air supplied will be determined by the number of doors and desired air-change rate.

7.8 There are four routes whereby airborne contaminants may appear in a room:-

- through the supply air;
- shed directly by the room occupants;
- arising as a result of the work activities;
- transferred from adjacent spaces.

7.9 Particles entering with the supply air can be controlled by the selection of suitable filter grades.

7.10 Particles shed directly by the room occupants can be controlled by:

- restricting access to essential persons only;
- the choice of the occupants' clothing;

- the room's air-change rate.

7.11 Particles arising as a result of the work activity can be controlled by:

- enclosing, semi-enclosing or otherwise controlling the work-based source;
- the room air-change rate.

7.12 The transfer of particles from adjacent spaces can be controlled by:

- differential pressure;
- air-flow paths.

7.13 Air change rates are given in Table A1. These figures have been found to give sufficient dilution of airborne contaminants, provided the mixing of room air is reasonably uniform.

7.14 A downward-displacement turbulent air distribution is generally preferred. The supply and extract diffusers should be positioned to ensure that all parts of the room are actively ventilated and that where necessary the staff will be in a clean air-flow path. (See Section 5 for additional guidance on supply terminals).

7.15 Horizontal-flow room-air distribution with or without a Coanda effect can be a source of draughts and difficult to set up correctly. Its use should be confined to non-critical areas.

Air movement control

7.16 The design of the system should seek to minimise the movement of contaminated air from less clean to cleaner areas. Transfer grilles enable air to pass in either direction between rooms of equal class and pressure. Pressure stabilisers operate in one direction only; they allow excess air to be directed to the area desired and assist in maintaining room pressure differentials. When closed they prevent significant reverse air-flow.

7.17 The relative locations of supply and extract terminals and their design air-volume rates will determine the basic airflow between adjacent spaces. Transfer grilles and pressure stabilisers will permit and control the flow of air between spaces ensuring a flow from the clean to less clean areas. Failure to provide such devices will lead to uncontrolled air flows when personnel move between rooms. They may also result in doors being held partially open by air pressure

Temperature and humidity control

7.18 To achieve the required room conditions, supply flow rates are calculated conventionally, taking account of all heat and moisture gains and losses, and of maximum permissible temperature differences between the room and supply air. In most applications the base heating load will be provided by a heating system. In critical systems the room or suite being considered will be within the heated building envelope so the ventilation will be sized to suit the casual gains or losses.

7.19 Temperature differences of up to 10K for winter heating and 7K for summer cooling must not be exceeded.

7.20 It is acceptable for the humidity to swing uncontrolled between 35% and 70% saturation.

Removal and dilution of waste anaesthetic gases

7.21 Anaesthetic gases are subject to occupational exposure limits. Waste anaesthetic gas must be contained and removed by a suitable gas-scavenging system. Some leakage from the anaesthetic equipment and the patient's breathing circuit will occur with all systems, particularly during connection and disconnection; and from the interface with the patient. The air movement scheme should ensure that this leakage is diluted and removed from the room. Anaesthetic agents are heavier than air so placing the supply terminal at high level with an extract at low level, adjacent to the anaesthetic gas terminal units will ensure that staff are in a clean air-flow path.

7.22 In LDRP and delivery rooms the use of anaesthetic gas is controlled on demand by the patient. This may result in significant leakage which, in order to reduce staff exposure, will need to be controlled by establishing a clean airflow path. A supply at high level at the foot-end of the bed with extract at low level at the head-end will provide such a path.

Fire aspects

7.23 When considering the overall airflow movement, careful thought needs to be given to the operation of the ventilation system, to limit smoke spread in the event of a fire.

Door protection

7.24 Air should flow from the cleaner to the less clean areas as shown in Table A2. There are several factors that affect the likelihood of a reverse air- flow through doorways:

- when a person passes through a doorway, both the passage of the person and the movement of the door flap cause a transfer of air between the areas separated by the door;
- when a door is left open there is a transfer of air between the two areas separated by the doorway. This is caused by air turbulence, but is greatly increased by any temperature differential between the areas (a 1.4m wide doorway may allow the transfer of 0.19 m^3/s of air in each direction when there is no temperature difference, but when the temperature differential increases to say 2K, the volume transferred may increase to 0.24 m^3/s).

7.25 Two methods of door protection are used in order to reduce the likelihood of contamination of clean area by a reverse air-flow from a less clean area:

- closed door protection – a pressure differential is created across a closed door so that any air leakage is from the clean to the less clean area.

Table A3 gives details of closed door leakage rates for a range of differential pressures;

- open door protection – the pressure differential drops (See Table A5) and is effectively replaced by a flow of air through the doorway from the clean to the less clean area. The flow of air needs to be sufficiently large to ensure that significant reverse airflow cannot occur and will be related to the relative cleanliness of the areas being considered. Table A4 gives air-flow rates for open door protection related to door / opening size and classification of the adjoining areas.

7.26 Pressure stabilisers enable the room differential pressure to be set when the doors are shut, thus providing closed-door protection. When a door is opened the stabilisers will close, forcing air to be directed through the doorway thus providing open-door protection.

7.27 The recommended air-flow rates to achieve this are given in Table A3. Provided that the dilution criteria in Table A1 are met, the occasional small back-flows created (when two doors are opened simultaneously; or when there is a high temperature difference across an open door) will have little effect on the overall air cleanliness of the affected room.

7.28 In applications where it is critical to maintain a specific airflow and /or pressure regime (for example isolation rooms) all windows in the zone should be locked shut or sealed. Trickle vents, if fitted, will also need to be sealed.

Systems design

7.29 The design of the ventilation system for an area depends on the overall configuration of the department. Where the department is served by more than one AHU, the control of the units may need to be interlocked so that reverse air-flow patterns do not occur.

7.30 Dual-duct high velocity systems have advantages, but are noisy, costly and may give rise to unacceptable values of humidity. Single-duct, low velocity/pressure systems are preferred.

7.31 Extract grilles should be sited and balanced to promote air movement in the desired direction.

7.0 (a) Operating department ventilation systems

7.32 The information given in this section relates to general operating suites. It will be applicable to other types of theatre suite such as maternity, burns, cardiac, etc. The standard values given may need to be adjusted to reflect non-standard room sizes, pressure regimes and air change rates.

7.33 A method of obtaining a design solution for non-standard theatres is given in Appendix 4.

7.34 Additional information for Ultra-clean ventilation (UCV) theatres is given in Section 7.0 (b).

General

7.35 The supply of air to an operating room has four main functions:

- to dilute airborne contamination;
- to control air movement within the suite such that the transfer of airborne contaminants from less clean to cleaner areas is minimized;
- to control the temperature and if necessary the humidity of the space;
- to assist the removal of, and dilute, waste anaesthetic gases.

7.36 Because of the complexities of controlling air-movement patterns, much design effort will be required for this aspect. It is important that the design makes the best possible use of the air available, as excessive supply airflows for the control of air movement should not be used. The amount of air supplied to the operating room will be determined by the number of doors and desired air-change rate.

7.37 The detailed considerations upon which the supply air-flow rate is based are as follows.

Dilution of airborne bacterial contaminants

7.38 There are four routes that airborne contaminants may appear in an operating room:

- through the supply air;
- shed by operating staff;
- produced by the surgical activities;
- transferred from adjacent spaces.

7.39 Supply flow rates for the main rooms of the operating suite are given in Appendix 3. For the other areas where room sizes and activities vary from site to site, air-change rates are given in Table A1. These figures have been found to give sufficient dilution of airborne bacterial contaminants, provided the mixing of room air is reasonably uniform.

7.40 A downward-displacement air distribution is preferred; it may be either turbulent or laminar flow. For turbulent flow the supply-air diffusers should be positioned either in the centre of each quadrant of the ceiling or along a line between the centres of each quadrant. This should ensure that all parts of the room are actively ventilated and that there will be adequate air movement at the operating table. Laminar flow would be provided by a perforated plenum terminal centred above the operating table. (See Section 5 for additional guidance on supply terminals).

7.41 Suspended articulated equipment is usually fitted in theatres. These require significant structural steelwork in the ceiling void to cater for the loads imposed by the resulting bending moments. It is important to ensure that the void is

deep enough to accommodate both the steelwork and the ventilation ducts. The location of the steelwork must not prevent a suitable layout of the ventilation ductwork and correct positioning of the supply air terminals. It needs to be recognised that the correct ventilation of an operating theatre plays a significant part in controlling healthcare acquired infections and is not subordinate to the desire to make equipment easy to move.

7.42 Horizontal flow distribution with or without a Coanda effect can be difficult to set up correctly and are unlikely to be as effective in Theatre applications. It should not be used in new installations. However space constraints may force its retention or replacement when refurbishing existing installations. Where fitted, the supply grilles will require a means of directional adjustment.

7.43 For general operating theatres, the air supply would be filtered in the AHU. Terminal HEPA filters are not generally required.

Control of air movement within the suite

7.44 The design of the system should seek to minimise the movement of contaminated air from less clean to cleaner areas. Transfer grilles enable air to pass in either direction between rooms of equal class and pressure. In older designs suitably dimensioned door undercuts were often used in lieu of transfer grilles. Pressure stabilisers operate in one direction only; they allow excess air to be directed to the area desired and assist in maintaining room-pressure differentials.

7.45 The relative locations of supply and extract terminals and their design air-volume rates will determine the basic air-flow between adjacent spaces. Transfer grilles and pressure stabilisers will permit and control the flow of air between spaces ensuring a flow from the clean to less-clean areas of the suite. Failure to provide such devices will lead to uncontrolled airflows when personnel move between rooms and doors being held partially open by air pressure.

Temperature and humidity control

7.46 Supply flow rates to achieve the required room conditions, are calculated conventionally, taking account of all heat and moisture gains and losses, and of maximum permissible temperature differences between the room and supply air. In most applications the room being considered will be within the heated building envelope.

7.47 Temperature differences of up to 10K for winter heating and 7K for summer cooling must not be exceeded.

7.48 It is acceptable for the humidity to swing uncontrolled between 35% and 60% saturation.

Removal and dilution of waste anaesthetic gases

7.49 Anaesthetic gases are subject to occupational exposure limits. The air-movement scheme should ensure that staff are in a clean air-flow path. (See Paragraph 7.21).

7.50 Air extracted from operating suites should not be re-circulated, as it may contain malodorous contaminants. However an energy recovery system should be fitted in the extract in order to reduce the plant energy consumption. (See Paragraphs 4.142 - 4.147).

Fire aspects

7.51 When considering the overall air-flow movement, careful thought needs to be given to the operation of the ventilation system, to limit smoke spread in the event of a fire. However, this is a highly staffed department with a low fire risk/load status and these factors need to be recognised when developing the fire strategy. It is considered satisfactory to treat the complete operating department as a single fire compartment providing there are at least two exits from it. Over-compartmentalisation can lead to difficulties in establishing clean air-flow paths and room-air dilution rates. This will lead to an increased risk of healthcare-associated infections. Staff areas within the department should be treated as a sub-compartment. (See Paragraph 6.18).

Door protection

7.52 Air should flow from the cleaner to the less clean areas as shown in Table A2. The factors that affect the likelihood of a reverse airflow through doorways are discussed in Paragraphs 7.24 - 7.26.

7.53 It is not possible to design an air-movement scheme, within the restraints of the amount of air available that will protect the operating room when two doors are simultaneously opened. The design process that has been used considers that each door is opened in turn and ensures that the direction and rate of air-flow through any open doorway is sufficient to prevent any serious back-flow of air to a cleaner area.

7.54 Provided that the air-change rates in Table A1 are met, dilution will be sufficient to ensure that the occasional small back-flows created (when two doors are opened simultaneously; or when there is a high temperature difference across an open door) will have little effect on the overall air cleanliness of the affected room.

7.55 The following general points should be taken into consideration during the design of operating suites:

- Number of exits – the fewer the number of rooms (and therefore doorways) leading from the operating room the better, as traffic is reduced and less complicated air-movement control schemes are required.
- Scrub and hand-wash facilities – these may be a part of the operating room, often in a bay. The bay would count as part of the operating room volume

and should have a low-level active or passive extract to remove the moisture-laden air. Should a separate room be required for the scrub area, a door between the scrub-up room and the operating room is an inconvenience to scrubbed staff, and could be replaced by an opening. This opening should be larger than a normal single doorway, but the scrub would not, in these circumstances, be considered part of the operating room volume.

- If an alcohol scrub regime is employed, individual theatre scrubs may not be required and would be replaced by a common departmental pre-/post-operation scrub position in the corridor. This would require local extract to prevent a build-up of moisture.
- Preparation 'Sterile Pack Store' (SPS) – if it is intended to 'lay-up' instruments in the operating room, the preparation room is then used simply as a sterile pack store. The nominal room pressure can therefore be the same as that of the operating room and the airflow between the two rooms in either direction. Air supplied to the preparation room may be directed into the operating room either through a door mounted transfer grille or if no door is fitted, through the opening. Alternatively, stock ready-use sterile items can be located in a bay within the theatre. In this case, a portion of the total theatre supply air should be provided in the bay to ensure it is actively ventilated.
- Preparation room 'lay-up' – when the preparation room is used as an instrument 'lay-up' room, it should be regarded as being of greater cleanliness than the operating room, and the design should minimise the transfer of air from the operating room to the preparation room. Air supplied to the room may be directed to the operating room through a pressure stabiliser taking care not to compromise the airflow pattern in the operating room. The air may also be directed into a corridor;
- Service corridor – if materials to be disposed of are placed in impervious material for transportation, it is not necessary to have a separate corridor for this purpose. However, a service corridor has many operational advantages it terms of the flow of materials through the theatre suite. It also permits routine service and maintenance access without compromising the use of adjacent theatre suites.

Standard air-movement control schemes

7.56 In the previous versions of this guidance standard air movement control schemes were given that provided a range of design solutions to typical operating suite layouts. These were satisfactory design solutions for 'standard' sized rooms within the suite but were never intended to be universal for any sized room or suite. Guidance on operating suites contained in HBN 26 (2004) has increased the recommended size of operating room from approximately 35m^2 to 55m^2. Associated room sizes and air change rates have also increased. This means that the original standard solutions are no longer appropriate for new-build installations.

7.57 Because of the resulting increase in the volume of air supplied to the theatre, provision needs to be made either to actively remove it or allow it to escape

passively through pressure stabilisers. The increase in room size has also made the number and position of air-supply terminals critical to the effective ventilation of the room.

7.58 Four new standard solutions have been developed to reflect the current guidance on theatre suite layout and room sizes given in HBN 26 (2004) as well as the general increase in air-change rates.

7.59 The most commonly used original standard solutions have been revised and updated. They have been retained in this guidance, as they will remain applicable to older theatre suites that are being refurbished to their original performance standards. They will also be applicable in existing departments where space constrains do not permit the upgrading of suites to the latest standard of performance or where a pre-built "shell" is being fitted out.

7.60 It is important to recognise that in any situation where a "non-standard" room size or theatre suite layout is being considered, the designer must return to first principles when developing a solution. Examples of non-standard configurations would be:

- cardiac theatres that typically have an operating room half as big again as normal, a perfusion laboratory and no anaesthetic room;
- operating departments served by a central instrument lay-up preparation area rather than individual prep rooms;
- balanced-flow theatres for infectious cases.

Appendix 4 contains a methodology for assisting the designer to arrive at a suitable solution.

7.61 The new and revised standard design solutions are as follows:

No 1 – Typical Conventional theatre – room sizes as HBN 26;

No 2 – Typical UCV theatre – room sizes as HBN 26;

No 3 – HBN 26 illustrated Conventional theatre;

No 4 – HBN 26 illustrated theatre with UCV terminal fitted;

No 5 – Pre-2006 Conventional theatre, single corridor (former SHTM 2025; 1b);

No 6 – Pre-2006 UCV theatre, single corridor (former SHTM 2025; 1a);

No 7 – Pre-2006 Conventional theatre, two corridor (former SHTM 2025; 5b);

No 8 – Pre-2006 UCV theatre, two corridor (former SHTM 2025; 5a).

7.62 Details of these standard solutions are given in Appendix 3. They contain diagrams that show the relationship of rooms and the various doors and transfer devices between them, **but should not be regarded as architectural layouts.**

The schemes have been developed using the calculation procedure described in Appendix 4. Important features of the solutions are:

- Zone trimmer heaters – a trimmer heater battery is advocated when calculations indicate that the temperature differential between rooms may be greater than 2K. Generally this will only be the case in the preparation room when designated as a lay-up.
- The preparation room (sterile pack store)/operating room interface – these rooms are deemed to be of equal cleanliness, and thus a transfer grille is required between these rooms or the door can be replaced with an opening wider than a standard door.
- Preparation (lay-up)/disposal room interface – pressure relief dampers are recommended here to provide an air path when doors are closed, while preventing back-flow when a door is opened elsewhere.
- Operating room/anaesthetic room interface – pressure stabilisers, or in some cases, carefully sized transfer grilles are recommended here, and between the anaesthetic room and corridor, and between the operating room and corridor.
- Operating room/scrub room interface – an opening is provided between these rooms. The flow of air through the opening provides protection, and gives bacterial dilution within the scrub room; the air is then exhausted to the corridor via a pressure stabiliser.

7.63 No mechanical supply or extract ventilation is provided in the scrub room, and thus when a door is opened elsewhere in the suite, the stabiliser will close, allowing the air to be re-directed to help protect the doorway. If the scrub is a bay within the theatre then a suitably positioned pressure stabiliser and / or active extract should be provided to ensure air movement and prevent a local build-up of moisture.

7.64 Any other scheme may be used and the standard solutions applied, if the following conditions are met:

- room relationships in air network terms are as shown in the plans;
- door-gap measurements approximate to those given in Scottish Health Technical Memorandum 58: ‘Internal doorsets’, (but see also Table A3 and Note 3);
- casual heat gains are accounted for;
- a trimmer battery is installed in the air supply system to the preparation room;
- leakage through the structure is kept to a minimum.

Note 3: It should be noted that many doors are now fitted with cold smoke seals as standard. These will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design door leakage is factored into the sizing of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air gap whistles and doors being held partially open by air pressure.

7.65 It is recommended that every effort should be made to adopt one of the schemes described above.

Air terminals and air distribution within rooms

7.66 The selection and sighting of air diffusers will be critical in establishing an efficient pattern of mixing. To this end the diffusers selected must be fit for purpose. Ceiling mounted circular 'air master' style, square 'four-way blow' or similar diffuser designs that provide a downward displacement, turbulent airflow are the preferred option. (See Paragraph 5.68).

7.67 Plenum-type 'laminar'-flow-style diffusers with a footprint that encompasses the operating site are acceptable but may be prone to buoyancy effects as a result of temperature difference. Manufacturers' type-test data should be consulted to ensure that the terminal will achieve the required performance envelope. Note that these are not true laminar-flow systems in the strict sense of the word but produce a downward-displacement parallel-flow style of air distribution.

7.68 The diffuser equipment chosen should not cause 'dumping' and it should provide a velocity 1 metre above floor level at the operating position of between 0.2 m/s and 0.3 m/s.

7.69 In the operating room, the supply air terminals must be at high level, and should all be adjustable for rate of flow as well as being easily cleaned and silent in operation.

7.70 In order to ensure that all parts of the operating room are actively ventilated, there should be an air-out path on each face or in each corner of the theatre. This may be provided by a pressure stabiliser, transfer grille, active or passive extract terminal. A minimum of three, but preferably four, air-out paths - approximately equally spaced - should be provided.

Automatic control

7.71 The automatic control of ventilation in operating suites needs to be simple and robust. Over-reliance on complex room pressure and flow relationships linked to automatic fan speed control is unnecessary and in the long term have been shown to be unreliable. Complex software algorithms that can only be accessed and interpreted by off-site specialists should not be used. Whichever control strategy is chosen it is important that on-site staff have the facility to override the control system and keep the ventilation operating at least until the surgical procedure is complete. (See also Paragraph 6.11)

7.72 Theatre air-conditioning control sensors should be actively ventilated. They would typically be located in a sampling extract duct mounted in the surgeon's

panel, positioned at normal working height (1.8m above finished floor level) and be accessible for cleaning and the removal of fluff and lint.

7.73 Wall-mounted passive-temperature and humidity sensors are not recommended.

7.74 Controls should be provided to enable operating department ventilation plants to be closed down when the operating suites are unoccupied. (See also Paragraphs 6.24 - 6.26)

7.75 When in the 'off' mode, the control system should ensure that the ventilation plant is automatically reinstated if the space temperature falls below 15°C.

7.76 The theatre control panel should include plant status indication; clearly-readable temperature and humidity indicating gauges; and means of adjusting the set point for temperature. Theatre ventilation plant status indication should be located at the staff control base.

7.77 Where it is considered necessary to fit a humidifier, it should be selected to humidify to 40% saturation at 20°C during the design winter outside conditions. The cooling coil should be able to remove sufficient moisture so that 60% saturation at 20°C is not exceeded during the design summer outside conditions.

7.78 Each operating suite should be served by an independent supply and extract plant.

Ventilation of operating department ancillary areas

General

7.79 There are advantages in providing mechanical ventilation to all areas of the department. Maintaining operating suite airflow patterns is simpler and grilles and diffusers can be sited to eliminate condensation on windows. Where radiators or embedded wall or ceiling panels are installed they should be confined to the corridors and staff-only areas of the department.

Ventilation requirements

7.80 Table A2 gives guidance on the operating department areas in descending order of cleanliness, and this should be considered in the overall design of the department ventilation systems. The specified flow rates of air through doors given in Table A4 for the operating suite are not necessary for other areas of the department. However, the air-flow directions must be maintained from the clean to the less clean areas.

7.81 All windows in the department should be double-glazed and hermetically-sealed in order to ensure that the desired airflow pattern is maintained under all external environmental conditions and to avoid infestation. Trickle vents if fitted will need to be sealed.

Systems design

7.82 The design of the ventilation system for the ancillary rooms depends on the overall configuration of the department. The plant for the ancillary rooms may need to be interlocked to the theatre suite plants so that reverse air-flow patterns do not occur.

7.83 Extract grilles should be sited and balanced to promote air movement along the clean and access corridors towards the reception/transfer areas. This should not affect the air distribution in the operating suite(s).

Reception

7.84 The aim in these areas is to provide comfortable conditions having regard to the movement control requirements of the department as a whole. The number of air changes will depend on the particular design.

Sterile pack bulk store

7.85 The store needs to be maintained at a positive pressure in order to preserve the cleanliness of the outside of the packs; 6 air changes are recommended.

Recovery

7.86 The air-change rate in the recovery room will be rather higher than that needed merely to provide clean, comfortable conditions, as it is necessary to control the level of anaesthetic gas pollution; 15 air changes are recommended, with a balanced air flow.

7.87 The supply air terminals should be ceiling mounted above the foot-end of the recovery bed positions. Extract should be at low (bed height or below) level behind the bed head positions or in the corners. This will establish a clean airflow path so that staff do not inhale anaesthetic gases exhaled by recovering patients.

7.0 (b) Ultra-clean ventilation systems

General requirements

7.88 The design philosophy of a conventionally ventilated operating suite is based on the need to dilute contaminants and control both the condition and movement of air in an operating suite. Ultra-clean ventilation (UCV) is a means of significantly increasing the dilution effect by providing a large volume of clean filtered air to the zone in which an operation is performed and sterile items are exposed. Air is discharged above the operating zone and while not truly laminar, its downward displacement purges the clean zone of contaminants and particles generated by the activities within it. The airflow in and around the clean zone also serves to prevent particles originating outside the zone from entering it. The resulting reduction in contaminants has been shown to reduce significantly post-operative sepsis following certain orthopaedic procedures.

7.89 The number of bacteria that are present in the air at the wound site and exposed surgical items is dependent on the operating team, their procedural discipline, choice of clothing and the type of UCV system. Ultra-Clean air is defined as that containing not more than 10 CFU/m^3.

7.90 UCV systems are very successful in reducing contaminants at the wound site so it is often considered that there is no need for complex air movement control schemes in the rest of the suite. However, when designing the ventilation scheme, it should be noted that the users may switch the UCV terminal to "set-back" when non-orthopaedic surgery is taking place. This is because the high airflow rates can cause increased moisture evaporation of exposed tissue that may be detrimental to the surgical outcome. In recognition of this, the ventilation scheme should be capable of providing operating conditions to at least a "conventional" theatre standard throughout the suite with the UCV in set-back mode. It should also be remembered that suitable levels of ventilation will always be required in the peripheral rooms.

7.91 UCV systems can be designed and built from first principles or a range of bespoke modular units of varying shapes and sizes are available with each manufacturer having a slightly different approach to UCV design. Some systems are fitted with partial or full walls to delineate the clean zone and direct a laminar or exponential downflow of air within it. Other designs utilise slotted linear supply terminals to produce an air curtain around the clean zone together with laminar-flow diffusers to provide a downward-displacement supply within it. **Notwithstanding any variation in the design philosophy, all UCV systems will be required to achieve completely the performance standard set out in the "Validation" section of this document**. (Section 8)

7.92 As with conventional theatres, each UCV operating suite should have its own dedicated air handling unit (AHU) to the standard set out in Section 4 of this document. To ensure operational flexibility and permit routine maintenance, air handling units should not be shared between suites.

7.93 In retrofit installations, site conditions may preclude individual AHUs for each suite. In these circumstances an AHU may be shared between not more than two operating suites providing each suite has its own control of temperature. An accessible airflow measurement test point should be provided in the supply branch duct to each theatre so that the primary air volume to each UCV canopy can be determined. In addition the branch supply and extract should be capable of being physically isolated and the main air-flow rate reduced so that either suite can be taken out of use without detriment to operating conditions in the other.

7.94 An inherent feature of a UCV system is its large airflow so it is essential to re-circulate the air supplied to the operating theatre and/or to recover its energy in order to optimise operating costs.

7.95 The primary fresh-air volume supplied to a UCV suite will be the same as in a conventional suite and it should be dispersed to the rooms in the suite in the same manner. This is an important aspect of the design and requests by UCV suppliers for increased primary air-supply volumes should be resisted.

7.96 Laying-up in the clean zone is preferable for infection control reasons. Where a Sterile Pack Store (SPS) Preparation room is provided a transfer grille will be required in the preparation room / theatre door.

7.97 If the Preparation room is intended to be used for laying-up instruments, a pressure stabiliser will be required between the prep room and theatre. It should be fitted with a stand-off baffle to prevent air transfer interfering with the ultra-clean airflow distribution.

7.98 Separate scrub-up or disposal facilities are not necessary for air cleanliness although operational policy may prefer such a provision. A separate anaesthetic room should, however, be provided.

7.99 There is no aerobiological reason why two or more UCV systems should not be installed in a common area as long as adequate spacing is provided. These are known as “barn theatres” and require special design considerations and operational discipline. The relative positions of the UCV units, temperature control range and location of doors and openings to other areas will all significantly affect the airflow at the operating positions.

Types of UCV system

Remote plant systems

7.100 In a remote plant system, all the air-conditioning equipment is located outside of the operating room, except for the unidirectional air-flow terminal, terminal filter, air diffuser and the return-air grilles (see Figure 6).

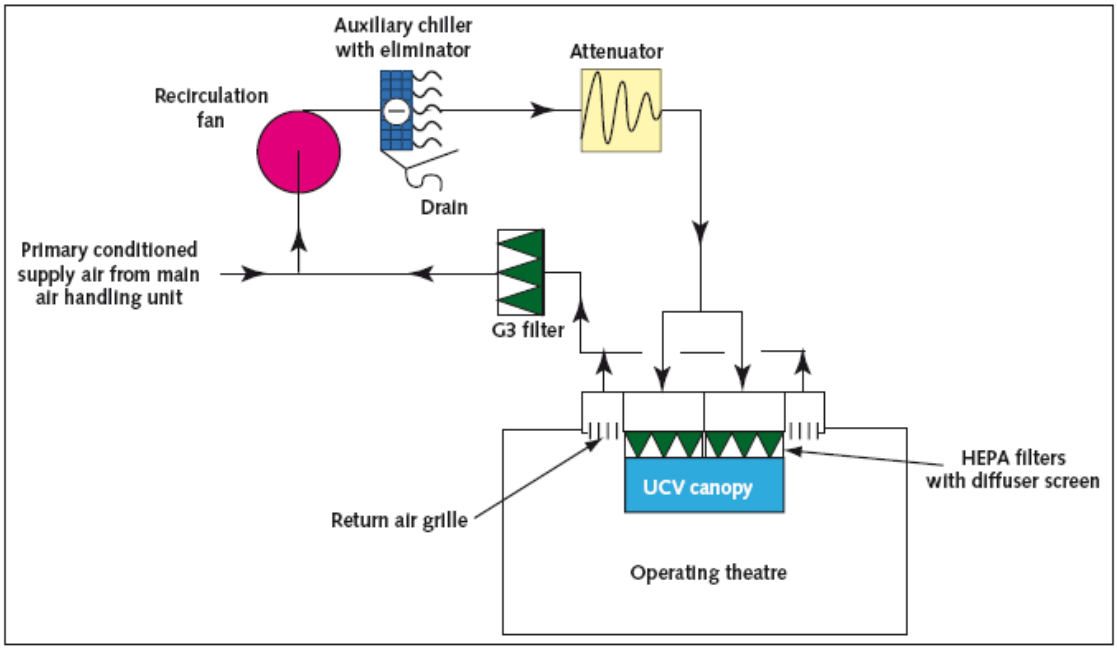


Figure 6: UCV theatre with remote air recirculation

7.101 This arrangement is the preferred option for new installations as it has the following advantages:

- the recirculation fans are out of the theatre thus reducing noise. Multiple recirculation fans can be replaced by a single fan unit with its drive out of the air stream;
- casual heat gains from recirculation fan(s), canopy lights, equipment and people within the theatre can be removed by a chiller battery in the return air stream. This will prevent heat build-up in the theatre;
- the return-air filters can be changed without needing access to the theatre making routine maintenance more feasible;
- the opportunity exists to locate the HEPA filter in the primary supply duct rather than the theatre terminal. This will reduce the number of filters required and allow them to be changed without entering the theatre.

Modular systems

7.102 Modular systems are frequently used in retrofit applications. Vertical or horizontal units are available.

7.103 Vertical-flow modular units comprise a ceiling-mounted air-terminal module containing return-air filters, return-air fans, final filter and air diffuser. Primary air is supplied by a remote air-conditioning unit at the volume and to the standard required for a conventional operating suite. (see Figure 7)

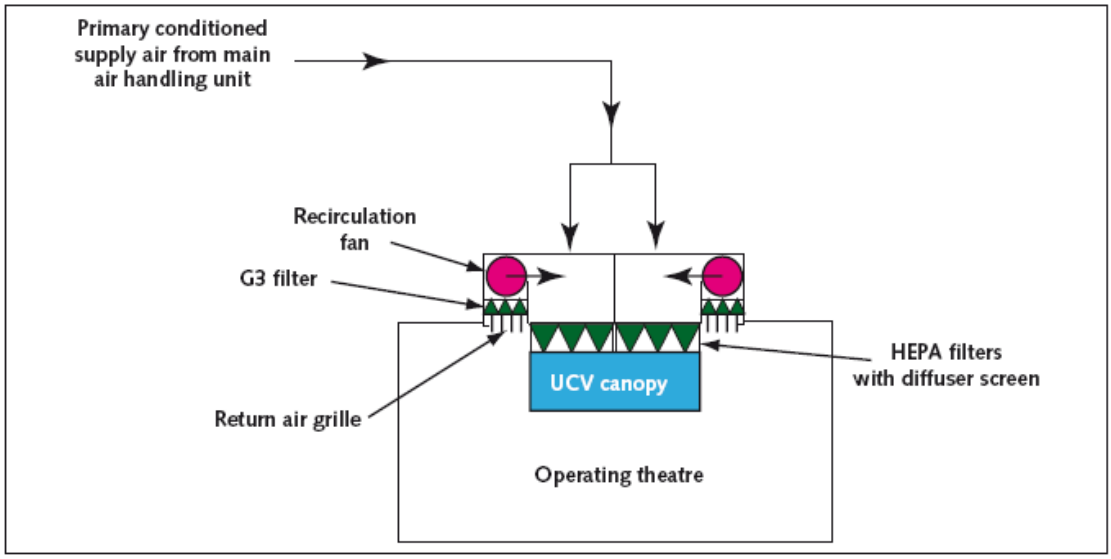


Figure 7: UCV theatre with modular system

7.104 Horizontal or cross-flow modular units comprise a wall-mounted air-terminal module standing vertically to produce a horizontal flow of air and containing final filter/diffuser, return-air filters and fans. The module may incorporate a cooling unit or be supplied with 'fresh air' from a separate primary cooling system.

Vertical flow UCV systems

7.105 Vertical-flow systems have a superior performance and are more effective at reducing infection risks. Air-curtain or partial-wall systems are acceptable, but are known to be more susceptible to problems arising from performance

deterioration, poor operating-team discipline and high occupancy rates than is the case with full-wall systems. A full-wall is considered to be any wall terminating not more than one metre above the finished floor level.

7.106 Because of the large volume of air being moved in a relatively small space, the siting of the return-air grilles can cause short-circuiting of the air discharged through the UCV terminal. If the return-air grilles are positioned at high level, partial walls should be provided to control short-circuiting. The partial-walls shall be not less than 1m from the operating room walls and terminate at least 2m above floor level. The clearance should be increased proportionally for larger terminals (that is, 1.15m for 3.2m x 3.2m units and 1.25m for 3.5m x 3.5m units). In all cases, the sidewalls should terminate at 2m above floor level.

7.107 Siting the return-air grilles around the periphery of the theatre at low level will eliminate short-circuiting, remove the need for partial walls and give an improved airflow path. In any event there should be an air-out path on each face or in each corner of the theatre. These may be provided by combination of pressure stabilisers and passive or active low level extract grilles. Failure to provide air-out paths on all faces of the theatre may result in the surplus air causing entrainment into the clean zone.

7.108 Vertical systems should have a clean zone large enough to encompass the operating site and all of the instrument trays likely to be needed for the surgical procedures to be undertaken. Ophthalmic and minor hand surgery would typically require a 1·4m circular or rectangular terminal. For major orthopaedic procedures a minimum size of 2·8m x 2·8m will be required. This is the area projected on the floor under the supply air terminal within the partial walls, full walls or air curtain. Any air outside this zone cannot be guaranteed to be ultra-clean although given the dilution factor the level of microbiological contamination will be much lower than the general level in a conventional operating room. The use of lines or a coloured area on the floor delineating the extent of the clean zone will assist staff and is therefore essential.

7.109 When upgrading an existing conventional theatre to an ultra-clean standard the only solution may be the installation of a modular system. In these units, the heat gains from the return-air fans and terminal lights may warrant the inclusion of supplementary cooling within the module although modern luminaries contribute substantially less unwanted heat. However issues of cooling coil drainage, condensate removal and maintenance access within the space constraints of the module may make this option impracticable. The additional cooling load should then be catered for by conditioning the primary air to compensate.

7.110 If an existing AHU is to be retained, it may require modification to ensure that it achieves the minimum standards set out in Section 4 of this document. The fan may need re-rating to accommodate the change in system resistance. The cooling coil may also need to be upgraded to cater for the increased load resulting from the return air fans and terminal lights. Failure to make adequate provision for this may make the theatre unusable during prolonged warm spells.

7.111 A factor affecting the air-flow pattern is the supply or room air temperature difference. When the supply-air temperature is significantly above room temperature, buoyancy effects will reduce the volume of air reaching the operating zone. If it is anticipated at design stage that this will be a regular occurrence, then a system incorporating full-walls should be used. Demountable extensions that convert a partial-wall to a full-wall unit are available.

7.112 Convection up-currents from the surgical team and operating lamp tend to counter the movement of clean air towards the operating site, hence the air velocity reaching the operating level is critical. The minimum velocity given below has been selected to take account of these factors and is greater than the theoretical minimum value.

7.113 For all vertical UCV systems the design discharge velocities will be as follows:

Air velocity 2 metres above floor level:

- partial-wall system = 0.38 m/s average;
- full-wall system = 0.30 m/s average.

Air velocity 1 metre above floor level:

- all systems = 0·2 m/s minimum within the operating zone.

The validation Paragraphs 8.75 – 8.86, gives details of the method of measurement.

7.114 Variable-speed recirculation fans with differential pressure control may be the most suitable solution for maintaining consistent performance and energy saving.

Horizontal UCV systems

7.115 Horizontal UCV air-flow systems have been shown to be less effective than vertical systems and are not the preferred solution. There may be occasions, however, where architectural, engineering, economic or workload considerations prevent the installation of a vertical-flow system and only a horizontal-flow system can be installed.

7.116 Horizontal- or cross-flow modular units comprise a wall-mounted air terminal standing vertically to produce a horizontal flow of air across the operating field. The terminal module contains the final filters, air diffuser, return-air grilles, filters and fans. The module may incorporate a full air-conditioning unit or be supplied with 'fresh-air' from a separate primary air-conditioning system. In the latter case the return-air fan power may warrant the inclusion of a supplementary cooling coil within the module.

7.117 The system should have sidewall panels at least 2·4m apart. The panels may fold to facilitate cleaning of the theatre. The minimum height of the terminal should be 2·1m and a deflector at the top of the filter/diffuser will be acceptable

as an alternative to a full roof. These dimensions reflect currently available equipment and may impose operational constraints in addition to a lower level of performance common to these systems.

7.118 In the horizontal flow systems, personnel working between the filter and surgical wound will disperse bacteria that are more likely to contaminate exposed surgical instruments and enter the wound. This may be minimised by the use of improved clothing and operating procedure to reduce dispersion of bacteria. The use of lines on the floor delineating the extent of the clean zone and hatching or colour coding the 'no-entry' zone between the air diffuser and patient will serve to prompt staff and are therefore essential.

7.119 The air discharge velocity as measured 1m from the diffuser face should have a mean value of 0·4 m/s. The validation Section 8 gives details of the method of measurement.

Filters

7.120 The main plant primary and secondary filters should be to the standards and in the location set out in Section 4.

7.121 Terminal filters should be provided within the airflow terminal or in the air supply to it. High efficiency particulate air (HEPA) filters grade H10 as specified in BS EN 1822 will be required as a minimum. There is no aerobiological benefit in fitting filters of a higher grade than this, although for practical reasons most UCV manufacturer recommend the fitting of H12-grade filters.

7.122 In some modular UCV units, the terminal filter is used as a pressure equaliser to balance airflow and filters of a higher grade with a greater pressure drop may be recommended by their manufacturer. The increased resistance may affect the velocity of air reaching the operating level and there will be penalties in terms of installed fan power and higher noise levels.

7.123 The final filters should be installed in a leak-proof housing in a manner that allows the terminal unit, filters and their seals to be validated. A challenge test will be carried out during commissioning to prove the effectiveness of the complete installation.

7.124 Where UCV units are constructed in sections, a means of measuring the pressure drop across the terminal filters in each section should be provided. The pressure test-points should be located outside of the partial wall, capped to prevent air leakage and accessible within the theatre without the need to open the unit inspection panels. Alternatively direct-reading pressure gauges should be fitted.

7.125 The UCV system will require a return-air filter to capture the relatively coarse particles that would otherwise significantly reduce the life of the final filter. This should be at least a G3 grade to BS EN 779. In remote recirculation systems there may be advantages in fitting a higher grade return air filter, as it will reduce the load on the terminal HEPA filters and extend their life.

Noise level

7.126 If sound-attenuating material is used to line any portion of the inside of the UCV unit it should be non-particle-shedding and fire-resistant. (Further guidance can be found in SHTM Firecode suite of documents).

7.127 The maximum noise level in an operating room fitted with a UCV terminal of any type shall not exceed 50 NR. The validation section gives details of the method of measurement.

Lighting and operating lights

7.128 CIBSE lighting guide LG2 and BS EN 12464-1 give detailed information of lighting requirements. Operating luminaires should comply with the photometric requirements detailed in relevant sections of BS EN 60601.

7.129 The position of the UCV light fittings and style of partial walls, where fitted, should neither adversely disturb the airflow nor result in significant spatial variations in illuminance levels.

7.130 In vertical units, specialised task lighting should be provided by toroidal, cruciform or small multiple dome-shaped luminaires as they have good aerodynamic properties. The ideal luminaire will have a minimal effect on the airflow regardless of where it is positioned. Large-diameter saucer-shaped luminaires should not be used in vertical-flow systems as they will occlude the airflow in the critical central zone. It is important to consider the suitability of existing luminaires when retrofitting UCV systems.

7.131 In vertical UCV installations a minimum of 2·75m from floor to underside of the diffuser is required to allow for supporting mechanisms and lamp articulation. When upgrading existing systems this dimension may not be achievable. However, when parked, the lowest point of the central light stem, luminaire and articulation arms should never be less than 2m above floor level.

7.132 The traditional means of light support is a central column that passes through the UCV terminal and is rigidly fixed to the building structure. The position of the support therefore prevents air being supplied at the centre of the terminal. Separate supports displaced from the centre of the clean zone would lead to improved airflow. This approach was advocated in the 1994 version of HTM 2025 but at the time of writing no UK manufacturer has chosen to adopt this solution.

7.133 In horizontal units the size or shape of the specialised task luminaire has little effect on the air-flow pattern.

Controls and instrumentation

7.134 The functions of the supply AHU and extract ventilation should be continuously monitored by a BEMS control unit. The controls and instrumentation for the main plant are set out in Section 6.

7.135 UCV systems will additionally require:

- a set-back facility that can reduce the air supplied through the UCV terminal to a volume that equates to not less than 25 air changes per hour of the operating room gross volume whilst still leaving the supply AHU operating at full speed;
- a facility to turn the entire system, supply AHU and UCV terminal, off. (an emergency stop is not required);
- a read-out sufficiently large to be clearly visible from the operating table that shows the temperature of the air being supplied by the UCV terminal;
- a read-out sufficiently large to be clearly visible from the operating table that shows the relative humidity of the air being supplied by the UCV terminal;
- a red indicator light that will illuminate when either the supply AHU or the UCV terminal fails, either or both are switched off or are at set-back;
- an amber indicator light that will illuminate when the UCV terminal is at set-back and the supply AHU is running;
- a green indicator light that will illuminate when both the supply AHU and UCV terminal are operating at full speed;
- a blue indicator light that will illuminate when the UCV terminal air flow, as detected by a differential pressure sensor, falls below 80% of the design flow rate.

AHU	UVC terminal	Indicator light	Comment
Off or Fault	Off or Fault	Red	Ventilation not operating at a suitable level to commence surgical procedures
Off or Fault	On (set-back)		
Off or Fault	On (full speed)		
On (set-back)	Off or Fault		
On (full speed)	Off or Fault		
On (set-back)	On (set-back)		
On (full speed)	On (set-back)	Amber	Ventilation provided to at least conventional theatre standard
On (full speed)	On (full speed)	Green	Full UCV standard conditions
-	-	Blue	HEPA-filter resistance causing low air flow

Table 7: Indicator light logic table

7.136 The switching devices and indicators should be incorporated in the surgeon's panel and their functions clearly labelled. In retrofit installations an auxiliary panel for the UCV may be the most practical option. If fitted it should be mounted adjacent to the surgeon's panel and their control functions interlocked as necessary.

7.137 When a system is designed to have partial walls with full-wall extensions, a volume control facility may be incorporated to allow the system to be run with reduced velocity when the demountable full-walls are in place. It would be the responsibility of the user to ensure correct operation of the system. To assist the user an explanatory notice should be included on the theatre control panel.

7.138 A direct-reading gauge should be fitted in the theatre to show a representative pressure drop across the final filters. If the UCV control box is located out of the theatre and has a means of manually adjusting the return air-fan speed then it should also be fitted with a direct-reading differential pressure gauge. The means of adjusting the return-air fan speed should be lockable to prevent casual adjustment. The direct-reading gauges should be fitted with a means of indicating the correct operating pressure range.

7.139 The UCV-unit manufacturer's control box should be located in an accessible position preferably in the operating department adjacent to the operating theatre that it serves. A service corridor, if provided, is an ideal location. The control box should be clearly labelled with the identity of the operating theatre that it serves.

7.0 (c) Extract systems

7.140 Extracts may be provided for a variety of reasons including:

- simple odour control (for example in a WC or mortuary);
- to receive and remove moisture-laden air (for example, in a kitchen);
- as part of a combined supply/extract balanced system (for example, in an operating suite);
- to capture a hazardous substance at source (for example a safety cabinet).

7.141 Devices that use an inflow of air to control exposure of staff to hazardous substances are classified as Local Exhaust Ventilation (LEV) systems under the COSHH Regulations.

7.142 An LEV system may comprise a self-contained unit incorporating its own carbon filter such as a simple bench-top fume cupboard. Alternatively it may be a complete "ventilation system" comprising a make-up air supply, multiple-exhaust-protected work stations, branch and central extract ductwork, duplex extract fans and a high-level discharge terminal. It may also incorporate a special filtration system appropriate to the hazardous substance being controlled. Such systems could be required for workshops containing woodworking machinery or large centralised pathology laboratories housing multiple safety cabinets, dissection benches, fume cupboards and specimen stores.

7.143 It is important to recognise at the design stage whether an extract is being provided for comfort or as an LEV system. Typical systems in healthcare include:

- microbiological safety cabinets and Category 3 containment rooms;
- fume cupboards;
- welding-fume extracts;
- woodworking machinery duct collectors;
- battery-charging bay extracts;

- powered plaster and bone saws;
- pharmaceutical preparation cabinets and tablet machines;
- dissection benches, cut-up tables and some specimen stores;
- medium- and high-risk infectious disease isolation facilities;
- decontamination facilities;
- dental furnaces, grinders and polishers.

7.144 General design information and guidance for LEV systems is produced by the Health and Safety Executive (HSE) as HS(G)37. Information on the design and installation of microbiological safety cabinets is given in BS5726 and that for fume cupboards is given in BS EN 14175. Their recommendations should be closely followed.

7.145 LEV systems are statutory items that will be subject to an independent inspection every 14 months.

Hood extract systems

Special requirements

7.146 Extract canopies will be required over steam-and-heat-emitting appliances, for example sterilisers, catering and washing equipment; and for the extraction of toxic fumes over benches used for mixing, sifting and blending procedures.

7.147 Perimeter-drain gulleys and corrosion-proof grease eliminators should be provided on kitchen hoods.

Typical arrangements

7.148 The air-flow rate must be sufficient to ensure an adequate capture velocity in the vicinity of the process; typical values are as follows:

- evaporation of steam and like vapours 0.25 m/s to 0.5 m/s;
- chemical and solvent releases 1.0 m/s;
- vapour of gases 5 m/s to 6 m/s;
- light dusts 7 m/s to 10.0 m/s.

Excessive velocities will be wasteful of power and generate noise.

7.149 The lowest edge of the canopy should be 2m above finished floor level, with a minimum of 300mm overhang beyond the edge of the equipment on all sides.

7.150 A compact arrangement of equipment (but with access for maintenance) will minimise the canopy area, and hence reduce the air volume necessary to achieve the optimum capture velocity.

7.151 Hoods required for the control of heat gain and vapours may be connected to the general extract system when it is convenient to do so, but where non-corrosive ductwork materials are necessary, a separate discharge is preferred.

7.152 Lighting and internal divider plates are often required to be built into the perimeter of large canopies. However, built-in shelving systems are not recommended, as they interfere with the air-flow, and constitute a maintenance problem.

Control of hood extracts

7.153 Provided that it does not interfere with the operation of the department when not in use, the ventilation system for the hood extract and any associated supply can be shut down. To this end, local control should be provided.

Bench extract systems

Special requirements

7.154 Bench extract ventilation is required in departments such as pathology and mortuary, where activities involve the release of malodorous or toxic fumes that should not be inhaled. Where hazardous substances are being controlled, the system should be designated an LEV.

Typical arrangements

7.155 Each ventilated position will usually be accommodated in a continuous run of benching, which should not be more than 650mm from front to rear and which should be provided with a continuous upstand at the rear. Each position should have a 1200mm x 150mm linear extract grille mounted on a purpose-designed plenum box (incorporating guide vanes as necessary), with its face flush with the upstand. The bottom of the grille should be as close as practicable to the level of the working surface (usually 75mm above, to allow for cleaning). The minimum velocity across any part of the grille should be 1 m/s. The grille should be readily demountable to allow for cleaning.

Control of bench extract systems

7.156 Provided that it does not interfere with the operation of the department when not in use, the ventilation system for the bench extract and any associated make-up supply can be shut down. However, a run-on timer with a minimum setting of 30 minutes must be provided. To this end, local or automatic-use control should be provided.

7.157 Processes that produce hazardous vapours, fumes, dusts or noxious vapours should be enclosed or semi-enclosed in a suitable cabinet or exhaust protected workstation.

Safety cabinet and fume-cupboard extract systems

7.158 Safety cabinets and fume cupboards are devices that use an inflow of air to control exposure of staff to hazardous substances. The units, their exhaust

systems, filters, fans and discharge terminals are all classified as Local Exhaust Ventilation (LEV) systems under the COSHH Regulations. The make-up air system to a room that contains an LEV system should also be considered as an essential part of the system and be included in the LEV classification. Information on the design and installation of microbiological safety cabinets is given in BS5726 and that for fume cupboards is given in BS EN 14175. Their recommendations should be closely followed.

7.159 The Advisory Committee on Dangerous Pathogens (ACDP) publishes 'The Management, Design and Operation of Microbiological Containment Laboratories' covering the general environment in which they are used and operational considerations.

Special requirements

7.160 The supply-air system should not distort the unidirectional and stable air pattern required for fume cupboards and microbiological safety cabinets. In general, supply-air ceiling diffusers should not discharge directly towards fume cupboards or safety cabinets, unless the terminal velocity is such that the air-flow pattern of the cabinet is unaffected. The design should ensure that high air-change rates, and/or the opening and closing of doors do not have any adverse effect on the performance of safety cabinets or fume cupboards. A damped door-closure mechanism may help.

7.161 In order to safeguard the user, all safety cabinets and fume cupboards must be fitted with a clear indication that they are operating correctly. Direct-reading gauges or falling-ball indicators are preferred (in addition to electronic pressure indicators). The system should be set to alarm audibly if the face velocity falls below the minimum safe operating level.

Arrangements for safety cabinet installations

7.162 The manufacture and installation of microbiological safety cabinets must be in accordance with the relevant national standards and guidance issued by the Advisory Committee on Dangerous Pathogens (ACDP).

7.163 A Class 1 microbiological safety cabinet must be specified for routine work involving Group 3 pathogens. It should be housed in a Category 3 containment room. Specific design information on containment rooms is issued by ACDP in conjunction with the Health and Safety Commission.

7.164 Siting and installation of microbiological safety cabinets are of particular importance because:

- the protection afforded to the operator by the cabinet depends on a specific and stable unidirectional air flow through the open front;
- the protection to the environment by the cabinet depends on the high efficiency particulate air (HEPA) filters. The exhaust air should never be considered as totally free from microbiological hazard.

7.165 Microbiological safety cabinet is HEPA filtered prior to being discharged to outside. The extract ductwork should as far as practicable be kept under negative pressure while inside the building.

7.166 Current standards permit the installation of microbiological safety cabinets with integral fans, provided that the extract ductwork can be kept short (that is, less than 2m); such an installation however, is likely to be noisy and is not recommended for use in new buildings.

7.167 The discharge from the cabinet should be fitted with a back-draft damper. In multiple installations where several cabinets discharge into a common extract and discharge duct, it must be possible to isolate each cabinet from the system when not in use.

7.168 Roof-level discharge, wherever practicable, is preferred since it removes much of the uncertainty over air re-entering the building through ventilation inlets and/or windows. In such an installation, the extract fan should be situated separately from the cabinet and close to the discharge outlet, to maintain the duct within the building under negative pressure. The discharge point on a flat roof should be through a 3m high terminal. This is required to safeguard staff who may need to access the roof periodically for maintenance. This requirement will also be applicable to fume-cupboard discharges.

7.169 Where this is impracticable, discharge into the room via a double HEPA filter has been accepted. The preferred method, however, is to discharge 3m above the roofline in line with the similar standard for fume cupboard designs.

Arrangements for fume cupboard installations

7.170 The manufacture and installation of fume cupboards must be in accordance with the relevant national standards and associated guidance.

7.171 The primary factors that contribute to the effective performance of fume cupboards include:

- an adequate volume of supply air;
- an effective exhaust system to promote the safe dispersal of waste products to atmosphere.

7.172 The air velocities through sash openings must be sufficient to prevent hazardous materials from entering the laboratory while avoiding excess flow rates that interfere with the investigation process. Average face velocities should be between 0.5 and 1.0 m/s, with a minimum at any point within 20% of the average, the upper end of the range being applicable to the containment of materials of high toxicity. The design velocity must be maintained irrespective of whether the sash opening is varied, or whether doors or windows are open or closed. Variable Air Volume (VAV) cupboards are available which offer a reduction in energy use.

7.173 The possibility of a fire or explosion that may not be contained by a fume cupboard must always be considered. A fume cupboard should not, therefore,

be sited in a position where exit to an escape route will necessitate passing directly in front of it.

7.174 Fume-cupboard fans should be installed as near as possible to the termination of the duct, thus maintaining the maximum amount of ductwork at negative pressure.

7.175 Where there are adjacent buildings with opening windows, or where downdraughts occur, it may be necessary to increase the height of discharge ducts in order to achieve adequate dispersal. In complex locations, airflow modelling or wind tunnel tests may be required to determine the optimum height of the stack (see also Paragraph 7.167).

7.176 Fume-cupboards for certain processes must have separate extract systems. However, where appropriate, individual fume-cupboard exhaust systems may discharge via non-returning dampers into a single collection duct rather than having a large number of separate stacks. The collection duct should have a large cross-sectional area to minimise its effect on the individual exhaust systems; be open to atmosphere upstream of the first connection; and be designed to discharge a total air volume at least equal to the combined individual extract systems.

7.177 Individual fume-cupboard extract systems, discharging either directly to atmosphere or into a collection duct, do not require duplex fans. However, a collection duct designed to provide dispersal of effluent from a number of individual extracts, should have duplex fans with automatic changeover.

7.178 Some fumes are particularly corrosive, so the choice of material for the ductwork, and type of extract fan fitted should reflect the nature of the fume being conveyed.

Control of extract systems

7.179 It is desirable to provide local control of safety cabinets in order to maximise the life of the HEPA filter, and to permit the sealing of the cabinet and room for fumigation if spillage occurs.

7.180 To cope with the risk of an accident or spillage outside safety cabinets, a ‘panic button’ should be provided to switch off the supply to that area; and discharge all extracted air to atmosphere.

7.181 In pathology departments, it will be necessary to have one or more microbiological safety cabinets and one or more fume cupboards available for use at all times, including weekends, therefore, local overriding controls for all these items and any associated ventilation plant will be necessary.

7.0(d) Plantroom ventilation

General requirements

7.182 Plant rooms are required to be ventilated in order to maintain acceptable temperatures for satisfactory operation of the plant and controls, and for

maintenance activities. In the case of plant rooms housing combustion equipment, a secondary function of the ventilation is to provide make-up air for the combustion process.

7.183 The air required for these purposes should be introduced into the space through inlets positioned to minimise the discomfort to occupants; they should be unlikely to be blocked, closed deliberately (except in the case of fire shutters if required), or rendered inoperative by prevailing winds.

7.184 Plantroom ventilation air should not be used for any other purposes, such as make-up air for extract; and where the plantroom contains combustion equipment, the appliance pressure must not fall below the outside air pressure.

7.185 Specialised healthcare air handling equipment must not be located in a fire compartment that houses combustion equipment.

7.186 Statutory regulations for plantroom ventilation are contained in the Scottish Building Regulations, and further guidance is given in CIBSE Guides A & B.

Assessment of ventilation levels

7.187 Ventilation requirements must take into account all heat sources within a plantroom, and where there are large glazing areas, solar gains. The ventilation rate should limit the maximum temperature within the plantroom to 32°C.

7.188 As the level of equipment operating during mid-season and summer is often lower than the winter condition, and the cooling effect of the outside air is reduced, it is necessary to calculate the minimum volume for each season of operation, and the inlet and outlet grilles or fan sizes should be chosen to cater for the largest seasonal air volume.

7.189 Replacement air should not be drawn through pipe trenches or fuel service ducts. Where metal ducts penetrate walls and floors, effective sealing should be provided to confine the ventilation to the boiler room and to meet fire protection requirements. Penetration of fire barrier walls by ventilation ducts should be avoided if possible.

7.190 Fire dampers in plant room ventilation ducts should be electrically interlocked with the boiler plant.

7.191 Care must be taken to prevent any noise generated in the boiler room emerging from natural or mechanical ventilation openings to the detriment of the surrounding environment. Particular care is necessary with mechanical flue draughts and fan-diluted flue systems.

7.192 Information on required air volumes in contained in the CIBSE Guide A & B.

7.193 Where combustion plant is installed, the high-level (outlet) openings should be sized to cater for the total ventilating air quantity; and the low-level (supply) openings sized to cater for the total combined ventilating and combustion air quantity.

Choice of ventilation system

7.194 Ventilation air may be introduced and exhausted by either natural or mechanical means or a combination of both. However, natural systems are preferred where possible.

7.195 Generally, small installations at or above ground level should have their combustion and ventilation air provided by natural means, employing both high- and low-level openings.

7.196 Basement, internal and large installations at or above ground level will usually require a combination of natural and mechanical ventilation. If the airflow rate is difficult, both supply and extract may require mechanical means.

7.197 Whether natural or mechanical, the system should be designed to avoid both horizontal and vertical temperature gradients. Both inlet and outlet openings should be placed on opposite or adjacent sites of the building to reduce the effect of wind forces.

7.198 Where mechanical air supply is employed, electrical interlocks with the boiler plant should be provided to prevent damage in the event of failure of the supply fan(s) once the air volume is established.

7.199 The necessary free opening areas for a naturally ventilated plantroom may be calculated using either the method in A4 of the CIBSE Guide A or the table in section B13 of CIBSE Guide B.

7.200 A combined natural and mechanical ventilation system should allow for natural extract at high level, to take advantage of convective forces in the room, with mechanical supply at low level. The high level natural ventilators should be sized to cope with the total quantity of ventilation air, as above.

7.201 To prevent leakage of flue gases and to ensure that the flue draught is not impeded at any time, the air pressure in the boiler room must not exceed the prevailing outside pressure. Therefore, the fan duty should exceed the calculated total combined combustion and ventilation air quantity by at least 25%. Fan-powered inlets should be arranged to flow outside air into the space at a point where cross-ventilation will ensure pick-up of heat without causing discomfort to occupiers.

7.202 Where it is impractical to provide sufficient natural ventilation to remove the heat emitted by the plant, both mechanical supply and extract will be required.

7.203 The high-level extract should be sized to cater for the total ventilating air quantity and the low-level supply should exceed the total combined combustion and ventilating air quantity by at least 25%, as above.

7.0(e) Ventilation of hydrotherapy suites

General requirements

7.204 In a hydrotherapy suite heat recovery should be via heat pump.

7.205 The quantity of supply air should be calculated as 25 litres/sec/m^2 wetted surface, with the wetted surface taken as 110% of the pool water surface area.

7.206 A re-circulation plant is recommended, with a minimum of 20% fresh air.

7.207 As far as practicable, re-circulated pool air should be provided to the ancillary changing and recover accommodation, with the only extract from the toilets, laundry/utility room and pool hall.

7.208 Supply air to the pool hall should be introduced at high level and directed towards the perimeter to mitigate condensation, with extract air taken from directly over the pool. Dampers should not be located over the pool water.

Control of hydrotherapy pool installations

7.209 The supply and extract fans should be interlocked so that the supply fan does not operate until flow is established within the extract system.

7.210 Time-clock control should be provided, with a local override switch to extend the normal operating period as required.

7.211 Night setback temperature (in the range of 21°C -25°C) and high humidity control (in the range of 60-75% sat) should be provided to override the time clock in order to prevent condensation. The exact set points should be ascertained post-installation.

7.212 A remote indication panel should be provided in the pool hall, giving a visual display of the pool water and pool air temperature.

8. Validation of specialised ventilation systems

Definitions

Commissioning - Commissioning is the process of advancing a system from physical completion to an operating condition. It will normally be carried out by specialist commissioning contractors working in conjunction with equipment suppliers. Commissioning will normally be the responsibility of the main or mechanical services contractor.

Validation - A process of proving that the system is fit for purpose and achieves the operating performance originally specified. It will normally be a condition of contract that "*The system will be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.*"

Note: Commissioning is often sub divided into sections e.g. air handling unit, automatic controls, airside balance, building fabric and fittings. Each section may be commissioned by its specialist installer and they are often accepted in isolation. Validation differs from commissioning in that its purpose is to look at the complete installation from air intake to extract discharge and assess its fitness for purpose as a whole. This involves examining the fabric of the building being served by the system and inspecting the ventilation equipment fitted as well as measuring the actual ventilation performance.

It is unlikely that 'in house' staff will possess the knowledge or equipment necessary to validate critical ventilation systems such as those serving operating suites, pharmacy clean rooms and local exhaust ventilation systems. Validation of these systems should therefore be carried out by a suitably qualified independent Authorised Person appointed by the NHS Board.

It is anticipated that training in the validation of specialised healthcare ventilation systems for independent Authorised Persons will become available during the life of this SHTM.

Commissioning general

8.1 Commissioning is an essential process for ventilation systems. It is therefore important that adequate provision for the process be made at the design stage of the project. Procedures for commissioning air-handling systems are given in CIBSE Commissioning Codes and BSRIA Application Guide Set COMPAK 1.

8.2 The duct-sizing procedure should take into account the requirements of system balancing, and the position and number of regulating dampers included in the design should be sufficient for this purpose.

Location of dampers and test holes

8.3 Balancing/commissioning dampers will be required in each branch of the distribution ductwork.

8.4 Test holes for the measurement of air-flow will be required at carefully selected points in main and all branch ducts. The number and spacing of holes are given in the BSRIA Application Guide Set COMPAK 1. Their positions must be identified at the design stage.

8.5 The test positions need to be accessible for commissioning to take place. They may also be required for subsequent annual verification of the system performance, so they should not be covered by permanent lagging.

8.6 The measurement point should be in a straight length of duct as far away as possible from any upstream bends, dampers or other elements that could cause disturbance to the airflow. The actual location should be:

- at least 1.5 duct diameters upstream of sources of turbulence such as dampers and bends;
- if this is not possible, 10 diameters downstream of dampers, bends or tees, and 5 diameters downstream of eccentric reducers;
- where there is enough space round the duct to insert the pitot tube and take readings;
- where the duct has a constant cross-sectional area.

8.7 Test holes for measuring total airflow from a fan should be located either 4 diameters upstream or 10 diameters downstream of the fan. Provision should also be made for measuring the speed of rotation.

Information to be provided

8.8 It is essential that the designer should pass on his intentions fully to the commissioning engineer by indicating which parts of the system are high, medium and low pressure, and by providing:

- relevant parts of the specification;
- schematic drawings indicating performance data as indicated in Table 8;
- equipment schedules;
- controller and regulator schedule;
- fan performance curves;
- wiring diagrams for electrical equipment, including interlock details.

Items in system	Information to be provided
Fans	Fan total pressure Volume flow rate at high and low speed Maximum motor current
Plant items	Type and identification numbers from equipment schedules Fluid and air volume flow rates Fluid and air side pressure losses Dry bulb temperatures Wet bulb temperatures Humidity
Dampers, including motorised and fire dampers	Identification numbers from equipment schedules Location Identification number Volume flow rate
Main and branch ducts	Dimensions Volume flow rates and velocities Identification numbers from equipment schedules
Terminal	Location Identification number Grille or diffuser factor Volume flow rate and neck velocity Operating static pressure
Test holes and access panels	Location Identification number
Controllers	Set points

Table 8: Information to be provided on schematic drawings

Notes: For Table 8

1. Fan total pressure is the difference between the total pressure (static pressure + velocity pressure) at the fan outlet and the total pressure at the fan inlet.

2. Where volume flow rates are variable, maximum and minimum values should be provided.

Commissioning personnel

8.9 As one individual is unlikely to possess all of the required commissioning skills, a commissioning team is therefore usually needed. The objective of commissioning is to ensure that the necessary performance and safety requirements are met.

8.10 During the commissioning process a great deal of information will be generated which will form an invaluable future source of reference about the plant. It is essential to ensure that it is collected together in the form of a commissioning manual and handed over to the client on completion of the contract together with the 'as fitted' drawings. This information should be both in hard copy and electronic format.

8.11 In order to be successful the commissioning process must start before achieving practical completion as many parts of the system will become progressively less accessible. The correct installation of those parts will need to be witnessed and leak-rate tests carried out as construction proceeds. Failure to establish responsibility for commissioning early enough will delay the completion of the project or lead to unsatisfactory plant performance.

Commissioning brief

8.12 The commissioning team will require a detailed brief from the system designer. This should include:

- a 'user' brief comprising a description of the installation and its intended mode of operation;
- the precise design requirements with regard to the scheme of air movement, room static pressures, supply and extract air-flow rates and acceptable tolerances;
- full details of the design conditions both inside and out, for winter and summer together with the control strategy;
- equipment manufacturer's type test data, commissioning, operation and maintenance recommendations;
- drawings showing the layout of the system, positions of air-flow measurement test points, dampers, regulating devices and filters within the duct runs, together with sizes of ducts and terminal fittings. It will save time if these drawings are annotated with the design volumes and static pressures required at each branch and outlet point;
- wiring diagrams for all electrical equipment associated with the air handling systems including motor control circuit details and any interlocking and safety devices such as emergency-stop buttons adjacent to the item of plant.

8.13 The CIBSE Commissioning Code, Series 'A' – "Air Distribution", provides full guidance on the information that will be required by the commissioning team.

8.14 The designer should include in the contract document instructions on verifying the accuracy of test instruments that should be supported by reference to relevant calibration certificates.

8.15 The system, on completion, should be operated by the contractor as a whole and subject to performance tests in accordance with the contract requirements. For critical systems, these may include independent validation of the system performance on behalf of the client.

8.16 Prior to dynamic commissioning, it is essential that builders' work in the area served by the system is complete, all rubbish and dust is removed, concealed plumbing (IPS-type) panels are in position and ceiling tiles are in place and clipped. Floors should be mopped and visible dust removed from all other surfaces.

8.17 Once the system is shown to meet the design intent the handover documentation should be completed. In the event of performance not being acceptable, the matter should be dealt with in accordance with the contract arrangements.

Pre-commissioning checks

8.18 The pre-commissioning checks consist of visual inspection, manual operation of equipment, static measurements and functional tests of individual components. They should be carried out prior to setting the system to work and undertaking the dynamic commissioning process set out in Paragraph 8.29 onwards of this guidance.

Standard of installation

8.19 During the installation of the system the following must be witnessed:

- that the plant and installations have been provided and installed in accordance with the design specification and drawings;
- that only approved sealants have been used in the installation;
- that all components function correctly;
- that the satisfactory sealing of access doors and viewing ports have been carried out;
- that air pressure tests and air-leakage tests on ventilation ducting have been carried out in accordance with the methods set out in the HVCA's DW/143: Ductwork Leakage Testing. It is usual to carry out these tests, a section at a time, as the ductwork is installed and before its insulation is applied. The results must be recorded in the commissioning manual;
- that gaps around doors and hatches are as specified in the design;
- that the correct operation of pressure stabilisers, control dampers, isolating and non-return dampers have been checked and installed in the correct orientation for air-flow;
- that test holes have been provided in their specified locations and are sealed with suitable grommets;
- that control dampers are secured and their quadrants fitted correctly;
- that any interlocks are operative and in accordance with specification;
- that the electric circuits are completed, tested and energised;
- that electric motors have been checked for correct direction of rotation both at full speed and set-back;
- that cooling and heating media are available at correct temperatures and pressures and in specified quantities;
- that the air-conditioning plant components and controls function correctly;
- that the air-conditioning plant interlocks and safety controls function correctly;

- that the plant is physically complete, insulation is applied and all ducts and pipework are identified as specified;
- that the building housing the ventilation plant is generally in a fit condition for commissioning and performance tests to commence, that is, windows, doors, partitions etc are completed, surfaces sealed and their final finish applied;
- that the areas containing the ventilation plant and those being served by it are clean;
- that access to all parts of the system is safe and satisfactory.

Cleanliness of installation

8.20 During installation it must be established that ductwork is being installed to the 'advanced level' as defined in the HVCA (2005) 'TR/19 – Guide to good practice: internal cleanliness of ventilation systems'. This specifically includes ensuring that ductwork sections arrive on site and are stored with their open ends sealed and that open ends remain sealed during installation to prevent the ingress of builders' dust.

8.21 Should any doubt exist whether the guidance has been observed, the ducts must be cleaned internally to restore them to this standard before being taken into use.

8.22 "Builders work" ducts of brick or concrete must be surface sealed to prevent the release of dust before being taken into use.

8.23 The area around the supply air intake must be free of vegetation, waste, rubbish, builders' debris or any other possible source of contamination.

Certification of equipment

8.24 The following test certificates should be assembled by the commissioning team and be available for inspection at any time during the contract period. They will form part of the handover information and should be placed in the commissioning manual:

- type-test performance certificates for fans;
- pressure-test certificates for:
  - heater-batteries;
  - cooling coils;
  - humidifiers (if appropriate);
- type-test certificates for attenuators;
- type-test certificates for primary and secondary filters;
- individual test certificates for high efficiency particulate air (HEPA) filters.

Equipment tests

8.25 Prior to setting the system to work, the checks in Paragraphs 8.26 - 8.28 should be witnessed, and proving tests should be carried out as detailed.

Filters

8.26 The quality of filter housing and in particular, the seals is a critical factor in maintaining the efficacy of the filtration system by ensuring that air does not bypass the filter panels. Therefore, the following checks should be made:

- filter seals should be fitted and in good condition;
- filters should be installed correctly with respect to air flow;
- bag filters should be installed so that the bags are vertical and their pockets free;
- HEPA filters should be installed in a sealed housing and their seals tested to DIN 1946 if specified;
- all filters should be checked to ensure they are free of visible damage;
- the differential pressure indicators should be checked for accuracy and that they are marked with the initial and final filter resistance.

Drainage arrangements

8.27 The drain should conform in all respects to the “Design considerations” of this SHTM. In addition the following must be proved:

- that the drain tray is easily removable;
- that a clear trap is fitted and is easily removable;
- that the drain has a clear air gap of at least 15mm;
- that the pipework is supported so that the air break cannot be reduced;
- that the drain system from each drain tray is independent up to the air break;
- that the operation of the drainage system is proved by introducing water into the duct at the drain tray and observing that it completely drains out. This check is to be repeated both at normal speed and set back once the fans have been commissioned. At this time the clear trap can be marked to indicate the normal water level with the fan running.

Fire dampers

8.28 The following must be witnessed and proving tests should be carried out as detailed:

- the operation of all fire dampers;
- the access provided to enable the dampers’ to be visually inspected and / or re-set should be sufficient for the purpose;

- indication should be provided of the dampers' position (open/tripped);
- indication of the fire dampers' location should be provided both on the ductwork and at a visible point on the building fabric if the ductwork is concealed.

Dynamic commissioning

Air-handling and distribution system

8.29 The fan drive, direction of rotation, speed and current drawn should be set in accordance with their manufacturer's instructions.

8.30 After the installation has been checked to ensure that it is in a satisfactory and safe condition for start-up, it should be set to work and regulated to enable the plant to meet its design specification. The proportional balancing method described in the CIBSE Commissioning Code "A" must be followed. The air-flow rates must be set within the tolerances laid down in the design brief. This will normally be the design airflow rate +10% -0%.

8.31 When combined supply and extract systems are to be balanced and the area that they serve is to be at or above atmospheric pressure then the supply should be balanced first with the extract fan switched off, and then the extract balanced with the supply fan(s) on.

8.32 For combined systems where the area that they serve is to be below atmospheric pressure then the extract should be balanced first with the supply fan switched off and then the supply balanced with the extract fan on.

8.33 On completion of the balance all volume air-flows in supply and extract ducts and from grilles and diffusers must be measured and recorded. The true air change rate can them be calculated from the data obtained.

8.34 The main supply and extract duct volume control dampers must be locked and their position marked.

8.35 All grille and diffuser volume control registers must be locked to prevent alteration and their final position marked.

Room air distribution

8.36 The pressure-relief dampers and pressure stabilisers must be set to achieve the specified room static pressures and locked. The grille direction control vanes and diffuser cones must be set to give the specified air-movement pattern. Visualisation techniques may need to be employed in order to prove that the required air-flow pattern is being achieved. This may be a potential requirement when commissioning LEV systems or rooms that contain them.

Air-conditioning plant

8.37 The specified flow rate and/or pressure drops must be set for all heater batteries, cooling coils and humidifiers. The methods described in the CIBSE

Commissioning Codes “W” and “R” should be followed. On completion their regulating devices must be locked to prevent alteration.

Control system

8.38 The control system should not be commissioned until both the air distribution system and air-conditioning equipment have been commissioned.

8.39 Because of the specialised nature of control systems and the fact that each manufacturer’s system will contain its own specialist components and settings, the commissioning should be completed by the supplier and witnessed by a representative of the user.

8.40 The location of all control and monitoring sensors should be checked and their accuracy proved.

8.41 The control system’s ability to carry out its specified functions must be proved.

8.42 If the plant is provided with a “user’s” control panel in addition to the one located in the plantroom then the operation of both must be proved. This will typically apply to operating departments and laboratory systems.

Specific performance standards

Air movement

8.43 The performance of the system should be measured and compared with information provided by the designer.

Plant capacity and control

8.44 When setting to work and proving the design, both the manufacturer of the air-handling plant and the control specialist should attend site together and jointly commission the system.

8.45 If any doubt exists as to the capacity of the installed system, then its ability to achieve the specified inside design conditions with the plant operating at winter and summer outside design conditions must be proved. Artificial loads will be required in order to simulate the internal gains/losses and the outside design conditions.

8.46 On completion of the plant performance test, recording thermo-hygrographs should be placed in each room/area served by the plant and also the supply air duct upstream of the frost battery. The plant should be run for 24 hours with all doors closed. During this period the inside conditions must stay within the tolerances specified. The BEMS should be used to obtain the information required wherever possible. Periodic tests will be required during the defects liability period.

Noise levels - general

8.47 The commissioning noise level is the level measured with a sound-level meter in the unoccupied room and taking account of the external noise together with the noise generated by the ventilation system. When occupied and in use this commissioning level will constitute a continuous background noise that will allow the overall noise level to be achieved. The ventilation plant design noise level is that generated by the plant alone with no other noise source being considered. The levels suggested make recognised allowance for the ingress of environmental noise.

8.48 The noise levels apply at the maximum velocity for which the system is designed to operate. Acoustic commissioning tests should be carried out with all plant and machinery running normally and achieving the design conditions of airflow, temperature and humidity.

8.49 An industrial-grade sound-level meter to BS3489 or IEC 651 Type 2 will normally be sufficient to check the noise level.

8.50 The noise level readings are to be taken at typical normal listening position 1.5m above floor level and at least 1m from any surface and not on any line of symmetry. In critical rooms the noise should be measured at the centre of the room and at the centre of each quarter. The mean of the 5 readings should then be calculated.

8.51 In the event of a contractual deficiency, a Type 1 precision-grade sound-level meter should be used and the noise level determined by the procedure given in Scottish Health Technical Memorandum 08-01 (2011).

Filter challenge

General ventilation filters

8.52 In-situ performance tests will not normally be required for primary and secondary filters and their housings. However the filters should be visually inspected for grade, tears, orientation and fit within their housing. Filters should be clean and a replacement set available. Bag filters should be installed so that their bags are vertical and spaced so that air can move through them freely. Any filter found to be wet should be replaced and the cause investigated.

HEPA filters (for exhaust protective enclosures and laboratories)

8.53 Pathogenic material may be discharged through damaged or badly installed HEPA terminal filters. The complete installation must be tested using the method set out in BS EN: 14644 ‘Method of Testing for the Determination of Filter Installation Leaks’.

8.54 The challenge tests may be carried out using either of the following techniques:

- use Dispersed Oil Generator (DOP) to provide the challenge and a photometer to detect leaks;

- use a Discrete Particle Counter (DPC) to detect leaks. (In order to obtain a sufficient challenge it may be necessary to remove temporarily the supply AHU secondary filters).

8.55 In both cases the upstream challenge should be measured. A measurement of particle penetration through a representative section of the HEPA filter media is then taken and used as the reference background level. These two readings enable the range of the detecting instrument to be set.

8.56 A challenge aerosol of inert particles of the type produced by a DOP generator should be introduced into the air, upstream of the HEPA filter. The downstream face of the filter, its mounting seal and housing would then be scanned for leakage using a photometer. A leak should be deemed to have occurred if a steady and repeatable reading on the photometer at any point exceeds 0.01% of the upstream reading.

8.57 Alternatively a Discrete Particle Counter (DPC) may be used. For the Discrete Particle Counter method the filter face is sampled at several points to establish the smallest non-penetrating particle size. If particles at or above this size are detected when subsequent scans of the filter face, its seal and housing are made, then there is deemed to be a significant leak at, or near, the test position.

8.58 Should the HEPA filter fail this test it must be replaced. Should the filter mounting seal or housing fail this test it may be repaired and the test repeated.

Bacteriological sampling

General ventilation systems

8.59 Bacteriological sampling will not normally be required for either general or local exhaust ventilation (LEV) systems unless otherwise specified.

Conventional operating rooms

8.60 The level of airborne bacteria introduced by the supply air can be checked by closing all doors and leaving the operating room empty with the ventilation system running for 15 minutes. An active air sampler set to 1 cubic metre and mounted on the operating table should then be activated remotely. Aerobic cultures on non-selective media should not exceed 10 bacterial and/or fungal colony forming units per cubic metre (CFU/m^3).

8.61 The results should be examined to establish the broad category of organisms present. A high preponderance of fungal organisms may be an indication of inadequate filtration for the particular installation. Precise guidance is inappropriate and will depend on local circumstances.

8.62 It may be appropriate to carry out a check of airborne bacteria during a surgical operation. If required this should be carried out as soon as possible after handover. Unless there are unusually high numbers of personnel or extensive activity in the room, the number of airborne bacterial and/or fungal CFU

averaged over any five-minute period, would be unlikely to exceed 180 per cubic metre.

8.63 Information on the additional validation testing of UCV Operating suites is given in Section 8.0(a).

Ventilation system commissioning/validation report

8.64 Following commissioning and/or validation a full report detailing the findings should be produced. The system will only be acceptable to the client if at the time of validation it is considered fit for purpose and will only require routine maintenance in order to remain so for its projected life.

8.65 The report shall conclude with a clear statement as to whether the ventilation system achieved or did not achieve the required standard. A copy of the report should be lodged with the following groups:

- the user department;
- infection control (where required);
- estates and facilities.

8.0(a) Validation of UCV operating suites

General

8.66 Commissioning of a UCV terminal will normally be carried out by its supplier. Commissioning of the air-handling unit, fire dampers, distribution ductwork and control systems may be undertaken by different teams. It is therefore important to recognise that the UCV terminal is only one element of the specialised ventilation system serving the operating suite and it cannot be accepted in isolation.

8.67 In order to ensure that the complete system operates correctly it will be necessary to validate the system as a whole from the air intake through to the extract discharge. It is unlikely that “in house” staff will possess the knowledge or equipment necessary to undertake this process. Validation of Ultra-Clean operating theatre ventilation systems should therefore be carried out by a suitably qualified independent Authorised Person appointed by the client.

8.68 It is anticipated that training in the validation of specialised healthcare ventilation systems for independent Authorised Persons will become available during the life of this SHTM.

8.69 The following regime of inspection and testing should be applied to the validation of new installations designed to provide Ultra-Clean conditions in an Operating suite. The test regime has been devised to ensure that the system as installed fully achieves the design requirement for these systems as set out in Section 7.0(b) of this document.

Basic requirement

8.70 The operating suite to be validated should be physically complete with final finishes applied. All ventilation systems serving it should be operating correctly and delivering the design air-flow rates.

8.71 In order to avoid pre-loading the UCV terminal's recirculation ducts and HEPA filters, the Operating suite should be free of any obvious dust and at least "builders clean" before the recirculation fans are set to work.

8.72 The validation procedure for a conventional theatre suite should have been satisfactorily completed to the standard set out in Section 8 prior to attempting to validate the UCV unit. In particular:

- the supply AHU will have achieved the minimum standard;
- the operation of all fire dampers will have been proved;
- the supply and extract air-flow rates as measured in ducts and at room terminals will achieve their design values +10%; -0%;
- room differential pressures will be correct.

Evidence of the satisfactory achievement of the foregoing standard should be available for inspection and independently measured as necessary *prior to validating the UCV unit.*

UCV unit validation procedure

8.73 Tests to validate the suitability and performance of an ultra-clean operating suite should be undertaken in the order that they appear below. Should an item fail to meet the required standard it should be rectified and successfully retested before passing on to the next test.

Summary of test regime

- Challenge tests to ensure that:
  - the UCV terminal unit is correctly assembled and sealed so that no air will bypass the filters;
  - the terminal filters are correctly sealed in their housings;
  - the terminal filters are of the same grade, of uniform quality and undamaged.
- Air velocity measurements to ensure that
  - a sufficient quantity of air is being delivered by the terminal;
  - the terminal quadrants are in balance;
  - the air flow has sufficient velocity to reach the working plane.
- An entrainment test to ensure that contaminants arising outside of the UCV terminal footprint are not drawn into it.

- Visualisation techniques to gain an understanding of the overall system performance.
- Noise measurement to ensure that working conditions are satisfactory.
- Control system checks to ensure that the system operates as specified.
- Biological monitoring to determine how effective the system is in use.

Test and measuring conditions

8.74 While validating the UCV terminal, the conditions in the Operating room shall be stable and within the given ranges.

temperature: – 19°C - 23°C dry bulb.

humidity: – 30 – 65% relative humidity.

Test and measuring equipment

8.75 Any test or measuring equipment used should have a certificate to prove that it has been validated within the previous 12 months at a calibration facility using traceable national standards.

8.76 In the case of a noise meter, its “matched sound source” should have a certificate to prove that it has been validated within the previous 12 months at a calibration facility using traceable national standards. The noise meter should be calibrated to the sound source on each occasion that it is used.

Test grid – vertical units

8.77 A test grid should be constructed on the floor within the ultra-clean terminal footprint as projected by the inside dimensions of the sidewalls or boundary air curtain. A suitably marked test sheet will provide a consistent standard of test grid.

8.78 The test grid should comprise test squares of 280mm each side.

8.79 The test grid should be aligned along the centre lines of the terminal footprint with its centre under the centre point of the terminal.

8.80 Any test square with 80% of its area within the UCV footprint should be used as a test position.

8.81 An inner zone should be designated that is not less than 36% of the total footprint. It should be made up of a number of test squares distributed symmetrically about the terminal footprint centre line. Regardless of the shape of the terminal footprint, the inner zone should comprise a minimum grid of 6 x 6 test squares.

8.82 Unless specified otherwise, a test position should be in the geometric centre of a test square.

8.83 Test position 1 should be the leftmost test square in the row nearest to the operating room wall that houses the surgeon's panel.

(For an example of a grid for a 2.8 x 2.8 metre terminal see Figure 8)

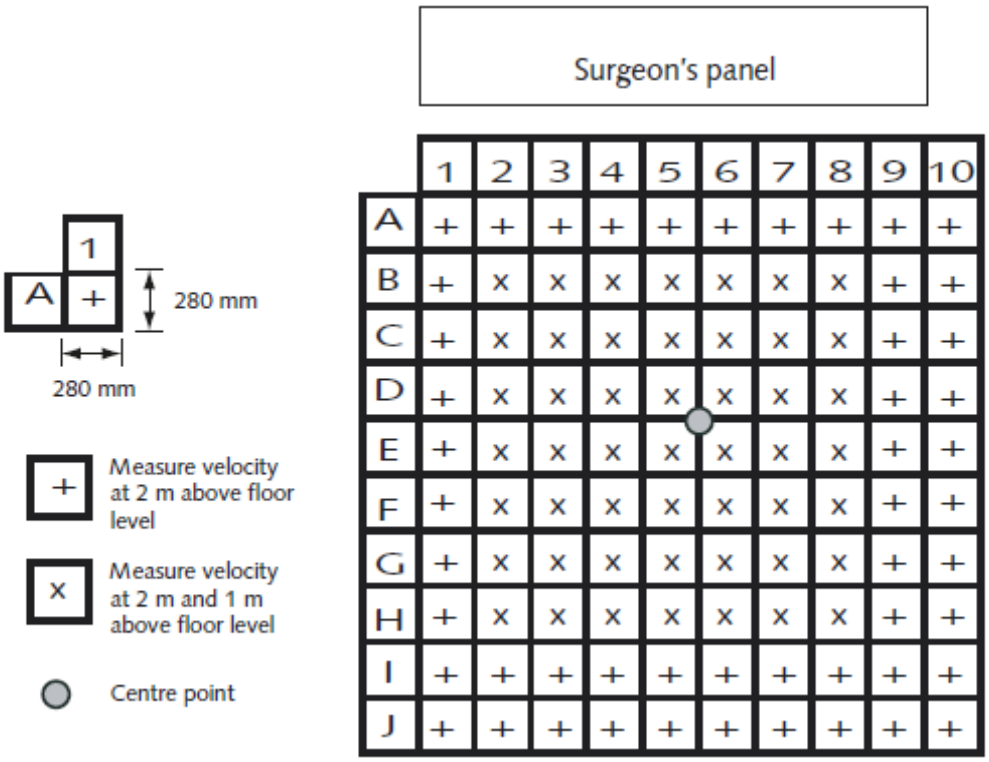


Figure 8: Example of a Test Grid for a 2.8m x 2.8m UCV Terminal

Test grid – horizontal units

8.84 A line of test positions should be marked on the floor 1m in front of the face of the UCV terminal.

8.85 A test position should be marked in the centre of the line. Additional test positions should be marked at 280mm spacing along the line either side of the centre position, up to the full-face width of the unit.

UCV terminal challenge tests (Vertical and horizontal systems)

8.86 The diffuser screen fitted below the face of the terminal HEPA filters should be lowered or removed while the challenge tests are being carried out.

8.87 The installed HEPA filters should be checked to ensure that their grade accords with the design specification and that their performance has been certified by the manufacturer.

8.88 The challenge tests may be carried out using either of the following techniques:

- use DOP to provide the challenge and a photometer to detect leaks;
- use a DPC to detect leaks. In order to obtain a sufficient challenge it may be necessary to remove temporarily the supply AHU secondary filters.

8.89 In both cases the upstream challenge should be measured. A measurement of particle penetration through a representative section of the HEPA filter media is then taken and used as the reference background level. These two readings enable the range of the detecting instrument to be set.

8.90 For the DOP test this should be set as the reference level and a leak will be declared significant if penetration greater than 0.01% of the range is detected. (See Paragraph 8.56 for details).

8.91 For the DPC method the filter face is scanned to establish the smallest non-penetrating particle size. If significant particles at or above this size are detected when subsequent scans are made then there is deemed to be a significant leak at, or near, the test position. (See Paragraph 8.57 for details)

UCV terminal unit clean zone leak test

8.92 This test will confirm that there is no unfiltered air bypassing the HEPA filter.

8.93 The joints and service penetration points under the UCV terminal within its side walls or boundary air curtain should be scanned to prove that there are no leaks.

8.94 A leak is defined as a significant rise above the background level.

Terminal HEPA filter seal leak test

8.95 The test will confirm that there is no unfiltered air bypassing the HEPA filter's seal.

8.96 Each HEPA filter's seal should be scanned to prove that there are no leaks.

8.97 A leak is defined as a significant rise above the background level.

Terminal HEPA filter media leak test

8.98 The test will confirm that the HEPA filters have not sustained damage while being installed.

8.99 The face of each HEPA filter should be scanned to prove that there are no leaks.

8.100 A leak is defined as a significant rise above the background level.

Vertical UCV terminal air velocity tests

Test set up

8.101 The terminal face diffuser screen should be in place for these tests.

8.102 Take spot readings to establish that the room is within the specified temperature and humidity test conditions.

8.103 Set out the test grid as described previously.

8.104 Swing the operating lamp arms and any other stem arms so that they align to present the least resistance to air flow, are perpendicular to the front edge of the test sheet and face the back edge. Any lamp and equipment heads should as far as practicable be outside of the UCV terminal footprint.

Test instrument

8.105 The measuring instrument should be a hot-wire anemometer with a digital read-out. The instrument resolution should be at least 0·01m/s, have a tolerance of ±0·015 m/s or 3% of that reading and be calibrated down to 0·15 m/s or lower. An alternative instrument may be used providing it is of no lesser specification.

Test method

8.106 The instrument should be mounted on a test stand and set to take a mean reading over a ten-second sample interval.

8.107 It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. Alternatively they could be downloaded to a computer or data logger at the end of the test.

8.108 The test stand to be positioned on each test point in turn and the reading taken when the instrument has stabilised.

8.109 When taking a reading the test person should not stand within the same quadrant as the test instrument.

8.110 Readings are to be taken at the test positions with the instrument probe facing the wall housing the surgeon's panel, commencing at the first test position. Readings are taken working along the row from left to right and back, or for all text positions in one quadrant at a time.

8.111 When all test positions under one half of the terminal have been covered, readings of temperature and humidity are then taken at the specified height in the centre of the terminal. The read-outs on the surgeon's panel should be recorded at the same time.

8.112 Having completed one half of the test grid, the operating lamp arms and any other stem arms should be swung round through 180º and the test stand reversed so that the wall housing the surgeon's panel is behind the test person. Readings are recommenced starting at the right of the test row and working from right to left a quadrant at a time, as above.

UCV high-level discharge velocity test

8.113 Measurements of air velocity are to be taken at every test position 2m above floor level and the results averaged.

8.114 The average of the total readings taken is to be not less than:

0.38 m/s for a partial-wall system;

0.30 m/s for a full-wall system.

The average air velocity for each quadrant should not exceed ±6% of the measured average velocity for the terminal

UCV low-level air velocity test

8.115 Measurements of air velocity are to be taken at each of the inner zone test position 1m above floor level.

8.116 The measured velocity at every test position in the inner (operating) zone shall be not less than 0·2 m/s.

Horizontal UCV terminal air velocity test

Test set up

8.117 Set out the line of test positions as described previously.

8.118 Swing the operating lamp arms and any other stem arms so that they align to present the least resistance to air flow and are perpendicular to the line of test positions.

Test instrument

8.119 See that specified for vertical systems (Paragraph 8.105 refers).

Test method

8.120 The instrument should be mounted on a test stand and set to take a mean reading over a ten-second sample interval.

8.121 It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. Alternatively, they could be downloaded to a computer or data-logger at the end of the test.

8.122 The test stand should be positioned on each test point in turn and the reading taken when the instrument has stabilised.

8.123 When taking readings the test person should stand well downstream of the instrument.

8.124 Readings are to be taken at the test positions with the instrument probe facing the UCV terminal, commencing at the first test position on the left and working along the row from left to right at the specified height.

8.125 The instrument should be reset to the next specified height and the test repeated and so on.

8.126 Readings of temperature and humidity should be taken at the specified height in the centre of the terminal. The read-outs on the surgeon's panel should be recorded at the same time.

UCV discharge velocity test

8.127 Measurements of air velocity are to be taken at all test positions at 1m, 1·5m and 2m above floor level.

8.128 The average of the total readings taken should be no less than 0·4 m/s.

UCV entrainment test (Vertical systems only)

Rationale for the entrainment test

8.129 The performance of UCV systems may be compromised by room air being drawn into the ultra-clean airflow, a phenomenon known as “entrainment.” Significant levels of entrainment could lead to microbial contamination of items left exposed on instrument trolleys laid out beneath the canopy.

8.130 UCV systems having permanently fitted full sidewalls do not need to be tested, as the sidewalls physically prevent entrainment.

Principle of the test

8.131 A source of particles is produced outside of the UCV terminal and is used to challenge the system. A detector is placed within the ultra-clean airflow and used to determine the percentage penetration of the test particles at predefined locations under the UCV terminal footprint. The source and detector are moved in tandem around the UCV canopy and pairs of readings taken, from which the percentage penetration at specified locations is calculated. The degree of penetration should be below specified maximum limits if entrainment is to be declared not significant.

8.132 The entrainment test may be carried out using either of the following techniques:

- use DOPs to provide the challenge source at the specified release position and a photometer to measure the entrainment; or
- duct non-HEPA-filtered air to the specified release position and use a DPC to measure the entrainment.

Test set-up

8.133 The terminal face diffuser screen should be in place for these tests.

8.134 The test should be performed without any equipment in place beneath or closely adjacent to the UCV terminal.

8.135 The theatre lights should be moved to a central position beneath the terminal and raised to 2m above floor level, so as not to interfere with the peripheral airflows.

8.136 Take spot readings at the centre of the canopy, one metre from floor level, to establish that the room is within the specified temperature and humidity test conditions.

8.137 Set out the test grid as described previously.

8.138 For either of the following entrainment tests, a measurement of particle penetration through a representative section of the HEPA filter media is to be taken and used as the reference background level.

Test equipment, challenge source, measuring instrument and detector head

8.139 The challenge and detector equipment should be chosen so that:

- the tracer particles are mainly within the size range 0.3 to 5 microns and thus capable of remaining airborne for a substantial time;
- the particles used should not be able to penetrate the terminal filters in sufficient numbers to cause a background count that is more than 0.1% of the challenge count;
- the choice of particle and detector will enable a minimum of a three-logarithm (1,000-fold) range of counts to be recorded between the highest (that is, source) and lowest (that is, background) readings expected. (A concentration of approximately 10^5 particles per cubic metre of source air has been shown to be adequate.)

Source – Dispersed Oil Particles (D.O.P.)

8.140 The DOP generator should be able to produce a cloud of test particles in the form of a visible smoke. The test smoke should be delivered via an aperture so that it flows vertically downward from the lowermost edge of the partial wall, on the outside of the UCV canopy.

8.141 The test smoke is to be delivered via an aperture.

Note 4: To prevent undue contamination of the theatre and filters with deposits of oil, DOP should only be released for the minimum amount of time necessary to complete the test.

Challenge source – natural particles

8.142 The source unit should be a fan/blower or other method that takes non-HEPA-filtered air and expels it via a delivery head at the specified release position to provide the particle challenge. The challenge air should be delivered vertically downwards from the lowermost edge of the partial wall, on the outside of the UCV canopy, parallel to the airflow coming from the diffusers. The challenge air velocity should be the same as the measured average velocity at 2m from the terminal under test.

Note 5: The use of DOP for testing is gradually being phased out and replaced by a natural challenge measured with a DPC. At the time of writing research is under way to define more precisely a challenge source unit for natural particles. It is anticipated that such a unit, together with a matching test methodology, will become available during the life of this Scottish Health Technical Memorandum.

The detector (defined in terms of range and resolution)

8.143 This may be a photometer or a DPC. It is recommended that a printer be linked to the test instrument so that readings are recorded automatically. The instrument should be capable of sampling a minimum a 28.3 litres of air per minute and in the case of the DPC, provide readings for particle size ranges from 0.3 microns to 5.0 microns and greater. The instrument should be compliant with the requirements of BS EN ISO 14644-1. An alternative instrument may be used providing it is of no lesser specification.

Test positions and orientation of source and detector

8.144 The test positions should be at the centre of each test square, as defined for the velocity test.

8.145 For rectangular UCV terminals, measurements of penetration are to be taken at the four corner test squares of the test grid and at intermediate positions along the line of test squares between the corners. The number of intermediate test positions will be as equally spaced as possible around the periphery with no fewer than 3 and no more than 5 complete test squares between test positions.

8.146 A further series of measurements are to be obtained around the periphery of the inner zone. Measurements of penetration are to be taken at the four corner test squares of the inner zone of the test grid and if necessary at intermediate positions along the line of test squares between the corners as equally spaced as possible, with no fewer than 3 and no more than 5 complete test squares between test positions.

8.147 A single measurement should be taken at the geometrical centre of the UCV terminal footprint. The centre measurement will be taken with the detector head mounted vertically upwards 1 metre above floor level.

8.148 The centre of the challenge particle source should be aligned with the centre of the designated test square, with its longer edge against the outer edge of the partial wall and delivering the challenge from the lower edge of the partial wall. The air containing challenge particles is directed vertically downwards from the lower edge of the partial wall, in a plane parallel to the adjacent partial wall. Where there is physical interference due to obstructions such as gas pendants, the source will be moved to the next available non-obstructed test-square location nearest to the stipulated sampling position. The detector should then also be moved to remain opposite the source.

8.149 In the case of non-rectangular terminals, an interpretation of the above strategy should be adopted that will yield a no less searching examination of the unit's ability to control entrainment.

Test method

8.150 The sampling head of the detector instrument is mounted on a test stand with its sampling orifice facing outwards horizontally from the centre of the UCV canopy, 1m above floor level. The sampling head should be orientated at right angles to the partial wall when sampling along the sides of the test grid but will be set to bisect the angle when measuring at the corner test positions (Figure 88 illustrates the challenge and detector orientations when evaluating a 2.8m x 2.8m UCV terminal).

8.151 The test will commence at the first test position, this being designated the leftmost corner of the test grid when facing the wall housing the surgeon's panel. The penetration will also be measured at the corresponding test point on the inner zone commencing at the corner nearest to the first test position. When these tests have been completed, the source and detector equipment should be moved to the next test positions, working around the test grid in a clockwise direction.

8.152 The test stand should be positioned on each test point in turn and a pair of readings (challenge, then penetration) taken when the instrument has stabilised. The detector should be set to take a reading over a 15 second sample interval.

8.153 When taking a reading the test person should stand within the UCV terminal footprint but not in the same quadrant as the detector head.

Analysis and interpretation

8.154 The following standard is to be achieved:

- penetration to be not greater than 10% of the challenge at each test position in the outer zone;
- penetration to be no greater than 1% of the challenge at each test position in the inner zone;
- penetration to be no greater than 0·1% of the challenge at the centre of the test grid.

If a result is close to, or above the given limits, then a further reading must be obtained using a longer time base (1 minute) and the penetration must not exceed the given limit.

Basis of the test

8.155 Whyte W, Shaw BH, Freeman MAR. An evaluation of a partial-walled laminar-flow operating room. *J Hyg Camb* 1974; 73: 61 – 75.

Whyte W, Lidwell OM, Lowbury EJL, Blowers R. Suggested bacteriological standards for air in ultraclean operating rooms. *J Hosp Infect* 1983; 4: 133 – 139.

UCV visualisation

8.156 The use of smoke to gain an understanding of the overall performance of the system may prove useful at this stage in the validation process but cannot be relied on to produce a contractually definitive measure of performance.

UCV noise level

8.157 An industrial-grade sound-level meter to BS EN 61672 Type 2 fitted with a muff should be used to check the noise level. The instrument should be calibrated using a matched sound source prior to each set of readings.

Vertical systems

8.158 The noise level readings should be taken at typical normal listening positions 1·5m above floor level and at least 1m from any surface and not on any line of symmetry. Measurements should be taken under the centre of each quadrant of the UCV terminal and the four readings averaged.

Horizontal systems

8.159 The noise level readings are to be taken at typical normal listening positions 1·5m above floor level on the test line. The width of the unit should be divided in two and a measurement taken in the centre of each half but avoiding any line of symmetry. The two readings should be averaged.

8.160 Measurements should also be taken in each room of the suite.

8.161 In the event of a contractual deficiency a Type 1 precision-grade sound-level meter complying with BS EN 61672 should be used. Readings should be taken at the positions specified above and in each case the logarithmic mean of the results should be calculated in order to determine the noise level. Further information can be found in SHTM 08-01 (2011).

8.162 For vertical or horizontal systems, the noise level shall not exceed:

- 50NR [55dB(A)] – for UCV operating rooms and spaces without doors that open directly on to it (for example the scrub);
- 40NR [45dB(A)] – for all other peripheral rooms of the suite.

UCV control system checks

Temperature

8.163 The readings of temperature taken under or in front of the UCV unit should be within ±1 K of each other and the read-out on the surgeon's panel.

Humidity

8.164 The readings of humidity taken under or in front of the UCV unit should be within ±5% of each other and the read-out on the surgeon's panel.

Direct-reading differential pressure gauges

8.165 The differential pressure across the terminal filter(s) should be measured to confirm the accuracy of the indicated reading of any gauge.

Control functions

8.166 The operation of all control functions provided on the surgeon's panel should be proved for conformity with the design specification.

8.167 If an auxiliary panel has been fitted then its interlocking with the main surgeon's panel control functions must be proved to conform to the design specification.

Panel indicator lights

8.168 The panel indicator lights should illuminate as appropriate when the control functions are selected or warning levels are reached

BEMS interface

8.169 The operation, monitoring and alarm functions must be proved to conform to those set out in the design specification.

UCV theatre microbiological tests

8.170 There is little value in performing microbiological sampling in a new theatre supplied with ultra-clean ventilation. The foregoing filter challenge tests, air velocity measurements and entrainment test should have proved that the system operates satisfactorily and achieves the contracted level of performance. The HEPA filters will remove bacteria-sized particles from the air supplied through the UCV terminal. Therefore there will be an insignificant number of bacterial and/or fungal CFUs present until the Theatre is actually used.

8.171 Once the theatre has been taken into use, microbial sampling during a surgical procedure should help to confirm the satisfactory performance of the system and discipline of the users. Before commencing bacteriological testing, the room and its ventilation system should have achieved a steady state condition: (see also Paragraph 8.74)

8.172 The installation should be tested during surgical procedure at intervals between the time of the first incision and final closure of the wound. On average, the air sampled within 300mm of the wound should not contain more than 10 CFU/m^3.

UCV validation report

8.173 Following validation a full report detailing the findings should be produced. The report shall conclude with a clear statement as to whether the UCV theatre suite achieved or did not achieve the standard set out above.

8.174 A copy of the report should be lodged with the following groups:

- operating department;
- infection control;
- estates and facilities.

Appendix 1: Recommended air-change rates

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
General ward	S / N	6	-	G4	30	18-28	
Communal ward toilet	E	10	-ve	-	40	-	
Single room	S / E / N	6	0 or –ve	G4	30	18-28	
Single room WC	E	3	-ve	-	40	-	
Clean utility	S	6	+ve	G4	40	18-28	
Dirty utility	E	6	-ve	-	40	-	
Ward Isolation room	-	-	-	-	-	-	See SHPN 4; Supplement 1
Infectious disease Iso room	E	10	-5	G4	30	18-28	Extract filtration may be required
Neutropenic patient ward	S	10	+10	H12	30	18-28	
Critical Care Areas	S	10	+10	F7	30	*18-25*	Isolation room may be –ve press
Birthing Room	S & E	15	-ve	G4	40	*18-25*	Provide clean air-flow path
SCBU	S	6	+ve	F7	30	*18-25*	Isolation room may be –ve press
Preparation room (Lay-up)	S	>25	35	F7*	40	*18-25*	*H12 if a lay-up for a UCV Theatre
Preparation room / bay sterile pack store	S	10	25	F7	40	*18-25*	*50NR if a bay in a UCV Theatre
Operating theatre	S	25	25	F7	40	*18-25*	
UCV Operating theatre	S	25*	25	H12	40	*18-25*	Fresh air rate; excludes re-circulation
Anaesthetic room	S & E	15	>10	F7	40	*18-25*	Provide clean air-flow path
Theatre Sluice/dirty utility	E	>20	-5	-	40	-	
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path

Table A1

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
Recovery room	S & E	15	0	F7	35	*18-25*	Provide clean air-flow path
Cardiac catheterisation lab	S	15	+ve	F7	40	*18-22*	
Endoscopy room	S	15	+ve	F7	40	*18-25*	
Endoscopy cleaning	E	>10	-ve	-	40	-	
Day case theatre	S	15	+ve	F7	40	*18-25*	
Treatment room	S	10	+ve	F7	35	*18-25*	
Pharmacy aseptic suite	S	20	#	H14	-	*18-22*	# See EGGMP (Orange guide) a
Cat 3 or 4 containment room	#	>20	#	H14*	-	*18-22*	# See ACDP guide; *Filter in extract
Post mortem room	S & E	S = 10 E = 12	-ve	G4	35	*18–22*	Provide clean air-flow path
Specimen store	E	-	-ve	-	-	-	Fan accessible from outside of store

Table A1 continued

Notes: 18°C-22°C indicates the range over which the temperature may float

18°C-22°C indicates the range over which the temperature should be capable of being controlled

S = supply N = natural ventilation

E = extract [a] – European guidelines on good manufacturing practice published by the Medicines and Healthcare products Regulatory Authority (MHRA)

Appendix 2: Hierarchy of cleanliness

			Air-flow rate for bacterial contaminant dilution	
Class	**Room**	**Nominal pressure (Pa) a**	**Flow in or supply m^3/s**	**Flow out or extract m^3/s**
Sterile	Preparation room (a) lay-up (b) sterile pack store Operating room Scrub bay b	 35 25 25 25	See standard schemes in Appendix 3 for recommended design values	
Clean	Sterile pack bulk store Anaesthetic room c Scrub room	 +ve 14 c 14	6 ac/h The greater of 15 ac/hr or 0.15 -	- The greater of 15 ac/hr or 0.15 0.10
Transitional	Recovery room Clean corridor General access corridor Changing rooms Plaster room	3 0 0 3 3	15 ac/hr d e e 7 ac/hr 7 ac/hr	15 ac/hr d 7 ac/hr 7 ac/hr 7 ac/hr 7 ac/hr
Dirty	Service corridor Disposal room	0 -5 or 0	- -	f 0.41 or 0.10

Table A2

Notes (applicable to Table A2):

a. Nominal room pressures are given to facilitate setting up of pressure relief dampers, the calculation process, and the sizing of transfer devices. In practice, the resultant pressures are not critical, provided the desired airflow rates and movement are achieved.

b. An open or semi-open bay is considered to be part of the operating room; provided air movement is satisfactory, no specific extract is required. However if the layout means that air movement is poor, a local extract may be required to control local condensation on the building surfaces, which can result in mould growth.

c. For design purposes, anaesthetic should be assumed to be at 14Pa. When commissioning 10Pa is considered suitable.

d. 15 ac/hr are considered necessary for the control of anaesthetic gas pollution.

e. Supply airflow rate necessary to make up 7 ac/hr after taking into account secondary air from cleaner areas.

f. No dilution requirement. Temperature control requirements only.

Type	Pressure difference - Pa						
	5	10	15	20	25	30	40
Single door (CDB Size 2.4.3.2.6.)	.03	.05	.06	.06	.07	.07	.08
Double door (CDB)	.04	.08	.10	.11	.12	.13	.14
High permanent length of 3mm gap	.004	.008	.010	.011	.012	.012	.013

Table A3: Leakage flows in m^3/s through closed door gaps

Note: CDB = Component Data Base

It should be noted that many doors are now fitted with cold smoke seals as standard. These will significantly reduce the door leakage rate when new and undamaged. It is therefore recommended that provision for the design leakage is factored into the sizing of the appropriate transfer grille or pressure stabiliser. Failure to do this will result in air gap whistles and doors being held partially open by air pressure.

Factory-assembled door-sets with a steel frame and pre-hung leaves have become common. There is effectively no leakage across these doors when closed. Therefore, when this type of door assembly is fitted, the door leakage can be ignored and the design airflow into the room reduced accordingly. The design airflow would then become that required either (i) for open door protection, or (ii) to achieve the specified air-change rate - whichever is the greater.

Room class		Dirty	Transitional	Clean	Sterile
Sterile	Hatch	0.3	0.24	0.18	
	Single door	0.47	0.39	0.28	0 or 0.28 a
	Double door	0.95	0.75	0.57	0 or 0.57 a
Clean	Single door	0.39	0.28	0 or 0.28 a	
	Double door	0.75	0.57	0 or 0.57 a	
Transitional	Single door	0.28	0 or 0.28 a		
	Double door	0.57	0 or 0.57 a		
Dirty	Single door	0	Open single door = 0.80m x 2.01m high		
	Double door	0	Open double door = 1.80m x 2.01m high		

Table A4: Recommended air flow rates in m^3/s through a doorway between rooms of different cleanliness to control cross-contamination

Designer's Notes:

a. The degree of protection required at an open doorway between rooms is dependent upon the degree of difference in cleanliness between them.

b. Flow rate required between rooms within the same class tends to zero as class reduces.

c. If two rooms are of equal cleanliness, no flow is required (in practice there will be an interchange in either direction) and the design of the air movement will assume zero air-flow. In certain cases, however, interchange is not permitted and protection airflow of 0.28 is assumed in the design, for example, in the case of a preparation room used as a "lay up".

		Effect on other rooms	
Door open between	Resultant pressure in these rooms (Pa)	Room	Pressure (Pa)
Operating room and corridor or Scrub bay and corridor	0	Anaesthetic Preparation – lay up Disposal Preparation – sterile pack store	0 12 -6 5
Operating room and anaesthetic room (or other series room with double doors)	17	Preparation – lay up Disposal Preparation – sterile pack store	26 -9 22
Operating room and disposal room or Operating room and preparation room	25	No change	
Anaesthetic room and corridor (or other series room with double doors)	0	Preparation – lay-up Disposal Operating room Preparation – sterile pack store	30 -6 20 25
Preparation room – corridor Disposal room & corridor	0	No change	
Disposal room & outer corridor	0	No change	

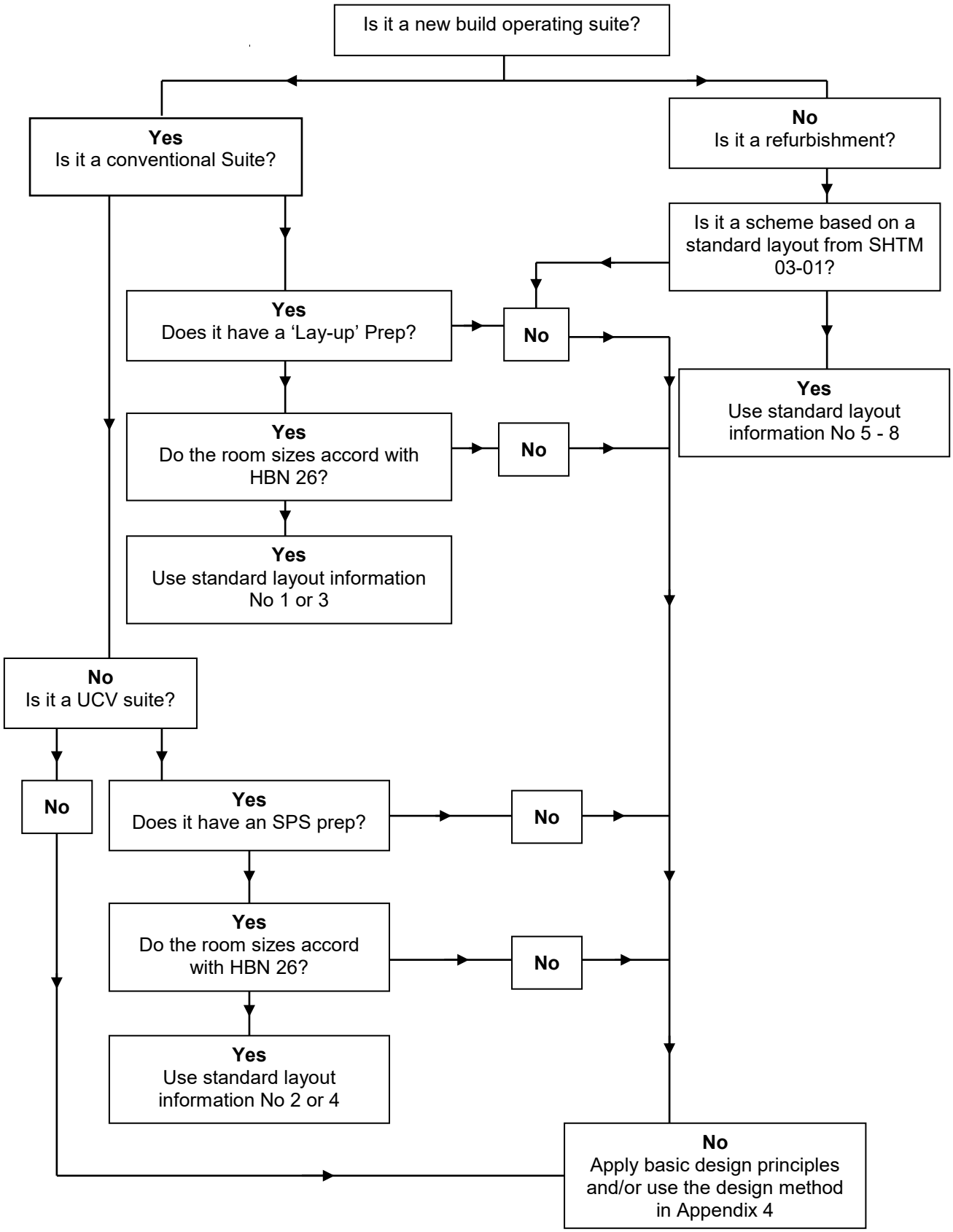
Table A5: Typical pressures in an operating suite when a given door is open

Notes: 1. The room differential pressure protects against reverse flows when the door is closed.

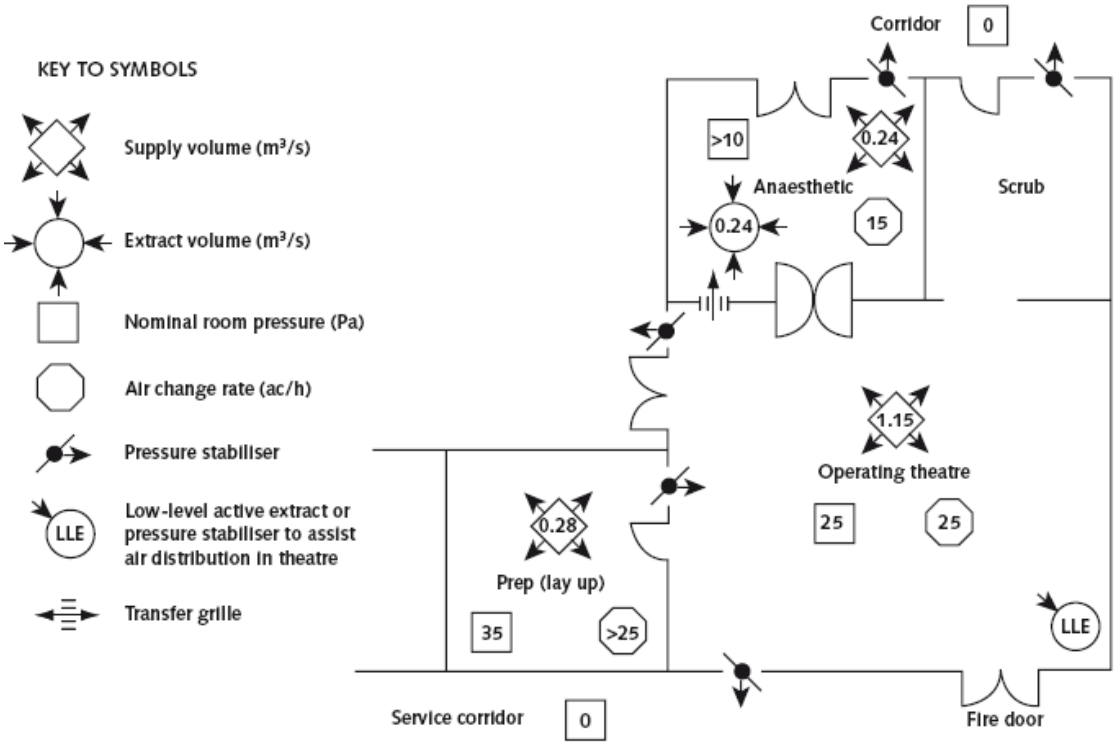
2. The flow of air through a doorway protects against reverse airflow when the door is open.

3. Pressure stabilisers control flow and ensure a known air-flow path between rooms when doors are closed and reduce back-flow between rooms when doors to other rooms are open.

Appendix 3: Operating suite design logic



New Standard Layout N° 1 - Suitable for a typical conventional theatre suite (Room sizes as specified in HBN 26)



Room	Size m³ Derived from HBN26	Air-Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15
Anaesthetic	57	15	>10	0.24
Lay-Up-Prep	36	>25	35	0.28**
Scrub	*	-	25	-

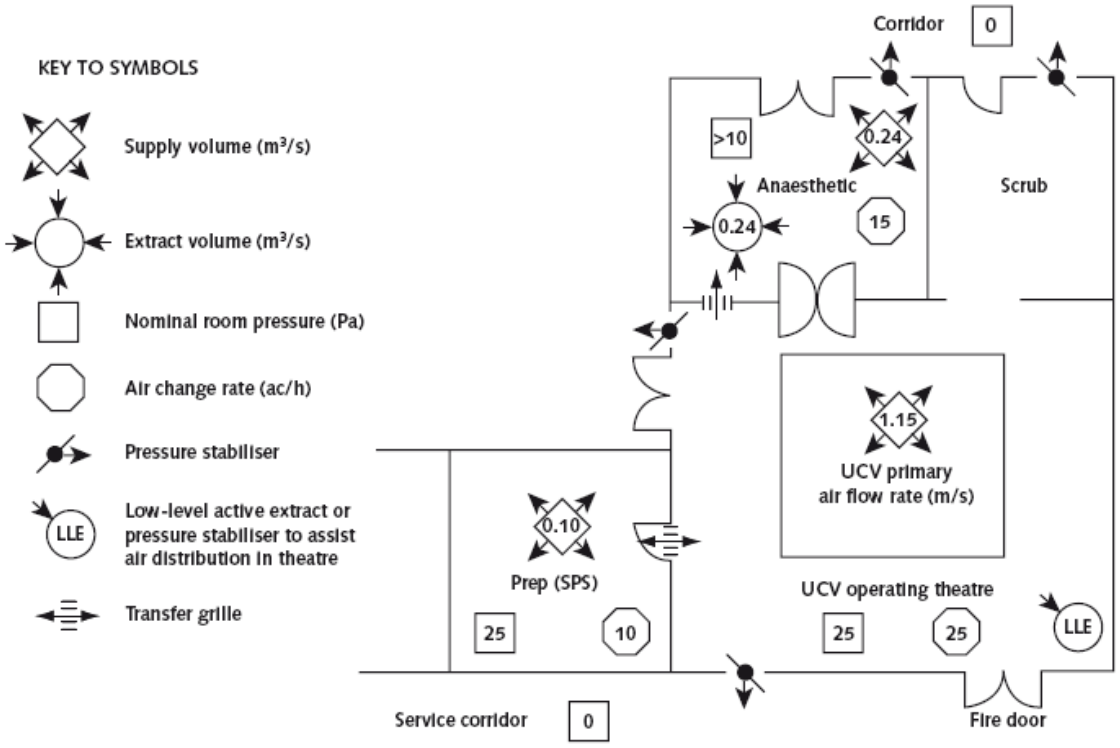
*This is a separate scrub and is not considered as being part of the theatre volume.

**Interchange is not permitted between the theatre and lay-up prep; therefore an airflow protection of 0.28 + 0.06 closed-door airflow is required as a minimum.

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilisers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 2 - Suitable for a typical UCV theatre suite (Room sizes as specified in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15**
Anaesthetic	57	15	>10	0.24
Sterile Prep	36	25	25	0.10
Scrub	*	-	25	-

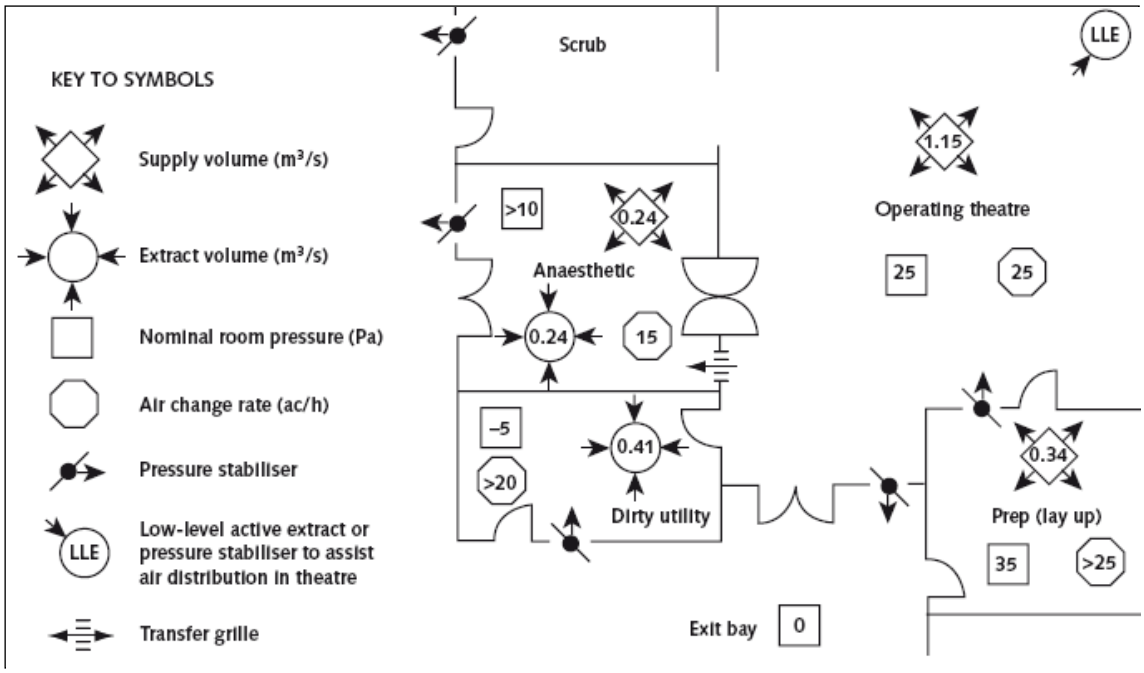
*Separate scrub and not considered as part of theatre volume

**Primary Fresh air Volume Only

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 3 - Suitable for a typical Conventional theatre suite (Layout and room sizes are as illustrated in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15
Anaesthetic	57	15	14	0.24
Lay-Up Prep	36	>25	35	0.34**
Scrub	*	-	25	-
Dirty Utility	36	-	-5	0.41

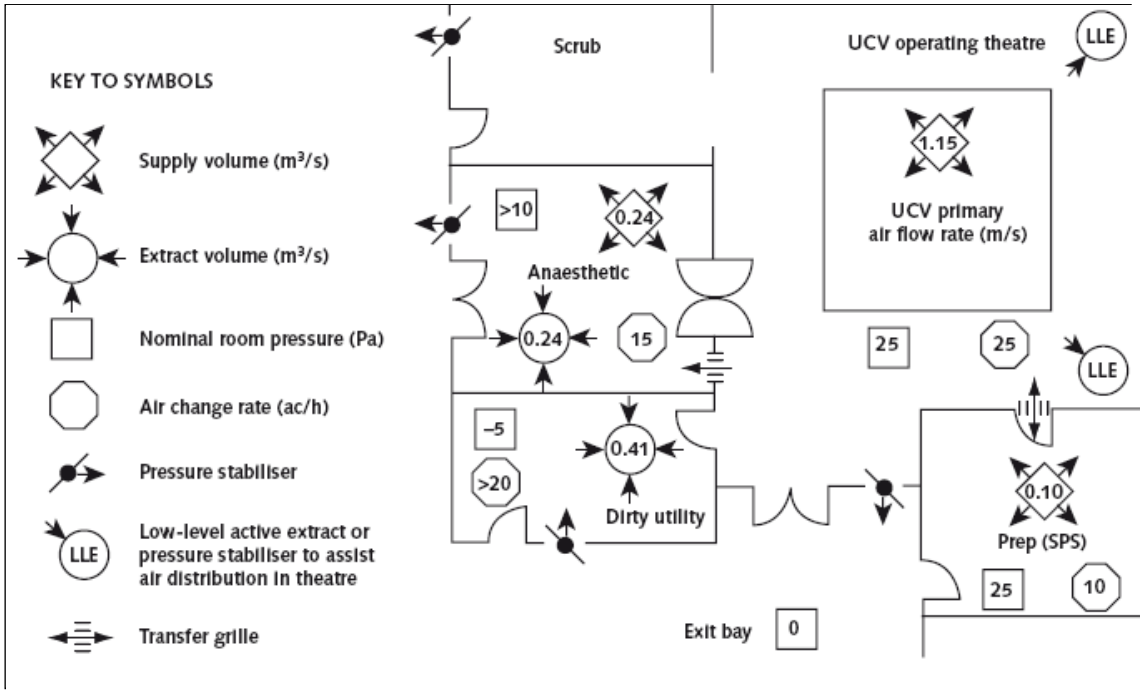
*Separate scrub not considered part of theatre volume.

**Interchange is not permitted between the theatre and lay up prep therefore as Table 4 an airflow protection of 0.28 + 0.06 closed door air flow is required as a minimum.

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 4 - Suitable for a typical UCV theatre suite (Layout and room sizes are as illustrated in HBN 26)



Room	Size m³ Derived from HBN26	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	165	25	25	1.15**
Anaesthetic	57	15	>10	0.24
Sterile Pack Prep	36	10	25	0.10
Scrub	*	-	25	-
Dirty Utility	36	-	-5	0.41

* Separate scrub not considered part of theatre volume

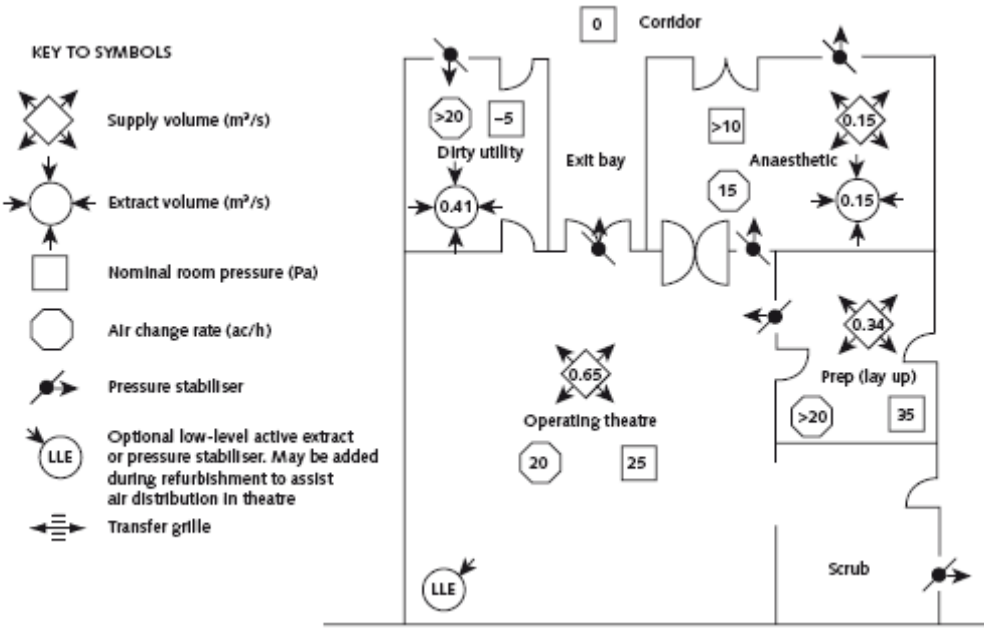
**Primary Fresh air Volume Only

The volume of air to be extracted from the theatre should be determined by subtracting the airflow required for door protection at the exits from the total air entering the theatre space. The balance should be equally divided between the passive or active extract locations.

The extracts within the theatre may be either passive and fitted with pressure stabilizers or active and connected to the extract system. They should be located at low level and positioned to promote the ventilation of all areas of the space.

New standard layout N° 5 - SHTM 2025 Existing standard plan '1b' typical layout for a conventional theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.

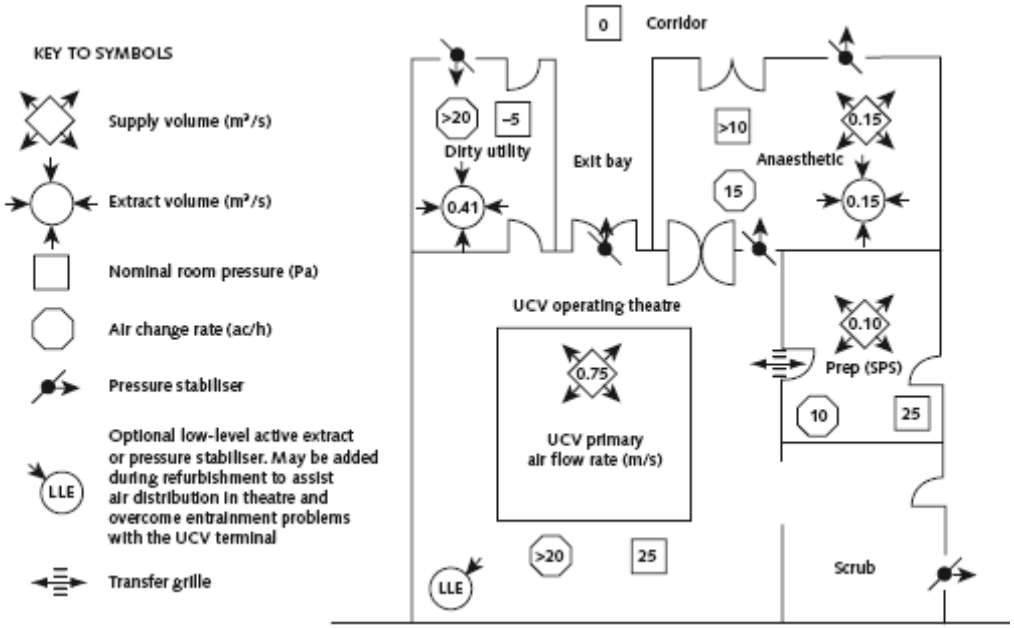


Room	Size m³	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	Existing Theatre Suite to Be measured on site	20	25	0.65
Anaesthetic		15	14	0.15
Lay-Up Prep		-	35	0.34
Scrub		-	25	Included within theatre
Disposal		-	-5	0.41

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor.

Standard layout No 6 - SHTM 2025 Existing standard Plan '1a' Typical layout for a UCV theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.



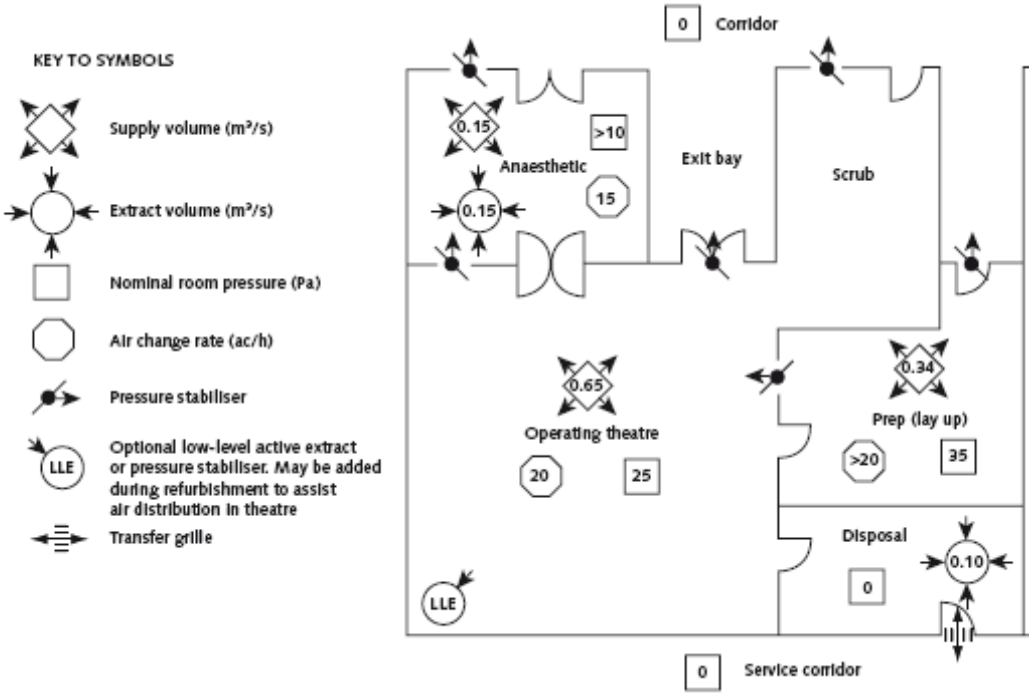
Room	Size m^3	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m^3/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.75*
Anaesthetic		15	>10	0.15
Sterile Pack Prep		10	25	0.1
Scrub		-	25	Included within theatre
Disposal		-	-5	0.41

*Primary fresh airflow volume

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor.

Standard layout N° 7 - SHTM 2025 Existing standard Plan '5b' Typical layout for a conventional theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.

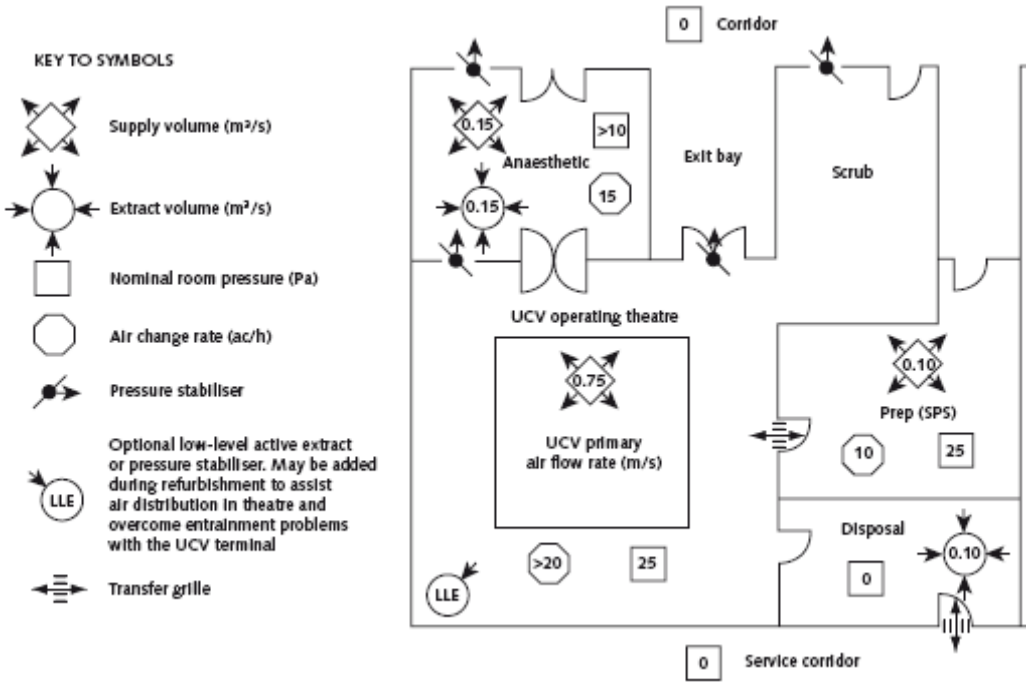


Room	Size m³	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.65
Anaesthetic		15	>10	0.15
Lay-Up Prep		>20	35	0.34
Scrub		-	25	Included within theatre
Disposal		-	0	0.1

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor. Alternatively the disposal room could be omitted and replaced with a disposal hatch between the theatre and corridor.

Standard layout N° 8 - SHTM 2025 Existing standard Plan '5a' Typical layout for a UCV theatre suite

This layout and data is for historical purposes only. The information is to be used for the evaluating of existing systems or rebalancing following ventilation system cleaning.



Room	Size m³	Air Change Rate per hour	Nominal Pressure Pa	Flowrate m³/s
Theatre	Existing Theatre Suite to be measured on site	20	25	0.75*
Anaesthetic		15	>10	0.15
Sterile Prep		10	25	0.1
Scrub		-	25	Included within theatre
Disposal		-	0	0.1

*Primary fresh air-flow volume only

The disposal layout detailed will remain the same should a hatch be utilised instead of a door onto the outer corridor. Alternatively the disposal room could be omitted and replaced with a disposal hatch between the theatre and corridor.

Appendix 4: Design of air-movement control schemes for operating theatres.

General

A4.1 Standard operating suite design solutions are given in Appendix 3. If these standard solutions cannot be used, the following procedure should be adopted, which will result in an acceptable design. Note that the method employed can equally be used to provide a design solution to a ventilated suite of rooms for any application.

A4.2 The method is concerned with the calculation of airflow rates to ensure that correct air movement occurs between rooms when any one door is open. Under most circumstances, the air quantities required for air-movement control will approximate to those for either temperature control or bacterial contaminant dilution. This flow rate is sufficient to control the effects of any slight reverse flows occurring when a door is opened.

A4.3 The progression through the design procedure is shown in the airflow design procedure chart (Figure A4/3) and is supported by worksheets WS1 to WS7 described in Paragraph A4.4. It is recommended that a plan of the suite and an airflow network be made (Figure A4/2) to collate all information. Flow rates, air-transfer devices etc should be entered as required. The remainder of this Appendix may be treated as reference data to assist in the various steps. The following symbols are used:

S_S – supply airflow rate for summer temperature control;

S_W – supply airflow rate for winter temperature control;

S_D – supply airflow rate for dilution of bacterial contaminants;

S_L – supply airflow rate for heat loss;

S_G – supply airflow rate for heat gain;

E_D – extract airflow rate for dilution of bacterial contaminants;

S_F – final supply airflow rates;

E_F – final extract flow rates;

S_{AMC} – air-supply flow rate for air-movement control;

E_{AMC} – air-extract flow for air-movement control;

L_{OUT} – leakage airflow rate outward;

L_{IN} – leakage airflow rate inward;

$\sum_{OUT}$ – total airflow rate outward;

$\sum_{IN}$ – total airflow rate inward.

A4.4 To simplify the procedure, standard worksheets (WS1 to WS7) have been devised. For each operating suite, a set is required comprising one each of WS1, WS3, WS5, WS6a, WS6b and WS7, one WS4 for each corridor and one WS2 to cover each peripheral room. WS2 has five versions:

- WS2a single flow;
- WS2b parallel/series multi-flow;
- WS2c parallel multi-flow or series multi-flow (unbalanced);
- WS2d series multi-flow (balanced); and
- WS2e bay (semi-open).

Peripheral room type

A4.5 The rooms in the operating suite other than the operating room and corridor are referred to as peripheral rooms. Peripheral rooms have been classified according to the flows in and out. These room classifications are defined below in Paragraphs A4.6 – A4.11.

Single flow

A4.6 This is a room with only one door and a net surplus of supply or extract air.

Parallel multi-flow

A4.7 This is a room with two or more doors through each of which the air-flows either outwards (high-pressure) or inwards (low-pressure) (for example the Prep (lay-up) in standard layout 5).

Parallel/series multi-flow

A4.8 This is a room having a net surplus of supply or extract and with two or more doors. One or more doors will be to an area of equal cleanliness and need not be protected; hence, the flow may vary between inwards and outwards, the remaining door being to an area of greater or lesser cleanliness (for example the Prep (SPS) in standard layout 6).

Series multi-flow (unbalanced)

A4.9 This is a room having a net surplus of supply or extract and with two or more doors. Air flows inwards through one or more doors and outwards through one or more doors.

Series multi-flow (balanced)

A4.10 This is a room as in Paragraph A4.9 above, but having either no mechanical ventilation or no net surplus of supply or extract. (for example an anaesthetic room).

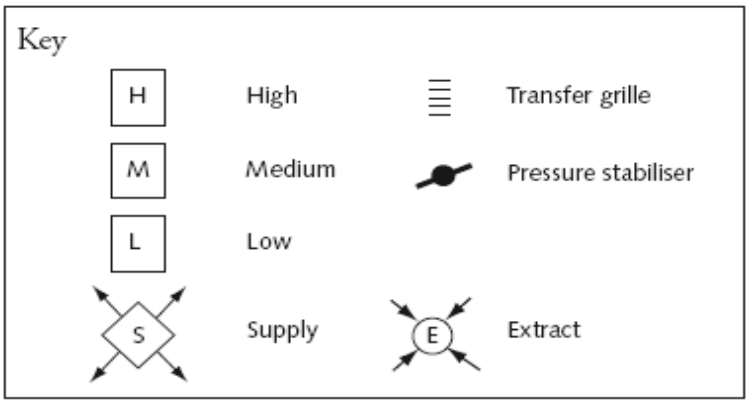
Bay

A4.11 A room that has a permanent opening to the operating room may be considered as a bay off the latter (for example a scrub). Two categories exist:

- open bay – the opening is larger than a normal single door opening. The bay may be considered as part of the main room;
- semi-open bay – the opening is no larger than a normal single door opening. In this case it is possible to protect the bay from the main room by provision of air supply or extract in the bay, or by passing air to or from another area.

Air-movement control in peripheral rooms

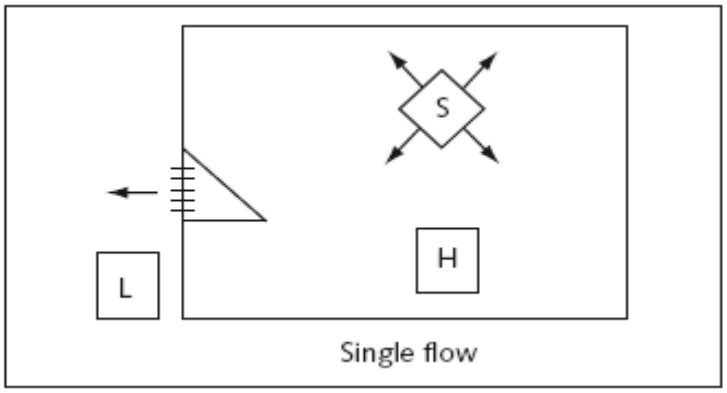
A4.12 For the design of air-movement control, two types of air-transfer device are considered. These are transfer grilles and pressure stabilisers. Each has a particular field of application within the design, as described in Paragraphs A4.34 – A4.43. Air movement is controlled in each of the different room types described in Paragraphs A4.13 – A4.31.



Note: This key applies to each diagram in A4.13 - A4.27.

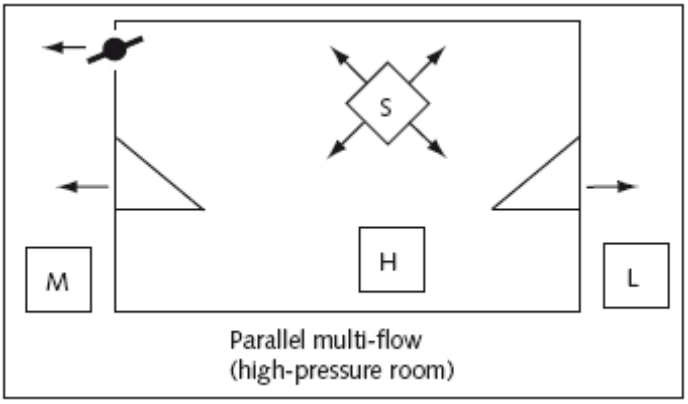
Single flow rooms

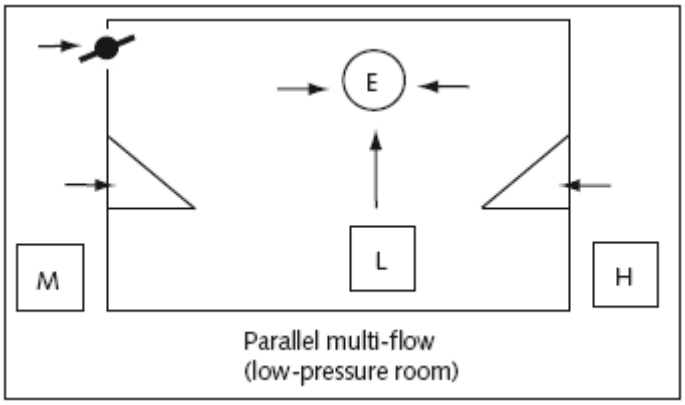
A4.13 An appropriately sized transfer grille should be located in or adjacent to the door of each single flow room to relieve the pressure differences across the door when closed.



Parallel multi-flow rooms

A4.14 The pressure difference across the closed doors must be relieved, but transfer grilles are not appropriate where two doors lead to areas of different pressures, because reverse flow could occur when the other door is open. For this reason, pressure stabilisers are used.



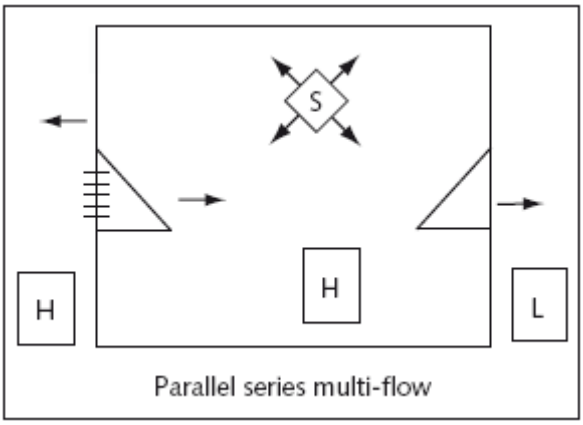


A4.15 These rooms will be either high-pressure or low-pressure with respect to the adjacent areas (see preparation lay-up room and disposal room, respectively, in standard layout 5). The pressure-relief damper is always situated between the room and area, which results in the smaller differential pressure to ensure best use of air.

A4.16 Just as reverse flow can occur if transfer grilles are used, it can similarly occur via door gaps when the other door is opened. It is not possible to avoid this, except by using air locks, but due to the low flow rates and short durations involved, this is not considered to be of importance.

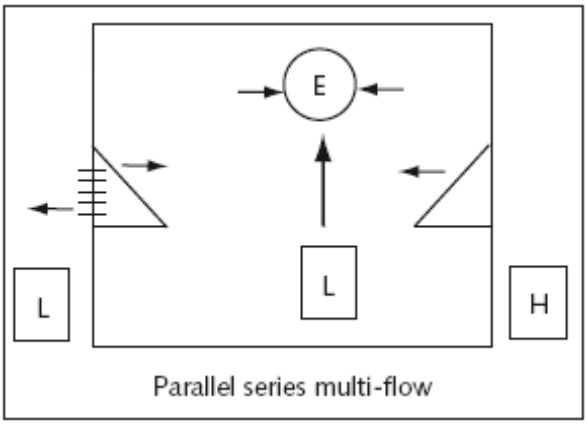
Parallel-series multi-flow rooms

A4.17 These rooms are similar to those in Paragraph A4.14 above, but because the room is of equal cleanliness to one of the adjacent rooms the nominal pressures will be equal and air may flow through the adjoining doorway in either direction. (for example the Prep (SPS) in standard layout 6).



Parallel series multi-flow

A4.18 Where the nominal room pressure equals that of the higher-pressure adjacent room, the best use of air is by supplying air required for bacterial dilution only and allowing this to exhaust via a transfer grille to the area of equal cleanliness. The doorway to the lower pressure area is protected by the combination of the supply air and the air that will flow inwards through the transfer grille from the area of equal cleanliness.

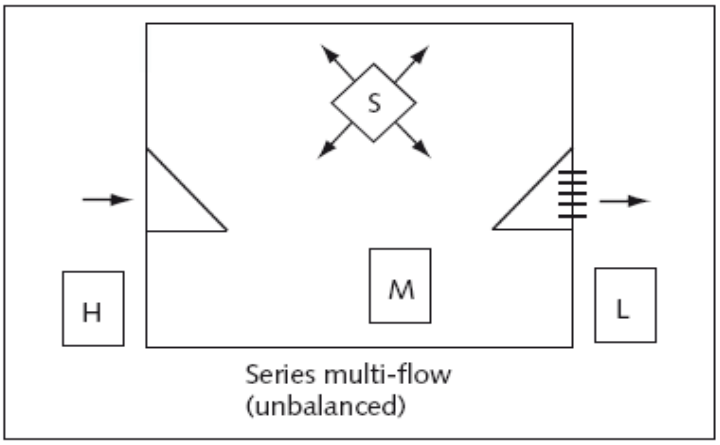


Parallel series multi-flow

A4.19 Conversely, where the nominal pressure equals that of the lower-pressure adjacent room, extract ventilation and a transfer grille to the lower pressure adjacent room should be provided. (for example, the disposal room in standard layout 8).

Series multi-flow (unbalanced)

A4.20 These rooms are somewhat similar to those in Paragraph A4.15 above, but because the pressure lies between that of the rooms on either side, the back-flow problem does not exist.



Series multi-flow (unbalanced)

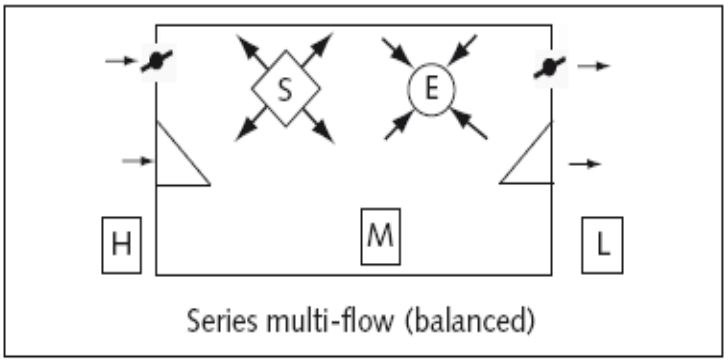
A4.21 Where the room has a net surplus of mechanical supply air, a transfer grille should be located in or adjacent to the door through which air flows outwards, and the mechanical supply flow rate to the room should be chosen to give protection when this door is open.

A4.22 Where the room has a net surplus of mechanical extract air, a transfer grille should be located adjacent to the door through which the air flows inwards, and the mechanical extract flow rate to the room should be chosen to give protection when this door is open.

A4.23 The grille must be sized for the protection requirement of the opposing door when open. When the room on the high-pressure side depressurises, there is a possibility of back-flow through gaps around the door, but this problem may be ignored.

Series multi-flow (balanced)

A4.24 In these rooms, a transfer device adjacent to each doorway is required in order to provide a flow path for the air required to protect the opposing door when opened.



Series multi-flow (balanced)

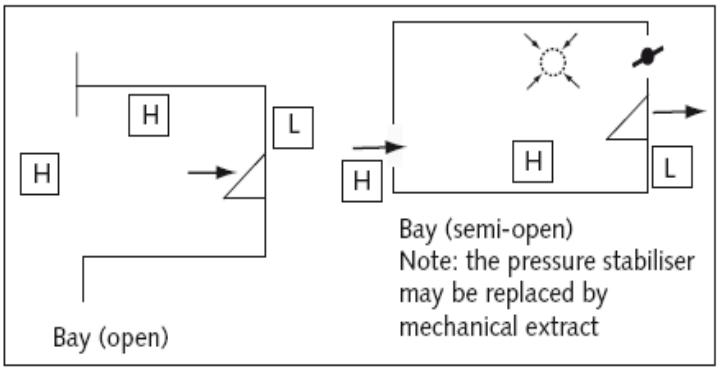
A4.25 These transfer devices will normally be pressure stabilisers, although transfer grilles may be used where a large amount of excess air is to be exhausted from the operating room when all doors are closed. (for example, anaesthetic rooms).

A4.26 The calculation procedure is to assume that pressure stabilisers are being used; then (if there is sufficient excess air) change to transfer grilles as described in Paragraph A4.50.

Bay

Open bay

A4.27 A bay of the open type (for example scrub-up) is considered to be part of the operating room. Provided air movement is satisfactory, no specific extract is required.



Semi-open bay

A4.28 In a bay of the semi-open type, protection of one area from the other is possible. (For example scrub-up).

A4.29 As stated previously, the need for protection between operating room and scrub-room is not very great. Better use of air can therefore be achieved in this case by installing a pressure stabiliser between the scrub-room and clean corridor. This will allow a flow of air through the scrub-room at all times, except when a door is opened elsewhere in the suite. The pressure stabiliser will then close and the air will be diverted to the other door. When it is considered necessary to protect the scrub-room at all times, either a transfer grille to the corridor or mechanical extract in the scrub-room should be provided.

Operating room

A4.30 Once the peripheral rooms have been considered, the operating room requirements may then be decided and the supply flow rate required for air-movement control calculated. This flow rate should be such that, with any one door open, the correct air movement directions are maintained. There will be one door in the suite that will require the largest supply flow rate to the operating room for protection when open. This is called the “key door” and is discussed separately in Paragraph A4.33. Use of this concept avoids repetitive

calculations for each door in turn. Having established the required supply flow rate, a relief route must be provided to the clean corridor for any excess air when the doors are closed. This would be via transfer grilles or pressure stabilisers through a series-flow room or via pressure stabilisers to the clean corridor directly.

Corridors

A4.31 All surplus air from the suite, except that lost through structure leakage and any passing to the outer corridor, will arrive in the patient/staff corridor. Should this air be insufficient to achieve the required air-change rate (see Appendices 1 and 2), some additional air supply should be provided. (The air balance should take account of structural leakage.)

Door opening

A4.32 Whereas the resulting pressures are dependent on ductwork layout, room relationships and characteristics of the fan, the generalisations shown in Appendix 2 can be used to estimate the change in room pressure when a door is opened.

A4.33 The “key door” will be the open double door which leaves the operating room at the highest pressure, and/or requires the largest air flow. This should be determined using the procedure in worksheet WS3.

Transfer grilles

A4.34 These may be used to limit the pressure differences across the closed door of a single-flow room or, in some instances, for protection of a series-flow or parallel-series-flow room. They allow airflow in both directions and may not be suitable for all applications.

A4.35 The free area of a grille is calculated from the following equation:

$$A = \frac{Q}{0.84\sqrt{\Delta P}}$$

where:

A is free area (m^2)

Q is flow rate (m^3/s)

P is pressure difference (Pa).

A4.36 The flow through a grille at a different pressure may be found from the following equation:

$$Q_2 = Q_1\sqrt{\frac{\Delta P_1}{\Delta P_2}}$$

where:

Q_1 and P_1 are original flow and differential pressure

Q_2 and P_2 are new flow and differential pressure.

A4.37 The transfer grille may be replaced by carefully proportioned door undercuts of the equivalent free area.

A4.38 The function of the transfer grille is to provide a means of airflow control by which the volume and pressure loss can be established. If a grille is used, it should have an easily removable core to facilitate cleaning.

Pressure-relief dampers

A4.39 The functions of a pressure-relief damper are now carried out by pressure stabilisers. Accordingly, all further mention of them has been removed from this document.

Pressure stabilisers

A4.40 Pressure stabilisers can be adjusted to hold the pressure constant over a wide range of flow rates. They are used where requirements exist for accurate room-pressure control or rapid shut-off on pressure fall.

A4.41 The installation of a grille or baffle in association with a stabiliser will alter the operating characteristics. It is recommended that a location be chosen to avoid the need for visual screening, for example, at high level. The location should be chosen to minimise the likelihood of damage.

A4.42 The stabilisers used should be virtually silent in operation, adjustable on site, maintenance-free and of a type that cannot be wrongly inserted. They should not be used in external walls or where the pressure difference is less than 5 Pa. The required size of a pressure stabiliser is dependent on the design pressure difference across it and flow rate through it. The manufacturer should provide data relating pressure difference to mean velocity (or flow rate per unit area). From this, the required area can be calculated and then rounded-up to the nearest size manufactured or nearest combination of smaller sizes.

A4.43 It is sometimes possible to arrange for a pressure stabiliser to perform two tasks. In an anaesthetic room, for example, the two pressure stabilisers may be made to pass the open door protection air, and also control the operating and anaesthetic room pressures with the door closed. To achieve this, the stabilisers are sized for the flow rate required with one of the doors open, but

the pressure setting is adjusted to be the value required with the doors closed. This is shown in Figure A4/1.

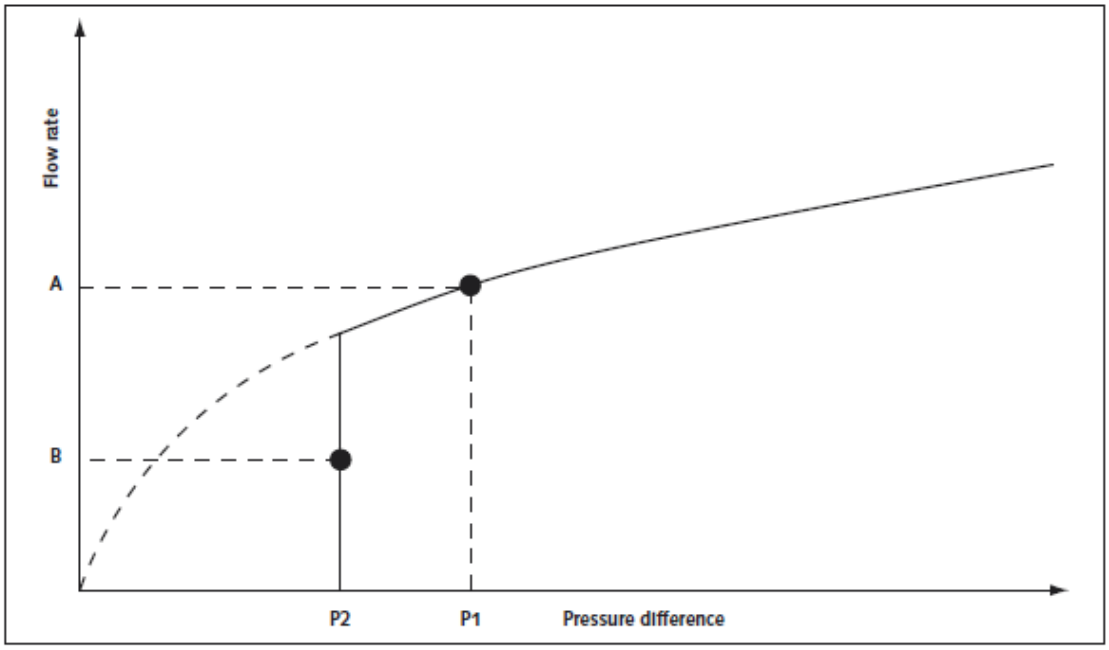


Figure A4/1

Door leakage flows

A4.44 For an air-movement control scheme to work satisfactorily, it is essential that the estimates of door-gap leakage made at the design stage are closely related to those which are achieved in practice. The calculation of gap-flows is complicated by the fact that such flows generally fall into the transition region between laminar and turbulent flow and hence do not follow the normal flow equations. The gaps assumed are 4mm along the bottom, 3mm at the top and sides, and 2mm between double leaves. Doors should not have wider gaps than these. Tighter gaps would result in lower flow-rate requirements and hence lower fan power, but care should be taken to ensure that all doors in the suite have similar gap dimensions. It may be possible to ignore the door leakage and so reduce the airflow requirement (see the notes in Appendix 3).

Room temperature estimation

A4.45 The air-flow rate required to prevent back-flow through an open door is dependent on the temperature difference across the door. The design figures shown in Appendix 3 are based on the temperature differences that will normally occur in practice, assuming heat gains and losses in accordance with Appendix 2.

A4.46 In accordance with the airflow design process, the temperature differences across the doors of all rooms classed as “sterile” is calculated. Worksheet WS6 is recommended for the calculations, using the following criteria:

- assume that the operating room is being controlled at 20°C and calculate the incoming air-supply temperature as shown on worksheet WS6;

- the calculation should be repeated for both summer and winter conditions, with an operation in progress;
- assume all doors are closed;
- use the room supply flow rates from WS1;
- use the inward air flows through air-transfer devices and closed door leakages from WS2a to WS2e;
- the formula used in worksheet WS6 is as follows:

$$T = \frac{(t_1Q_1 + t_2Q_2 + \cdots + t_nQ_n) + 0.828H}{(Q_1 + Q_2 + \cdots Q_n)}$$

where:

Q = flow rate from source (m^3/s)

t = the temperature of source (°C)

H = the room heat gain (kW).

A4.47 If the evaluated temperature differences between rooms do not exceed 2°C, the solution is satisfactory; otherwise proceed as follows:

- check the assumption on which the heat gains are based;
- take steps to reduce the heat gains;
- if the door is to a corridor, the flow through the open door will be larger than the value given in Appendix 2. Calculate on WS3, assuming it is the “key door” with door-flow unknown, and the supply as known;
- if the door leads to a room with mechanical supply, install a trimmer heater in the supply to the room controlled by either a differential thermostat or a thermostat slaved to the operating room thermostat to ensure that T is minimized.
- If the door leads to a room with no mechanical supply, increase the door protection flow as follows:

$$Q_{new} = Q_{old}\left[\frac{\Delta T + 1}{2}\right]$$

A4.48 These options should be considered in the above order, and the first three should be investigated thoroughly before proceeding to the latter two. The mechanical supply may need to be increased in order to achieve the desired air-change rates.

Relief of excess air from operating room when all doors are closed

A4.49 As the mechanical supply to the operating room is sized to provide an appropriate flow outward through any door that is opened, it follows that when all doors are closed, there will be more air supplied to the operating room than

can exit from it via leaks etc. This “excess” air can be relieved by either of the two methods described in Paragraphs A4.50 - 4.54.

By transfer devices via the anaesthetic room

A4.50 For door protection, the transfer devices in the anaesthetic room are typically designed to pass 0.47 m^3/s at a differential pressure of 14 Pa. When the doors are closed, the differential pressure will change to 11 Pa between theatre and anaesthetic room, and 14 Pa between anaesthetic room and corridor; the volume of air passed by the transfer devices will be modified as shown in the following formula:

$$Q = Q_1\left(\frac{\Delta P_1}{\Delta P_2}\right)^{1/2}$$

$$= 0.47\left(\frac{11}{14}\right)^{1/2}$$

$$= 0.42\ m^3/s$$

where:

Q = “excess” air to be vented with doors closed;

Q_1 = air-flow required for door protection through transfer device;

ΔP_1 = nominal differential pressure with door to operating room closed and door to corridor closed;

ΔP_2 = nominal differential pressure between either the anaesthetic room and corridor when the operating room door is open, or the anaesthetic room and operating room when the corridor is open. This differential pressure is used when selecting size of both devices.

A4.51 If the “excess” air is less than 0.42 m^3/s, a pressure stabiliser is required to ensure that the correct protection airflow is available to pass through the door.

A4.52 If the “excess” air is greater than 0.42 m^3/s, a transfer grille is acceptable because at all times the airflow will exceed the flow required for door protection.

By pressure stabilisers to the corridor

A4.53 If it is undesirable to pass operating room air through the anaesthetic room, it may be passed directly to a corridor via a separate pressure stabiliser.

A4.54 If there is sufficient “excess” air, the transfer grille solution at Paragraph A4.52 should be adopted, as it provides the simplest solution and, once set up, will require no further maintenance. With less excess air, it is recommended that the air be passed through the anaesthetic room via the pressure stabilisers as at Paragraph A4.51, thus keeping the number of pressure stabilisers to a minimum. Both these solutions increase the air-change rate in the anaesthetic

room, but care should be taken to avoid passing excessive amounts through that would cause discomfort to the occupants.

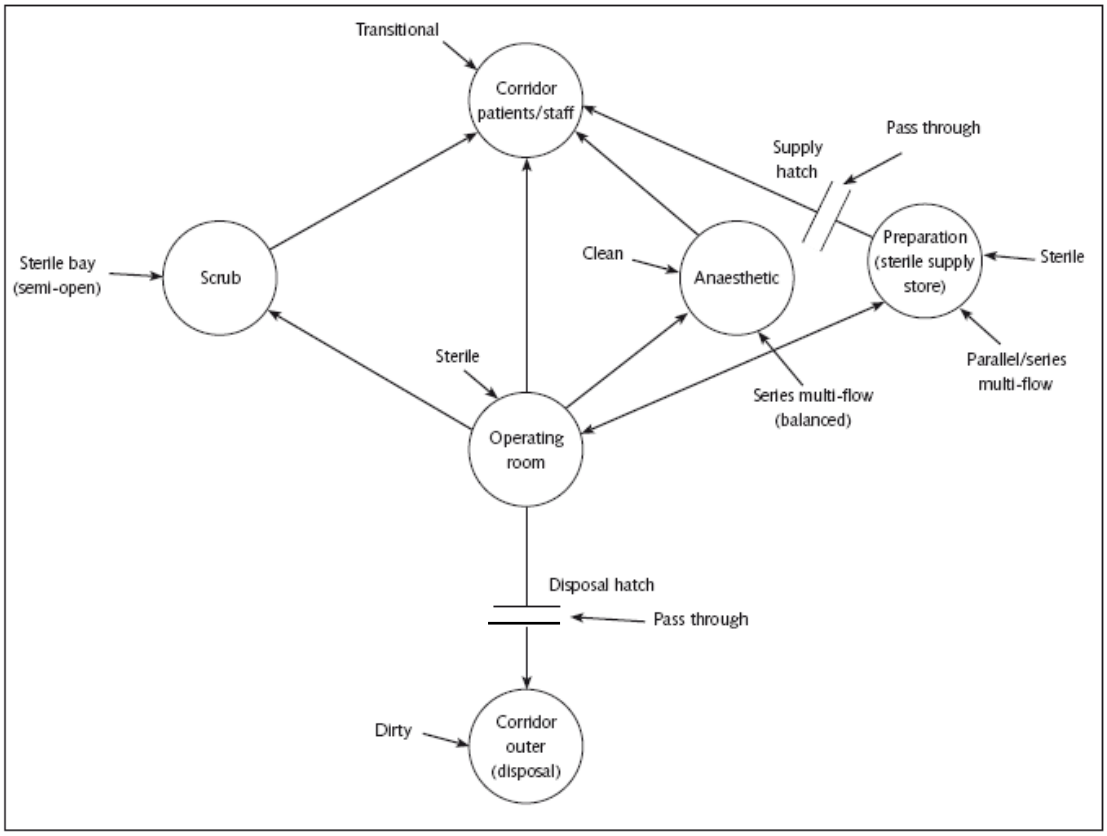
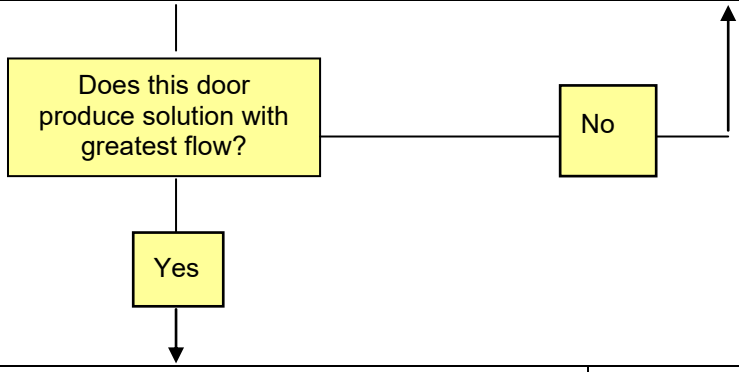
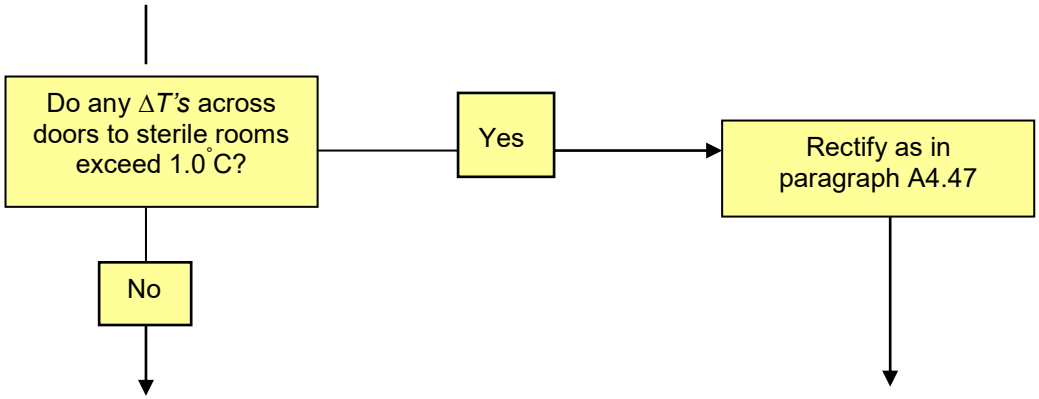


Figure A4/2: An example of an airflow network

Step	Description	Worksheet
1	Show nominal room pressures and air flow directions on the plan of the theatre suite and WS1	WS1
2	Enter heat/loss/gain data and calculate supply airflow rates for temperature control only. Categorise room types e.g. sterile, clean etc.	WS1
3	Enter airflows required for bacterial contamination control or air change rate whichever is the greater, add supply and extract volumes (S_D, E_D) on the plan.	WS1
4	Define peripheral room types, see paragraphs A4.5 - A4.11, and select appropriate worksheets.	Select from WS2a - WS2e
5	Locate air transfer devices, enter details on worksheets and locate on the plan and Figure A4/2	Selected worksheets from WS2a - WS2e
6	For each peripheral room, determine air flows through doors when open and calculate mechanical supply or extract and transfer device flows	As above
7	Select "Key Door" and calculate air supply for operating room	WS3



8	Transfer to WS1 and select final rate S_F and E_F	WS1. WS3
9	Make provision for relief of excess air with doors closed	Selected Worksheets and WS3
10	Calculate supply and extract flow rates for corridor(s)	WS4, WS5
11	Calculate room temperatures (all doors closed) and ΔT's	WS4, WS5



12	Make summary of flows	WS6a and WS6b
13	Size transfer devices, size ductwork, central plant etc	WS7
14	Design ductwork layout, control plant etc	

Figure A4/3: Airflow design procedures

Note: In the following worksheets WS1, WS2a-e, WS3, WS4, WS5, WS6a&b and WS7 it has been necessary to reduce the font size to 8pt instead of the usual 10pt in order to set out the complete tabular information for each within a single page for ease of use.

Calculation sheet for						**Worksheet WS1** **Reference:**
Room Name:						
1. Summer Temperature Control Heat Gain	kW					
2. Acceptable Δt	°C					
3. Air flow rate (S_G) $= \frac{\text{Gain}}{\Delta t \times 1.2}$	m^3/s					
4. Winter Temperature Control Heat Loss	kW					
5. Acceptable Δt	°C					
6. Air flow rate (S_L) $= \frac{\text{Loss}}{\Delta t \times 1.2}$	m^3/s					
7. Dilution of bacterial contaminations Air flow rate	m^3/s					
S_D or E_D						
8. Desired air change rate	ac/hr					
$\frac{\text{AC/hr x room volume } (m^3)}{3600}$	m^3/s					
9. Maximum of S_G, S_L, S_D or E_D or air change rate from Step 8	m^3/s					
10. Air movement control	S m^3/s					
Air flow for air movement control S_{AMC} or E_{AMC} (from WS2, WS3, or WS4)	E m^3/s					
11. Final Supply Flow Rate (S_F)	m^3/s					
12. Final Extract	m^3/s					
13. Total Supply	m^3/s					
14. Total Extract	m^3/s					

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Air Movement Control **Peripheral Room** ..... **type, single flow**	**Worksheet WS2a** **Reference:** **Nominal Pressure:** ..... **Pa**

Consider door to..... open

Flow required through doorway to give protection	Pa	Δt	Air flow, m^3/s Out	In	Remarks
Total					

S_{AMC} $(\sum_{OUT} - \sum_{IN})$ ____ m^3/s

or

E_{AMC} $(\sum_{OUT} - \sum_{IN})$ ____ m^3/s

Transfer S_{AMC} or E_{AMC} to WS1

Consider door to.....closed

Closed door leakage	Pa	Δt	Out	In	Remarks
Total					

Return S_F and E_F to WS1 ____ ____

Flow through transfer grille outward ($S_F - E_F - L_{OUT}$ ____

or

Flow through transfer grille inward ($E_F - S_F - L_{IN}$) ____

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Air movement control **Peripheral Room ..... type, parallel/series multi-flow**	**Worksheet WS2b** **References:** **Nominal Pressure: Pa**

Door from this room to ..... (room of equal cleanliness) is not to be protected.
A transfer grille is located in, or adjacent to, this door.

Consider door to..... open

Room pressure now becomes [ ] or [ ] or [ ] Pa (see Appendix 6)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Mechanical supply or extract (S_F/E_F)					
		Total			

X ($\sum_{OUT} - \sum_{IN}$) [ ] Or Y ($\sum_{IN} - \sum_{OUT}$) [ ]

Transfer grille required:

or from high-pressure zone Flow = *X* [ ] at [ ] ΔPa

to low-pressure zone Flow = *Y*

Size of transfer grille (free area) A1 [ ]

Consider doors and hatch closed – room pressure becomes [ ] Pa (nominal)

Closed door leakage from Appendix 4 (assuming no transfer grille)	Pa	ΔP	Out	In	Remarks
Mechanical supply or extract					
		Total			

Air flow required through transfer grille = IN – OUT = Z' [ ]

or OUT – IN = Z'' [ ]

Transfer grille required flow *Z' or Z''* [ ] @ [ ] ΔP

Size of transfer grille (free area) A2 = [ ]

Select larger of A1 or A2 [ ]

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Air movement control **Peripheral Room ..... type, parallel multi-flow high/low or series multi-flow (unbalanced)**	**Worksheet WS2c** **References:** **Nominal Pressure: Pa**

Consider door from this room to ..... open.

Room pressure now becomes [ ] or [ ] or [ ] Pa (see Appendix 6)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Total					

S_1 ($\sum_{OUT} - \sum_{IN}$) [ ] Or E_1 ($\sum_{IN} - \sum_{OUT}$) [ ]

Consider door from this room to ..... open

Room pressure then becomes [ ] or [ ] or [ ] Pa

			Out	In	Remarks
Flow required through open doorway to give protection					
At above pressures leaks through closed doors are:	Pa	ΔP			
Total					

S_2 ($\sum_{OUT} - \sum_{IN}$) [ ] Or E_2 ($\sum_{IN} - \sum_{OUT}$) [ ]

Consider doors closed. Closed doors leakage from Appendix 4

Door to:	Pa	ΔP	Out	In	Remarks
Total					

Return S_F and E_F to WS1 [ ] [ ]

Flow through transfer grille outward ($S_F - L_{OUT}$) [ ] to .....

or

Flow through transfer grille inward ($E_F - L_{IN}$) [ ] from.....

Transfer grille [ ] Pressure relief damper [ ]

Surveyor (AP(V)/CP(V))..... Date.....

Air movement control **Peripheral Room ..... type, parallel/series multi-flow**	**Worksheet WS2d** **References:** **Nominal Pressure:** **Pa**

Note: In this type of room the supply and extract air flow rates are equal and take no part in the air movement control (AMC)

First, open door to higher pressure area.

Room pressure then becomes [ ] or [ ] or [ ] Pa (see Appendix 2)

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
Total					

Q_1 ($\sum_{IN}$ - $\sum_{OUT}$) [ ] (+ve inwards)

Next, open door to lower pressure area.

Room pressure then becomes [ ] or [ ] or [ ] Pa

			Out	In	Remarks
Flow required through open doorway to give protection					
At above pressures leaks through closed doors are:	Pa	ΔP			
Total					

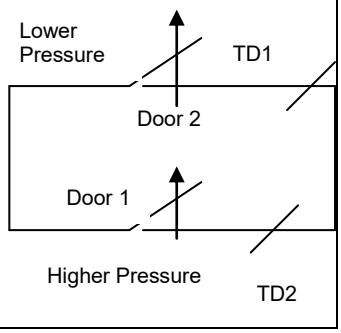
Q_1 ($\sum_{IN}$ - $\sum_{OUT}$) [ ] (+ve inwards)

Flow through transfer device (TD1) to protect Door 1 = Q1 at resultant [ ]

ΔP .....

Flow through transfer device (TD2) to protect Door 2 = Q2 at resultant [ ]

ΔP .....



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Air movement control **Peripheral Room ..... type bay (semi-open)**	**Worksheet WS2e** **References:** **Nominal Pressure:** **Pa**

Note: If the room is of the open bay type (i.e. opening is larger than normal single doorway), then room should be considered part of the main room. No air movement control considerations need then be made, and this sheet can be discarded. Supply and/or extract flow ill be based on air distribution considerations.

Consider permanent opening

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
At above pressures leaks through closed doors	Pa	ΔP			
		Total			

E_{AMC} [ ] or flow outward through transfer ($\sum_{IN} - \sum_{OUT}$) [ ]

Transfer S_{AMC} or E_{AMC} to WS1

Transfer device – transfer grille [ ]

– pressure stabiliser [ ]

Size select transfer device for flow rate [ ] @ ΔP [ ]

Note: A door from the bay is considered with the peripheral room to which it leads or, if it leads to the corridor, it is considered with the main room.

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Air movement control **Operating Room**	**Worksheet WS3** **References:** **Nominal Pressure:** **Pa**

Note: To avoid considering each door open in turn, the "key door" concept is introduced. This is the door which requires the greatest mechanical flow when open. See paragraph A4.33

Select "key door" (see above).

Consider this door open – room pressure now becomes _____ Pa (See Appendix 2)

See Appendix 3 for room pressures

			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
Air flow "out" or "in" via doors, transfer devices etc.	Pa	ΔP			
Mechanical extract					
Total					

S_{AMC} $(\sum_{OUT} - \sum_{IN})$ _____ Transfer S_{AMC} to WS1

Consider all doors closed.

Return S_F and E_F to WS1 _____ Room pressure now _____ Pa (nominal)

Air flow "out" or "in" via door leakage, transfer devices etc	Pa	Δt	Out	In	Remarks
Mechanical extract					
Total					

Flow $(\sum_{IN} - \sum_{OUT})$ through transfer device _____ @ ΔP _____ to……

……

For final selection of transfer device see paragraphs A4.50 – A4.54

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Air movement control **Corridor**			**Worksheet WS4** **References:** **Nominal Pressure:** **Pa**		
Consider all doors closed					
			Air flow, m^3/s		
			Out	In	Remarks
Flow required through doorway to give protection					
Leaks through closed doors, transfer devices, permanent openings etc.	Pa	ΔP			
Total flow inwards (S_1)					
Add mechanical input (S_2) if necessary to increase S_1 to give 7 AC/hr					
Total Flow Outwards and Inwards					
$S_{AMC} = (\sum_{OUT} - \sum_{IN} + S_2)$		Transfer to WS5			
or $E_{AMC} = (\sum_{IN} - \sum_{OUT} + S_2)$		Transfer to WS5			

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Air movement control **Corridor**	**Worksheet WS5** **References:**

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Air Flow to Corridor	All Doors Closed	Anaesthetic (key door open)
	m^3/s	m^3/s
From Preparation		
From Operating Room		
From Scrub		
From Anaesthetic		
Total (a)		
Air Flow to Corridor from Disposal		
From other source		
Total (b)		
Other Room Supplies.....Total (c)		
Total Air Supply (a) + (b) + (c)		

Consider corridor ventilation (see Appendix 2) and calculate air volume required, based on 7 ac/hr (see Note 1)	
	m^3/s
Additional Air to Ventilate Corridor	
Additional Air to Ventilate Service Corridor (see Note 2)	
Air Extract The size of the extract plant should be of the order of 10% below the supply to assist in maintaining the department under positive pressure relative to the outside departments.	
	m^3/s
Extract Plant = Supply less Leakage	
Less 10% of Supply	
Total Extract (see Note 3)	

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Room Temperature - Summer | **Worksheet WS6a**

References:

Find summer supply temperature T_{SS} = 20 – 0.828 H/(O/R) [ ]

= T_{SS} [ ] °C

Q(O/R) [ ]

Note: The temperature of a space may be calculated from

$$T = \frac{t_1 Q_1 + t_2 Q_2 + \ldots\ldots\ldots\ldots + t_n Q_n + (0.828H)}{Q_1 + Q_2 + \ldots Q_n}$$

Where t_1 is temperature of source (1°C)
Q_1 is flow from source 1 when all doors are closed (m^3/s)
H is heat gain in space (kW)

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Room	Heat Gain kWh	Supply		Flows Inwards										Temperature °C T
		Q	T_{SS}	From		From		From		From		From		
				Q	t	Q	t	Q	t	Q	t	Q	t	

Check Doors to Sterile Areas

Door Between	Calculated Room ΔT (°C)	Maximum ΔT *Permitted*	Remarks

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Room Temperature - Winter | **Worksheet WS6b**

References:

Find winter supply temperature T_{SW} = 20 – 0.828 H/(O/R) _____ = T_{SW} _____ °C

Q(O/R) _____

Note: The temperature of a space may be calculated from

$$T = \frac{t_1 Q_1 + t_2 Q_2 + \ldots\ldots\ldots\ldots + t_n Q_n + (0.828H)}{Q_1 + Q_2 + \ldots Q_n}$$

Where t_1 is temperature of source (1°C)
Q_1 is flow from source 1 when all doors are closed (m^3/s)
H is heat gain in space (kW)

Summary of Air Supply and extract for an Operating Suite

Consider all doors closed

Room	Heat Gain kWh	Supply		Flows Inwards										Temperature °C T
		Q	T_{SW}	From		From		From		From		From		
				Q	t	Q	t	Q	t	Q	t	Q	t	

Check Doors to Sterile Areas

Door Between	Calculated Room ΔT (°C)	Maximum ΔT *Permitted*	Remarks

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Transfer Grilles, Pressure Relief Dampers and Pressure Stabilisers	**Worksheet WS7** **Reference:**

Transfer Grilles – see paragraphs A4.34 – A4.38

Check Doors to Sterile Areas

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Model	Resultant Δp Pa	Remarks

Pressure Relief Dampers – see paragraph A4.39

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Pressure Setting Pa	Remarks

Pressure Stabilisers –see paragraphs A4.40 – A4.43

Note: where a stabiliser is acting both as series room door protection and operating pressure control, "pressure difference" and "flow rate" are from WS2d; "pressure setting" is from WS3

No	Location	Pressure Difference Pa	Flow Rate m^3/s	Free Area m^2	Pressure Setting Pa	Remarks

Surveyor (AP(V)/CP(V))…… Date…….

A47168969

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From: Roche R (Rowena)
To: Crowe B (Barbara)
Cc: Morrison A (Alan)
Subject: FW: ECYPH - Action List (Close Down)
Date: 22 July 2019 16:10:07
Attachments: NHS Lothian - Edinburgh Childrens"s Hospital - Action List Closure.docx

Hi Barbara,

This is the action list as it stood and that we will take forward now that resilience are stepping down. See Stuart's note below too.

Rowena

Rowena Roche
Directorate of Health Finance
Scottish Government | Floor BR | St Andrew's House | Regent Road | Edinburgh EH1 3DG
☎ [redacted] ✉ [redacted]

Please note that I do not work on Thursday afternoons or on Fridays.

From: Low S (Stuart) [redacted]
Sent: 18 July 2019 15:03
To: Morrison A (Alan) [redacted]
Cc: Roche R (Rowena) [redacted]; McLaughlin C (Christine) [redacted]; Connaghan J (John) (Health) [redacted]; Healy M (Michael) [redacted]
Subject: ECYPH - Action List (Close Down)

Alan
I have attached the Action List that Health Resilience were maintaining as part of the initial response arrangements around the delay to the ECYPH migration.

We are now closing off this action list and have identified two ongoing actions (highlighted amber) and one action in progress (all of which sit with Finance). Grateful if you could continue to monitor and review.

Outstanding / Ongoing Actions

-

Number	Actions	Lead Officer	Comments	Completed (Yes/No/In Progress)
1	Weekly Progress Reports requested from NHS Lothian on: a) Plan for critical care ventilation fix b) Contingency plan for remaining on existing site for up to 6 months Weekly updates to be provided to the Cabinet Secretary.	Director of Finance	Anticipated that development of full plan will take 4 weeks (9 Aug). Alex/Rowena to ensure updates provided	Ongoing
2	Cabinet Secretary and Ministers to be copied in on NHS Lothian IMT activity	Director of Finance	Alex/Rowena to ensure IMT summary provided to Cabinet Secretary	Ongoing
3	Letter to be drafted for Forth Valley	Director of Resilience & Delivery	John Connaghan has been in contact with Cathie Cowan to discuss. Christine taking forward in John Connaghan's absence. Helen Maitland copied into John's email of 17 July and Christine to clear letter .	In Progress

Kind regards
Stuart
Stuart Low, Scottish Government, Directorate for Health Performance & Delivery, Health Resilience Unit, Floor 2E, St Andrews House, Regent Road, Edinburgh, EH1 3DG
[redacted]

Official Sensitive

Number	Actions	Lead Officer	Comments	Completed (Yes/No/In Progress)
1 (8/7)	SG Finance to make immediate contact with NSS to ensure that HFS and HPS are on site at NHS Lothian.	Director of Finance	HFS/HPS engaged with Board Monday 8th July to scope and commence work. Director of Finance is meeting NSS Chief Executive 9th July on NHS L work	Yes
2	SG Finance to put in place appropriate audit with NHS Lothian and Terms of Reference to be produced.	Director of Finance	Engagement discussions held with KPMG. In principle agreed to undertake work and work can commence this week. Director of Finance meeting KPMG 9th July to scope out terms of reference.	Yes
3	SG Finance to establish and confirm reports that are in place in addition to the initial 'snagging' list received and confirm whether the report sent covers the whole building or part of the building.	Director of Finance	Response from NHS L was that snagging list was not part of a fuller report. Further confirmation requested from NHS L (by 10am 9th July) that no other assessment/reports have been produced.	Yes
4	Health Resilience arrangement to be set up for Health & Social Care Directorates to support activity.	Head of Health Resilience	Resilience Room operational	Yes
5	Group to meet up before meeting Cabinet Secretary on Tuesday 9th July	DG Office	Cabinet Secretary meeting to be confirmed by private office (proposed time 2:30pm). A meeting request will be scheduled in advance once known. Post Huddle note – meeting confirmed at 2:30	Yes
6. (9/7)	SG Finance to have discussion with NHS L Director of Finance on various information and reporting requests as discussed at huddle	Director of Finance		Yes
7.	SG Finance to circulate audit engagement terms of reference for comment before finalising.	Director of Finance	Terms of reference agreed	Yes
8.	SG Finance to check lines of advice and preparation of Cabinet Secretary's statement to parliament	Director of Finance		Yes

Number	Actions	Lead Officer	Comments	Completed (Yes/No/In Progress)
9.	SG Delivery and Resilience to prepare paper for HSCMB to discuss escalation on 10 July 2019. Escalation grid to be circulated in advance.	Director of Delivery & Resilience		Yes
10.	Health Resilience to invite NSS representative to provide update to huddle meetings	Head of Health Resilience	Jaquie Reilly (HPS) invited to attend	Yes
11.	All to consider support (if any) needed to supplement management capability at NHS Lothian (to be considered at HSCMB as part of action point 9)	All		Yes
12	Communications Healthier to work with NHS L on developing communications plan going forward. Update to be provided at Cabinet Secretary meeting.	Communications Healthier		Yes
13	Update Action List with all outstanding actions to create a comprehensive rolling action list	Health Resilience	Christine has provided note of additional actions for inclusion this list.	Yes
14	Detailed explanation requested from NHS Lothian about flow of information on critical care ventilation issues between 25 and 28 June – specifically when did anyone in the board become aware that the air flow change was 4 rather than 10 per hour	Director of Finance		Yes
15	Copy of report from inspections requested by Monday 15 July	Director of Finance		Yes
16	Weekly Progress Reports requested from NHS Lothian on: a) Plan for critical care ventilation fix b) Contingency plan for remaining on existing site for up to 6 months Weekly updates to be provided to the Cabinet Secretary.	Director of Finance	Anticipated that development of full plan will take 4 weeks (9 Aug). Alex/Rowena to ensure updates provided	Ongoing
17	Provide contact details for couterparts in KPMG Audit and HPS/HPA	Director of Finance		Yes
18	Provide acknowledgement to NSS to proceed to the next stage of development of the Centre for Expertise on Infection Control	Director of Finance		Review & confirm
19	Review information provided by NHS Lothian to SG on settlement agreement and whether it contained information on change to ventilation of critical care and ward areas	Director of Finance		Review & confirm

Number	Actions	Lead Officer	Comments	Completed (Yes/No/In Progress)
20	Contact Audit Scotland to inform them of the situation and action being taken	Director of Finance		Yes
21 (10/07)	Scope and prioritisation of HFS/HPS Audit to be agreed with SG Finance	Director of Finance	Reprioritised timescale for migration sent to SG by next Mon (15/07/19) for Christine to agree.	Yes
22	KPMG Audit letter of engagement to be signed by Friday (12/07/19) and Audit to start on Monday (15/07/19)	Director of Finance	Due Diligence phase completed	Yes
23	Q&A for staff to be posted on NHS Lothian website once point clarified on helpline.	Communications Healthier	Suzanne to confirm with Board comms team when this can be posted.	Yes
24	HRU to discuss formal situation reporting NHS Lothian on 10/07/19	HRU	Mike met with Alex McMahon and Jacquie Campbell and agreed that the Board would provide operational, helpline, staffing, comms and other relevant info to the SGHRU mailbox by 10.00 each day.	Yes
25	Christine to receive note of reason for delay in escalation to the SG from Tracy Gillies	Director of Finance		Yes
26	Discussion to be had with NHS Lothian around maintaining Helpline		Helpline will be maintained until Sunday 20th July and will be reviewed on Monday 21 July.	Yes
27	Make media announcement that KPMG have been appointed as auditors.	Director of Finance / Communications Healthier	Letter of engagement now signed – media announcement can be made.	Yes
28	Site visit to be arranged for Cabinet Secretary	Communications Healthier	Arranged for Thurs 18 July. This will be a social media visit. Consider whether the visit should take in both Edinburgh Children's Hospital and DCN. Letter to staff to issue ahead of visit.	Yes
29	NHS Lothian position to be considered with regard to presenting information on the delay to a Public Board and the SPF.	Director of Finance	NHS Lothian have now provided further information on planned staff briefings and events.	Yes
30	Prepare letter to MSPs /MPs, GIQ Q&A, and Media Release for concurrent issue when appropriate.	Director Finance	Finance to liaise with Comms regarding issue of media release	Yes
31	Prepare update for FM for Friday 12 July	HRU		Yes
32	Update to be provided on NHS Lothian escalation following HSCMB	Director of Finance		Yes
33 (15/07)	Set out delivery expectations and timeframes for NHS Lothian as a consequence of level 3 escalation.	Director of Finance	Christine to discuss with John.	Yes

Number	Actions	Lead Officer	Comments	Completed (Yes/No/In Progress)
34	Consider what a package of support might look like and how long this might need to be in place for.	Director of Finance	All to consider	Yes
35	Outline of contractual arrangements for the NDP agreement to be pulled together	Director of Finance	Rowena taking forward	Yes
36	Points 33-36 to be completed by Tues 16 July and information pack to be provided to DGHSC and Finance.	Director of Resilience & Delivery	John Connaghan to ask Roy Sturrock to compile contributions across performance related domains..	Yes
37	Cabinet Secretary and DGHSC to meet with SG officials prior to meeting with NHS Lothian Chair and CEO on Thurs 18 July. This will be followed by a site visit to meet staff.	DGHSC		Yes
38	Cabinet Secretary and Ministers to be copied in on NHS Lothian IMT activity	Director of Finance	Alex/Rowena to ensure IMT summary provided to Cabinet Secretary	Ongoing
39	Letter to be drafted for Forth Valley	Director of Resilience & Delivery	John Connaghan has been in contact with Cathie Cowan to discuss. Christine taking forward in John Connaghan's absence. Helen Maitland copied into John's email of 17 July and Christine to clear letter .	In Progress
40	Christine to discuss GIA and Board escalation with Susan Goldsmith on Mon 15 July.	Director of Finance	Follow up on NHS Lothian's plans for public engagement.	Yes

From:	Gillies, Tracey
To:	Executive, Chief
Cc:	McMahon, Alex; [redacted]; Goldsmith, Susan; Graham, Iain; Campbell, Jacquie; Currie, Brian; Curley, George; "MACKAY, Judith (NHS FIFE)"
Subject:	RHCYP critical care ventilation issues
Date:	01 July 2019 18:52:05
Sensitivity:	Confidential

Dear Tim,
This emerged today following testing by the independent validation engineer for ventilation on the site (IOM) . The main points are summarised below
I have discussed briefly with Susan and she advises obtaining urgent legal advice and I have asked Iain G to arrange a call for early tomorrow morning.
The points below have been commented on by those at the discussion this afternoon, and there are points to clarify and get further information on.

• IOM have tested critical care ventilation in RHCYP in 4 bedded and single rooms
•It delivers 4 air changes at balanced or slight negative pressure in the multiple occupancy 4 bedded room and single rooms in critical care. The 19 isolation rooms outside critical care are not affected
•The required standard as per SHTM 03-01 Appendix 1 (version 2 February 2014) for Critical Care areas is 10 air changes and less than 10 air changes per hour may facilitate airborne spread of viruses more than if 10 was achieved. Further advice on the likely impact of air change reduction is required.
•the only known way to improve air changes with the current plant is to accept positive pressure ventilation (i.e. increasing further the opportunity for spread primarily of pathogens with airborne transmission e.g. respiratory viruses between individuals :staff, visitors and patients in 4 bedded rooms) A request has been asked of MPX to verify the maximum capability of the existing plant while maintaining current pressure regimes.
• it is expected that a bigger plant would be required to deliver the correct air changes – the team are identifying what potential for existing system capacity enhancements might be (i.e. ramping up the existing air handling plant) and / or within the constraint of the existing ducting (so it would only be the external plant affected). The question has also been asked of MPX to assess what would be required to increase to 10 air changes/hr
•this leads us to question whether the space is fit for purpose
•If occupied now, there is risk to patients, visitors and staff of airborne virus transmission (?how much) and difficulties in correcting (would probably require a decant) Team to contact external experts for advice
• if not occupied now, move needs postponed

Tracey

From: Wright M (Malcolm)
To: DG Health & Social Care
Subject: FW: RHCYP/DCN Commissioning/ventilation
Date: 03 July 2019 17:32:31

Pls print

Sent with BlackBerry Work
(www.blackberry.com)

From: DG Health & Social Care [redacted]
Date: Wednesday, 03 Jul 2019, 4:40 pm
To: Wright M (Malcolm) [redacted]
Cc: DG Health & Social Care [redacted]
Subject: FW: RHCYP/DCN Commissioning/ventilation

From: "Executive, Chief" [redacted]
Sent: 3 Jul 2019 16:36
To: DG Health & Social Care [redacted]; "Connaghan J (John) (Health)" [redacted]
Subject: RHCYP/DCN Commissioning/ventilation

Malcolm and John

Further to our previous briefings and our telephone conversations over the last couple of days, I have set out below a brief note of the issues we have considered and our conclusions and propositions for dealing with the ventilation problems in the new RHCYP/DCN building at RIE. We believe the problem is capable of being resolved fully over a period of around 4 months. There are a number of options for how the solution can be arrived at and each carries a degree of risk and uncertainty.

It is worth reiterating that our guiding principle in dealing with this problem and all previous problems and delays associated with this building project has been to prioritise patient safety and only to commission services in the new building when we believed that it was fully fit for purpose..

Following the hand over of the facility, NHS Lothian has continued to monitor the performance of IHS Lothian and their supply chain given NHS Lothian's priority of providing a safe and robust facility. As part of that process, NHS Lothian commissioned an independent advisor to carry out a review of certain critical areas of the facilities. During that review, it has come to light in the last few of days that there is an issue regarding the ventilation in the bedrooms in the critical care unit of the new RHCYP part of the building. NHS Lothian is investigating how this issue has arisen and how best to address it in collaboration with IHS Lothian and their supply chain and is taking a range of professional advice (including legal and technical advice and advice from advisors in infection control, health and safety and facilities engineering)

Over the last 48 hours we have considered four main options for dealing with the ventilation problem and a range of key senior staff have been consulted including clinical staff and clinical leaders, executive and senior managers, project team staff, capital planning staff, the board chair and colleagues in Scottish Government, HFS and HPS.

These options are outlined below with some comments on how likely they are to deliver the most optimum solution.

1. Continue with the planned move of all services and attempt to deliver the permanent fix for the ventilation problem while the critical care unit remains occupied:

   This option was not supported because of the impact of noise and disruption during remedial works on patients, parents and staff; being unable to deliver the complete optimum solution of increasing the size of the ducting in an occupied clinical area; and the loss of capacity in critical care during the remedial works.

2. Continue with the planned move of all services and then decant critical care into a modular build unit to allow the optimum solution to be delivered in an empty environment:

   This option was not supported because of the lack of critical clinical adjacencies if critical care is remote from its ideal location; disruption and further works involved in securing a secure connection to the new

building; the significant likely time delay to deliver a modular building – estimated to be around 6 months; the risk associated with moving in to a critical care unit that we know does not comply with the highest ventilation standards required.

3. Defer moving in to the new building altogether:

This option was not supported because the rephrasing of the move of the critical care unit only really affects those services dealing with the sickest of paediatric patients including inpatient beds, the emergency department and theatres. It does not materially impact on DCN services and ambulatory paediatric services and therefore there is no need to defer these elements of the move;

4. Re-phase the timing of the move in to the building to allow a phased occupation over the next few weeks and months:

This option was supported as the best option. It would allow the permanent optimum solution for the critical care ventilation issue to be implemented in an empty ward without clinical risk and with limited disruption to the other users of the building; it prevents the need for double moves including a decant; it would allow DCN services to move in as planned; and it would allow ambulatory paediatric services including out patients, therapies, programmed investigations and day surgery to move in over the summer.

Following my meeting with senior colleagues this afternoon (which John attended), we agreed the following immediate actions:

- Develop a communications plan between SG and NHSL for implementation tomorrow morning (Thursday);
- Commission the permanent solution for the ventilation issue in critical care;
- Clinically risk assess and plan the re-phased moves described in option 4;
- Begin an investigation into how the agreed derogations for ventilation in the settlement agreement between NHSL and IHSL came to include critical care beds which was not consistent with the environmental matrix which included the requirement to comply with SHTM 03-01

As with all major estates developments, NHS Lothian will be undertaking a post-project evaluation. Given our high level review of aspects of the settlement agreement, the considerable time, resources and complexity involved in resolving the disputes with IHS Lothian and the late discovery of the ventilation issues, this evaluation will include an element specifically focused on the whole-project contracting, monitoring/timetabling and related “lessons-learned”. It is proposed that the key outcomes would be shared within NHS Lothian and with other NHS bodies in Scotland (as appropriate) to help with cumulative understanding of the issues arising, and to help with both preventative and reactive measures to mitigate the likelihood and impact in future projects.

I hope this is helpful.

Best wishes

Tim

Tim Davison
Chief Executive
NHS Lothian
Waverley Gate
2-4 Waterloo Place
Edinburgh EH1 3EG

[redacted]

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EDINBURGH CHILDREN'S HOSPITAL - UPDATE

Purpose

1. Please accept my apologies for the lateness of this note which has arisen as we sought to clarify some important details. Following our discussion on 3 July and my note of 4 July, this provides a further update on the current situation regarding the opening of the new Edinburgh Children's Hospital.

Priority

2. High.

Background

3. My note to you of 4 July set out the background and in that note I set out a number of actions to be taken forward and these are set out below for ease of reference:

- In order to ensure that patients are being treated in a safe, clean and clinically appropriate environment, I have instructed NHS Lothian to delay the transfer of patients to the new Edinburgh Children's Hospital. We expect that it will take at least six months for the problem to be resolved, but further work is required to test and validate the proposed solution and estimated timeline.

- I have also asked that we undertake an external series of checks, led by Health Facilities Scotland and Health Protection Scotland, to ensure that all the relevant technical specifications and standards applicable to the new Edinburgh Children's Hospital are being followed and implemented.

- Given that it is unclear today what services can be safely moved to the new site, I have instructed that a halt is place on the move in full, pending the outcome of the action set out above which will then trigger a phased move of services.

- I will lead on media communications and I will review and approve NHS Lothian's handling plan covering communications to staff, public and patients, before it is released. I have also been clear with NHS Lothian that assurances on critical patient safety areas must be given to SG before any patient moves in.

- Follow up work has been commissioned by me to audit the full decision and build process to identify how and where this ventilation problem initiated and why it has not been identified until this week. I will continue to keep you updated as this situation develops.

- I have held a teleconference with officials this morning to understand the updated position from the Board.

Boards Timeline for Escalation to Scottish Government

- NHS Lothian Chief Executive has advised: the actual test took place last week and we are chasing Lothian for actual date; On June 28 the Board Medical Director, Nurse Director and Finance Director attended a meeting at the new hospital to discuss progress and process around theatre ventilation as part of the pre-hospital opening sign-off. On Monday afternoon (4.30) 1 July, a further teleconference took place regarding the theatre progress and at this point the issue relating to paediatric critical care ventilation was raised. The Medical Director who was in attendance escalated this to the CE, by email for his return from leave on 2 July. The CE picked the escalation up on Tuesday 2 July and on the same day informed the Board Chairman and the Director General for Health & Social Care.

Boards Communication Plans and Support provided to Patients

- The Board has a detailed Comms plan for this weekend: key messages are: (i) A&E will not move and patients should attend to the existing building; (ii) the Health Board are in the process of contacting affected patients/families directly by telephone to confirm the revised site, date and time of their appointment. Contact is being made in date order, with soonest appointments first. No outpatient appointments were scheduled for the next 2 weeks so gives them a buffer to be able to reschedule.

- These are the 2 key messages from today until 8 July. These are also the key messages used with callers to the NHS 24 helpline. Comms approach following this weekend will reviewed and updated in the w/c 8 July.

- In terms of staff comms, the Health Board issued electronic communications and held staff briefings late yesterday afternoon/evening; they are also developing an ongoing, regular staff communications plan to keep staff informed as plans develop.

- NHS 24 has set up a dedicated helpline for this issue on (0800) 028 2816. This was operational from noon today and will run until 10pm. Thereafter, the line will be operational from 8am until 10pm during the week and from 9am to 5pm on Saturdays and Sundays.

- NHS 24 will provide us with regular updates on activity levels for the helpline.

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- NHS Lothian has assured us that they have identified all the patients booked to attend the new hospital from now until the end of July. The Health Board are in the process of contacting these patients/families directly by telephone to confirm the revised site, date and time of their appointment.

- Contact is being made in date order, with soonest appointments first. The service are maintaining a log of patients contacted on a daily basis. Contact will continue over the weekend.

- Volumes of patients affected are as follows: Paediatrics: 1800 outpatients, 169 inpatient/day cases; DCN: 666 outpatients, 11 inpatient/day cases; Radiology – 692 cases.

- The Board will have a vehicle based at the new site 24/7 from Monday (note: patients were not proposed to move until next Tuesday). NHS Lothian will have a staffed presence at the car parks to assist patients and visitors to ensure they are appropriately directed to clinical/medical services.

- There will be a minimum of two vehicles available to ensure easy access should transfer across town be necessary. The Board are preparing to have clinical support to ensure assistance for patients if required. As a further precaution, NHS Lothian will have access to a disabled capability taxi and this would be used in the event of any difficulties with access. Should any patient attend the new site for an appointment they will still be seen at the existing site even if later than the scheduled time.

Update on the work required

- My officials received a proposal from NSS which is being reviewed by officials. There is an initial estimate that a comprehensive review of the new site could take as long as four months to complete. Malcolm Wright has spoken to the Chief executive of NSS on Friday afternoon with a view to setting a speedier timeframe. If this involves additional resources we will ensure this is made available.

- The revised migration plan needs to be reviewed by HFS/HPS to ensure it can be actioned safely. RCPH also keen to avoid any two-site working in new migration plans as they feel that this may lead to confusion for staff and public.

- However, there is probably a good clinical case to prioritise migration of the Department of Clinical Neurosciences (DCN) in advance of other services. Delay to the migration of DCN services is not felt to be risk free; the fabric of the unit is poor and there have been increased pseudomonas infections; angiography equipment is aged too. The reduced occupancy associated with transfer of DCN would have allowed remedial work in the ITU normally used by DCN where a recent pseudomonas HAI was diagnosed, but this can no longer take place. There would be some short term need for augmentation of anaesthetic rotas should DCN move in advance of Children's Hospital services but this would not be insurmountable.

- I am keen that we along with NHS Lothian carry out a prioritisation exercise on which services should move as part of a phased approach and over what timeframe. HFS/HPS as part of their review would focus on these services in the first instance. We would also look to Scottish Government clinical experts including CMO and CNO to provide me with professional advice when it comes to signing off any decisions. Malcolm Wright has spoken with the Chief Executive of NHS Lothian on Friday afternoon where they discussed the beginning of a migration plan for the hospital which continues to prioritise on Patient safety

- Work is underway with regards to the ventilation issues I have asked that an update on the detail and timescale for early next week.

- The audit of the governance arrangements would be best undertaken by one of the accountancy firms with a good internal audit team, with HFS/HPS alongside. We will ensure where possible that the external company is not one used by NHSL as internal or external auditors.

- All Health Board Chief Executives were sent a letter by then DG Health & Social Care (Paul Gray) on 25 January (copied to and Directors of Estates) as a result of the initial QEUH investigations. The letter sought assurance that a number of specific controls were in place and working effectively, including: "All critical ventilation systems inspected and maintained in line with *Scottish Health Technical Memorandum 03-01: Ventilation for healthcare premises*."

- HFS co-ordinated the Board responses and a summary paper from 1 February indicates NHS Lothian responded that they were compliant (This response is attached for information).

Media

I have undertaken a number of media bids today with BBC and STV and overall today's media appears to be taking our lines and key messages. However the critical next steps are to ensure consistency of message and we will be mindful of that.

Role of HFS in all future builds for NHS Facilities

- My officials have today received a proposal from NSS which is currently being reviewed. There will be resource/capacity implications to consider for this and the other Sick Kids' reviews, given existing commitments to QEUH review, etc.

Response from Clinical professionals

- NHS Lothian MD Tracey Gillies briefed her AMDs this morning. Staff reported to be disappointed to hear news from sources other than NHS Lothian but want what's best for patients. It's felt to be unlikely that there will be any significant reaction to the news of delay.On RCPH, Gregor Smith spoke to College last night; appreciative of the heads up and able to let office bearers know in advance of news release. Good follow-up conversation with their CEO this morning; their position is that safety must always come first. As noted above, keen to avoid any two-site working in new migration plans as they feel that this will lead to confusion for staff and public alike.

- Diane Murray will closely engage with the RCN to understand their position.

Next Steps

- The Scottish Government has John Connaghan, Chief Performance Officer as on call Director who will chair a resilience call of relevant officials on Saturday the 6th July. NHS Lothian have ensured senior Director cover is provided for the weekend Jacquie Campbell, Chief Officer Acute and Alex McMahon, Nurse Director will be on call to support my officials.

- The Director General and I will discuss the position on Sunday the 7th of July.

- Malcolm Wright will meet with Tim Davison on Monday 8 July to receive an update on the boards submission of proposals to implement the move to the new hospital.

- Tim Davison has confirmed to Malcolm Wright on the afternoon of the 5th of July in a phone call that Lothian will introduce an Incident Management Team chaired by Susan Goldsmith, that will act in conduit with the Incident Management Team held within The Scottish Government chaired by Christine McLaughlin, Chief Finance Officer of NHS Scotland.

In the coming week I am considering visiting the existing site to speak with staff directly. However I am mindful of the need to provide them with more information than they currently have and so will consider timing when I have a clearer picture on the HFS/HPS work in relation to safety and standard compliance across the new hospital site and the link with a migration plan.

I hope this is helpful and will continue to provide you with updates as we make progress.

Cabinet Secretary for Health and Sport
5 July 2019

Oversight Board:
NHS Lothian Royal Hospital for Children and Young People, Department of Clinical Neurosciences and Child and Adolescent Mental Health Services

Terms of Reference

Date Published: July 2019
Version: V1.0
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Review Date: **N/A**

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Approvals: *This document requires the following signed approvals:*

Name	Title	Date	Version
Malcolm Wright	Director General and NHSScotland Chief Executive		
Ms Freeman	Cabinet Secretary		

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1.	Name of the Board

Oversight Board: NHS Lothian Royal Hospital for Sick Children, Department of Clinical Neurosciences and Child and Adolescent Mental Health Services

2.	Background

Following the decision to halt the planned move to the new Hospital facilities on 9 July an Oversight Board is being established to provide advice to ministers on the readiness of the facility to open and on the migration of services to the new facility.

On Tuesday 2 July, NHS Lothian alerted the Scottish Government to an issue with the ventilation system at the Royal Hospital for Children and Young People (RHCYP) in Edinburgh.

The Cabinet Secretary was not satisfied that the issue could be resolved within the very short timeframe available before services were to move to the new hospital, and required further assurance on all aspects of compliance with standards across the new hospital. For this reason, the planned move was halted in the interests of patient safety.

Work has been initiated to identify the solution needed to ensure the ventilation in the critical care unit in the new site meets the required clinical and safety standards. Scottish Government has commissioned NHS National Services Scotland (NSS) to undertake a detailed assessment of all buildings systems in the new hospital which could impact safe operation for patients and staff, recognising how infection prevention must always be embedded within the design, planning, construction and commissioning activities of all new and refurbished healthcare facilities. This work will be phased, with assessment of water, ventilation and drainage systems prioritised, including the proposed fix for the ventilation unit. This will determine the timeframe for migration of services to the new hospital and a full report is anticipated in September.

In order to provide co-ordinated advice to ministers, an Oversight Board is being established which will seek assurance from NHS Lothian that according to its due diligence and governance, the facility is ready to open; and from NHS NSS that its agreed diligence has been successfully completed.

3.	Scope of work

The Oversight Board will provide advice in relation to:

- Advice on phased occupation;
- Advice on the proposed solution for ventilation in critical care areas and on any other areas that require rectification works;
- Advice on facility and operational readiness to migrate;
- Gain information and give advice to NHS Lothian about commercial arrangements with IHSL for completion of works;
- The approach to NPD contract management
- Identification of areas that could be done differently in future

4.	Membership

The Board membership will be:

Christine McLaughlin, Chief Finance Officer, Scottish Government
Catherine Calderwood, Chief Medical Officer, Scottish Government
Prof Fiona McQueen, Chief Nursing Officer, Scottish Government
Susan Goldsmith, Director of Finance, NHS Lothian
Tracey Gillies, Executive Medical Director, NHS Lothian
Prof Alex McMahon, Nurse Director, NHS Lothian
Peter Reekie, Chief Executive, Scottish Futures Trust
Colin Sinclair, Chief Executive, NHS National Services Scotland
Alex Joyce, representative from NHS Lothian Joint Staff Side (deputy Gordon Archibald)

Attending the Board to provide advice and assurance will be:
Mary Morgan, Senior programme Director
Brian Currie, Project Director, NHS Lothian
Judith Mackay, Director of Communications, NHS Lothian
Prof Jacqui Reilly, HAI executive lead for NHS National Services Scotland and SRO for centre of excellence work
Gordon James, Health Facilities Scotland, NHS National Services Scotland
IHSL would be in attendance on as ‘as required’ basis

5.	Governance

The Board will provide advice to the Cabinet Secretary

6.	Meetings

The Board will commence their work in August 2019 and will meet frequently for the first 3 months as appropriate and will agree a plan of work which will determine future meetings. The first meeting will take place on Thursday 8 August 2019.

7.	Outputs

The Board will provide advice to the Cabinet Secretary on the decisions set out in the scope

Independent Assessment of Governance Arrangements

NHS Lothian Royal Hospital for Children and Young People

NHS National Services Scotland

September 2019
A47168969

Scottish Government
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Independent Assessment of Governance Arrangements

NHS Lothian Royal Hospital for Children and Young People

NHS National Services Scotland

KPMG LLP

9 September 2019

This Report contains 81 pages

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Glossary

73 Issues	73 issues which formed part of the Settlement Agreement
Ac/hr	Air-changes per hour
Approved RDD	RDD which is classified as Level A or Level B by NHSL Board Representatives
BCR	Board's Construction Requirements
Bouygues	Bouygues Energies and Services
Critical Care Clinical Output Based Specifications	Specific clinical requirements for Critical Care, contained within Sub-Section D of the BCR
CFO	Chief Financial Officer
DCN	Department of Clinical Neurosciences
DCPP	Director of Capital Planning and Projects
Delay	The opening of the Hospital, due to be on 9 July 2019, was postponed due to issues identified with the air ventilation system
DRP	Dispute Resolution Process
EM	Environmental Matrix
F&R Committee	Finance and Resources Committee
Financial Close	The date when the conditions of the financial agreement are fulfilled, prior to the funds being made available

HCP	HCP Management Services Limited
HDU	High Dependency Unit
HFS	Health Facilities Scotland
Hospital	NHS Lothian Royal Hospital for Children and Young People
HPS	Health Protection Scotland
IHSL	Integrated Health Services Lothian Limited
IMT	Incident Management Team
IOM	Institute of Occupational Medicine
IPC	Infection Prevention & Control
Issue	The non-compliance with the SHTM standards for air change rates in the Critical Care areas of the Hospital
IT	Independent Tester
ITPD	Invitation to Participate in Dialogue
ITPD EM	The Environmental Matrix provided as part of Room Information within the ITPD
KPMG	KPMG LLP
MacRoberts	MacRoberts LLP
Mott MacDonald	Mott MacDonald Group Limited
MRI	Magnetic Resonance Imaging
Multiplex	Brookfield Multiplex
NHSL	NHS Lothian

NHS-NSS	NHS National Services Scotland
NPD	Non-Profit Distributing
OJEU	Office Journal of the European Union
PAMIP	Project Asset Management Investment Programme
PCC	Project Co Change
PCNOC	Project Co Notice of Change
Preferred Bidder Letter	A letter issued by NHSL to IHSL on 5 March 2014, advising that their Final Tender, submitted on 13 January 2014, had been accepted
Programme Board	Had day-to-day responsibility for managing the Project
Project	The design and construction of the Hospital
Project Agreement	An agreement between the NSHL Board and IHSL for the design, build, finance and maintenance of the Project, dated 13 and 14 February 2015
Project Agreement EM	The Environmental Matrix included with the Project Agreement documentation
Project Co	IHSL and Macquarie Capital, along with the following contractors: Brookfield Multiplex, Bouygues Energies and Services and HCP Management Services Limited
Project Team	The Financial & Resources Committee established the Programme Board and a smaller team (the “Project Team”)
RDD	Reviewable Design Data
RDS	Room Data Sheets
Room Information	The specific room requirements for the Hospital contained within the Project documentation
Settlement Agreement	An agreement signed between the NHSL Board and IHSL on 22 February 2019

SG	Scottish Government
SHTM	Scottish Health Technical Memoranda
SHTM 03-01	Scottish Health Technical Memoranda 03-01 (Ventilation for healthcare premises)
Standards	Scottish Health Technical Memoranda 03-01 (Ventilation for healthcare premises)
The Client	NHS-NSS
TOR	Terms of Reference
TS	Technical Schedule

1 Introduction

1.1 Background

1.1.1 On 4 July 2019 it was announced by the Scottish Health Secretary that the opening of the newly built NHS Lothian Royal Hospital for Children and Young People (the **"Hospital**"), due to open on 9 July 2019, was to be postponed due to issues identified with the air ventilation system at the Hospital (the **"Delay**").

1.1.2 The Health Secretary took the decision to delay the opening of the Hospital following final safety checks which revealed that the ventilation system within the Critical Care department required further work to meet national standards, the relevant standards being the Scottish Health Technical Memoranda ("**SHTM**").

1.2 Our instructions and approach

1.2.1 KPMG LLP ("**KPMG**" or "**we**") has been instructed by NHS National Services Scotland ("**NHS-NSS**"), to independently establish the facts surrounding the decision to delay the move to the Hospital. As part of this assessment KPMG has specifically been instructed to consider the following areas:

a) To establish what decisions were made by NHS Lothian ("**NHSL**"), when these were made, by whom and on what basis these decisions were taken in relation to the air ventilation issues and any other material issues that led to the Delay;

b) To determine the extent to which the design specifications with regard to air ventilation complied with the SHTM standards at each stage of the Hospital

project[1], the 'project' being the design and construction of the Hospital (the "**Project**")[2];

c) To understand what professional and technical advice was given to the NHSL Board, in particular when derogations were proposed, who agreed them and the risk assessments that were undertaken to reach a final decision; and

d) To establish the governance arrangements that were in place in relation to the Project and the line of sight of NHSL and the Scottish Government ("**SG**"), along with the escalation arrangements to NHSL and SG.

1.2.2 The focus of our review has been on the activities and decisions taken within NHSL.

1.2.3 We have held discussions with individuals from NHSL, along with individuals from the following entities:

a) Mott MacDonald Group Limited ("**Mott MacDonald**") – NHSL's technical advisors and project managers for the Project;

b) MacRoberts LLP ("**MacRoberts**") – NHSL's legal advisors;

c) Integrated Health Services Lothian Limited ("**IHSL**") - the party that the NHSL Board entered into a project agreement with for the design, build, finance and maintenance of the Project;

d) Institute of Occupational Medicine ("**IOM**") – a third party firm of specialist validation experts whom NHSL instructed to undertake testing on the Hospital's ventilation;

e) Health Facilities Scotland ("**HFS**") - a division of National Services Scotland which provides operational guidance to NHS Scotland bodies on a range of healthcare facilities topics; and

[1] To design, build, finance and maintain a new facility to re-provide services from the Royal Hospital for Sick Children, Child and Adult Mental Health Service and the Department of Clinical Neurosciences in a single building adjoining the Royal Infirmary of Edinburgh at Little France (Source: Project Agreement, dated 13 February 2015, page 5)

[2] It was agreed that KPMG would not undertake a technical review in this respect but confirm whether the SHTM standards were included within the design specifications.

f) Arcadis NV - the Project's Independent Tester (**"IT"**).

1.2.4 In addition, we reviewed key documentation provided by NHSL and the above entities.

1.3 Structure of this Report

1.3.1 In Section 2, we set out the Executive Summary.

1.3.2 In Section 3, we set out the background to our work, including details of the Project relating to the build of the Hospital and the timeline of events leading up to the Delay.

1.3.3 In Section 4, we set out our observations in relation to whether the design specifications with regard to air ventilation made reference to the SHTM standards.

1.3.4 In Section 5, we set out details of the professional and technical advisors that advised the NHSL Board and the extent to which they were involved in providing advice in respect of derogations.

1.3.5 In Section 6, we set out our observations in relation to the governance arrangements that were in place for the Project.

1.4 Limitations of scope

1.4.1 The content of this Report is based on information provided to KPMG by representatives of NHSL, Mott MacDonald, MacRoberts, IOM and the IT. Except where explicitly stated, we have not independently verified this information and have relied on statements made and documents and data provided.

1.4.2 Whilst we make reference to SHTM in this Report, we are not technical experts on ventilation standards and give no comment on the technical accuracy of the content of documents we have been provided. We understand that the Health Secretary has commissioned a separate independent review in relation to the technical aspects of the Delay. Comments made in this Report by KPMG are

made in the context of our review and our understanding of the documents made available to us.

1.4.3 In undertaking our work we have had regard to elements of the contractual documentation relating to the Project, and have set out extracts of these in this Report. However, nothing in this Report should be regarded as constituting legal interpretation of such documents or the provision of legal advice.

1.4.4 We have not been instructed to determine exactly what led to the Issue[3] or to opine on the accountability of individuals or organisations in respect of the Issue.

1.4.5 Whilst we have considered the governance arrangements in place from the date of the project agreement, being an agreement with IHSL for the design, build, finance and maintenance of the Project on 13 February 2015 (the "**Project Agreement**"), we have not considered the governance arrangements prior to this time.

1.4.6 Should any additional information or documentation subsequently become available which is relevant to our scope of work, we reserve the right to amend our findings in light of that information.

1.4.7 The scope of our work is different from that of an audit and does not provide the same level of assurance as an audit.

1.5 Notice: About this Report

1.5.1 This Report has been prepared on the basis set out in our Engagement Letter addressed to NHS-NSS ("**the Client**").

1.5.2 Nothing in this report constitutes legal advice.

1.5.3 We have not verified the reliability or accuracy of any information obtained in the course of our work.

[3] As defined in paragraph 2.2.1

1.5.4 This Report is for the benefit of the Client and has not been designed to be of benefit to anyone except the Client. In preparing this Report we have not taken into account the interests, needs or circumstances of anyone apart from the Client, even though we may have been aware that others might read this Report. We have prepared this Report for the benefit of the Client alone.

1.5.5 This Report is not suitable to be relied on by any party wishing to acquire rights against KPMG LLP (other than the Client) for any purpose or in any context. Any party other than the Client that obtains access to this Report or a copy (under the Freedom of Information Act 2000, the Freedom of Information (Scotland) Act 2002, through the Client's Publication Scheme or otherwise) and chooses to rely on this Report (or any part of it) does so at its own risk. To the fullest extent permitted by law, KPMG LLP does not assume any responsibility and will not accept any liability in respect of this Report to any party other than the Client.

1.5.6 In particular, and without limiting the general statement above, since we have prepared this Report for the benefit of the Client alone, this Report has not been prepared for the benefit of any other Health Board nor for any other person or organisation who might have an interest in the matters discussed in this Report, including for example those who were involved in the Project detailed in this Report.

2 Executive Summary

2.1 Introduction

2.1.1 On 4 July 2019, the Scottish Health Secretary announced that the opening of the newly built NHS Lothian Royal Hospital for Children and Young People (the **"Hospital**"), due to open on 9 July 2019, was to be postponed due to issues identified with the air ventilation system at the Hospital (the **"Delay**").

2.1.2 The Scottish Health Secretary took the decision[4] to delay the opening of the Hospital following final safety checks which revealed that the ventilation system within the critical care areas of the Hospital required further work in order to meet national standards.

2.1.3 KPMG LLP ("**KPMG**" or **"we"**) has been instructed by NHS National Services Scotland ("**NHS-NSS**"), to independently establish the facts surrounding the decision to delay the move to the Hospital.

2.1.4 The focus of our review has been to establish what decisions were made by NHS Lothian ("**NHSL**") in relation to the air ventilation issues and any other material issues that led to the Delay. We have detailed our main observations in relation to this in Section 2.2 below, and provide further details on specific areas of our scope in Sections 2.3 to 2.5.

2.2 Summary of findings

2.2.1 The information available to us indicates that:

a) The key issue which led to the Delay was the non-compliance with the Scottish Health Technical Memoranda 03-01 ("**SHTM 03-01**" or the "**Standards**") for air change rates in some of the Critical Care areas of the Hospital (the **"Issue"**). This Issue was brought to the attention of the NHSL Board on 1 July 2019 as a result of testing undertaken by a third party

[4] The Cabinet Secretary announced this decision following communication with the NHSL chief executive regarding the identification of the ventilation system issues.

contractor, Institute of Occupational Medicine (**"IOM"**). This was as a result of IOM reporting the issue in relation to Critical Care to the NHSL Project Team[5] on 24 June 2019. The actions taken by the Project Team before the Issue was reported to the NHSL Board are reported in Section 3.4. Further details as to the decisions that were made by NHSL once the Issue had been identified, when these were made, by whom and on what basis, are provided in Section 3 of this Report;

b) Throughout all stages of the Project we have seen references made to the requirements of the Project Co[6] to adhere to the Scottish Health Technical Memoranda ("**SHTM**"), including specifically SHTM 03-01 relating to ventilation systems. However, notwithstanding any contractual obligations, it appears that there has been confusion between the parties as to the application of these Standards. This appears to have stemmed from a document which was contained within the Project tender documentation, a version of which was used throughout the Project, which included details on the environmental specifications of the Hospital, the Environmental Matrix ("**EM**"). Elements of the EM were inconsistent with SHTM 03-01 from the tender process (which commenced in late 2012) onwards. Further details in relation to design specifications and air ventilation standards are provided in **Section 2.3** below;

c) We have seen evidence of professional and technical advisors being involved throughout the Project. This included specific involvement in relation to ventilation issues. However, we have seen no evidence that professional or technical advice identified the Issue prior to June 2019. Further details in

[5] The NHSL Board delegated responsibility for oversight of the Project to the Financial & Resources Committee which established the Programme Board and a smaller team (the **"Project Team"**)

[6] Being Integrated Health Services Lothian Limited and Macquarie Capital, along with the following contractors: Brookfield Multiplex, Bouygues Energies and Services and HCP Management Services Limited. Collectively for the purposes of this Report referred to as **"Project Co"**

relation to professional and technical advice are provided in **Section 2.4** below;

d) The governance processes and procedures surrounding the construction and commissioning of the Hospital operated in line with the structure that was put in place. There was regular dialogue between NHSL and the Scottish Government ("**SG**") throughout the Project, with evidence of escalation of issues where required, albeit this was more focused on financial rather than technical matters. Further details of the governance arrangements are provided in **Section 2.5** below; and

e) Once the Issue in relation to air change rates was known to the NHSL Board, steps were taken to assess the impact of the Issue, resulting in the Delay (see Section 3.4).

2.2.2 Aside from the specific Issue referred to in this Report, other ventilation systems were identified by IOM as having some deficiencies. We understand that all these deficiencies were considered rectifiable by NHS-NSS, and NHSL have an action plan in place to address each issue.

2.3 Design specifications and air ventilation standards

2.3.1 Our specific instructions were:

To determine the extent to which the design specifications with regard to air ventilation complied with the SHTM standards, and specifically SHTM 03-01, being the ventilation for healthcare premises standards, at each stage of the Project. It was agreed that KPMG would not undertake a technical review in respect of this but confirm that the Standards were included within the design specifications.

2.3.2 A summary of our observations are detailed below, with further details provided in Section 4 of this Report.

2.3.3 Throughout all stages of the Project we have seen references made to the requirements to adhere to SHTM, and specifically SHTM 03-01 in respect of ventilation systems; in particular within the Board's Construction Requirements

("**BCR**") document which is the primary document at both the tender and Project Agreement[7] stages. The BCR stated that Project Co must comply with SHTM for the design of the Hospital and that all recommendations and preferred solutions contained within the SHTMs must be adopted as mandatory.

2.3.4 It appears that there has been confusion between NHSL and Project Co as to the application of these Standards throughout the Project. This appears to have stemmed from the EM, details of which were inconsistent with SHTM 03-01 from the tender process, as we describe below.

2.3.5 A version of the EM was included within the BCR at both the tender and Project Agreement stages. The EM was referred to within the tender document as detailing *"…the room environmental condition requirements of the Board required within each department / unit / space / area [of the Hospital]*[8]. The room environmental conditions included air change rates. There are inconsistencies within the tender process documentation in relation to the EM, with the BCR stating that bidders should *"…provide the Works to comply with the Environmental Matrix*"[9] and the tender submission requirements stating that whilst bidders were required to *"undertake their own design, the Board [has] provided a draft Environmental Matrix"* [10] and that *"bidders must confirm acceptance of the Board's Environmental Matrix, highlighting any proposed changes on an exception basis"* [11].

2.3.6 Our work has identified issues within the EM, including inconsistencies with SHTM 03-01 and discrepancies within the document itself. Specifically:

a) The version of the EM document provided by NHSL to bidders as part of the tender process, and referred to in the BCR as detailed above, included

[7] The Project Agreement being an agreement with IHSL for the design, build, finance and maintenance of the Project on 13 February 2015
[8] IPTD: Volume 3 Board's Construction Requirements, Rev C, Subsection B, B (page 9)
[9] IPTD: Volume 3 Board's Construction Requirements, Rev C, Subsection C, Section 8 (page 102)
[10] IPTD, Volume 1, Revision A, Appendix A (ii), Submission Requirements, Point C8.3 (page 105)
[11] IPTD, Volume 1, Revision A, Appendix A (ii), Submission Requirements, Point C8.3 (page 106)

reference to both the single bed cubicles and four-bed rooms in Critical Care as requiring four air changes per hour[12] ("**ac/hr**"). We understand this was not in compliance with SHTM 03-01 and should have been 10 ac/hr. This reference remained in subsequent versions of the EM; and

b) The guidance note at the front of the EM document, provided at the tender and Financial Close[13] stages of the Project, suggested that all Critical Care areas should be in accordance with SHTM 03-01, being the relevant part of the standards relating to ventilation, and *"10ac/hr Supply"*[14]. This is inconsistent with the content of the matrix, as detailed above. We note that this inconsistency appears to have been removed after Financial Close by the insertion of the words *'for isolation cubicles'*[15], suggesting that only 'isolation cubicles' in Critical Care should have an air change rate of 10 ac/hr. However, we were informed by NHSL that this change was made by the Project Co, but was not flagged to NHSL (see paragraph 4.4.10 for further details).

2.3.7 We have not been instructed to consider how the inconsistency made its way into the initial matrix. However, we have seen no evidence that any party to the Project identified the issue, specifically in relation to the incorrect air change rates having been applied to Critical Care rooms, until June 2019 (see paragraph 3.4.7 to paragraph 3.4.14 for further details).

2.3.8 NHSL told us they had not reviewed the EM in detail from a technical perspective and they reviewed it for 'operational functionality', as detailed in the Project Agreement (as referred to further in paragraphs 4.4.6 and 4.4.7 below). It was

[12] Reference Design Envisaged Solution – RHSC / DCN Environmental Matrix version third issue, dated 19 September 2012 (page 5)
[13] Being the date when the conditions of the financial agreement are fulfilled, prior to the funds being made available ("**Financial Close**")
[14] Document reference (tender version): Reference Design Envisaged Solution – RHSC / DCN Environmental Matrix version third issue, dated 19 September 2012 (page 2, note 15)). Document reference (Project Agreement version): WW-XX-XX-DC-001. Page 2, Note 15. Contained within Schedule Part 6, Construction Matters, Part 6 of the Project Agreement
[15] Full wording read: *"10ac/hr Supply for isolation cubicles"* in a version of the EM dated 26 November 2015

assumed by NHSL that any changes to the EM would be highlighted by Project Co for discussion with them, and that it would be in compliance with SHTM 03-01, as detailed in the BCR. Despite this, the "exception-basis" approach to highlight proposed changes, referred to at paragraph 2.3.5 above, may have contributed to an assumed position that the original document, provided as part of the tender process, was correct.

2.3.9 Despite our understanding that NHSL and its advisors did not consider that they had an obligation to review the EM in detail from a technical perspective, we have identified multiple instances of comments being provided by the 'Board'[16] on particular sections of the EM. These included those elements which specifically related to the four-bed rooms in the Critical Care department. However, at no point did these comments refer to there being incorrect air change rates for those rooms.

2.3.10 Through correspondence between NHSL and Project Co regarding the EM, we have seen evidence of Mott MacDonald (on behalf of the Board) reminding Project Co that they must comply with the BCR and SHTM and that the *"Board not commenting, does not remove that obligation on Project Co"*[17].

2.3.11 In addition to all of the above, in January 2019, the Board asked Integrated Health Services Lothian Limited ("**IHSL**")[18] for specific assurance that all critical ventilation systems were to be *"inspected and maintained in line with 'Scottish Health Technical Memorandum 03-01: Ventilation for healthcare premises"* [19]. IHSL confirmed in their response that all ventilation systems had been designed, installed and commissioned in line with SHTM 03-01[20].

[16] We understand from Mott MacDonald that the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board.
[17] Email from Mott MacDonald to Multiplex, among other recipients, on 17 October 2016 (document reference: 161017 MM-GC-002084). We understand from Mott MacDonald that the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board.
[18] The party that NHSL Board entered into a project agreement with for the design, build, finance and maintenance of the Project and who formed part of the Project Co
[19] Document: 10.11.4 31-01-19 IHSL.NHSL Plant Rooms Ventilation Systems
[20] Document: 10.11.4 31-01-19 IHSL.NHSL Plant Rooms Ventilation Systems

2.3.12 We have not been instructed to opine on the accountability of individuals or organisations in respect of the failure to identify the Issue and it is not within our area of expertise to consider the contractual implication of the failure. However, through our identification of the above matters, the following relevant observations have also come to light:

a) Lack of clarity in the Standards

Our work has identified that consideration of the Standards on a standalone basis, in relation to air change rates in rooms within the Critical Care areas of the Hospital, could be open to interpretation. Specifically, our review has identified that there is no definition of "Critical Care" in the Standards, and the extent to which "Critical Care" includes all types of rooms within that area of a hospital. Further, there is no explanation of the hierarchy which should be applied where different areas of the hospital overlap, for example, which standard should be applied to a 'clean utility' within a Critical Care unit.

However, the Project Agreement documentation, and specifically the BCR, referred to in paragraph 4.3.8 below, includes Clinical Output Based Specifications for each department. We note that the Critical Care Clinical Output Based Specification makes reference to the areas included in Critical Care with, for example, references to single cubicles, four bedded bays, isolation cubicles and clean and dirty utilities.

b) Opportunities to identify the Issue

It is our observation that, notwithstanding that the initial version of the EM issued by NHSL at the tender stage contained the inconsistency which ultimately resulted in the Delay, NHSL and its advisors did not regard the EM as their document and did not consider it their responsibility to ensure compliance with SHTM 03-01. Instead, NHSL considered the EM to be the responsibility of Project Co. NHSL considered it their responsibility to approve

it for 'operational functionality'[21] and it was for Project Co to highlight any inconsistencies between the EM and the Standards.

We have seen evidence that NHSL and its advisors did challenge and seek explanations in relation to certain aspects of the EM relating to specific rooms in Critical Care, but this did not include specific reference to the air change rates.

Regardless of the contractual responsibilities, our work identified at least three specific instances where errors regarding the details of the air change rates relating to the four-bed rooms could have been identified by either NHSL (and their advisors) or Project Co:

- **November 2016:** Correspondence between the Board[22] and Project Co referred to the air extraction of the four-bed rooms in Critical Care via the en-suite facilities. The specific comment noted by the Board was *"1-B1-063 Stated as supply of 4 ac/h, extract via en-suite, this room does not have en-suite facilities*"[23]. Project Co's response was *"Room extract rate added"*[24]. This suggests that both parties were in correspondence regarding a room in Critical Care (on the basis that rooms starting 'B1' were defined on the cover sheet of the EM as being located in Critical Care), which contained reference to four air changes an hour.
- **July 2018**[25]: A document entitled 'Multi Bed - Ventilation Amendment Proposal to Achieve Room Balance [pressure]' was provided by Project Co, and subsequently approved by an individual from NHSL. Whilst this document was focused on the pressure regime, it stated *"Retain the*

[21] As referred to a paragraphs 4.4.6 and 4.4.7
[22] We understand from Mott MacDonald that the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board
[23] REV 07 ww-xx-xx-dc-xxx-001 - signed copy. Environmental Matrix comments, Second Batch, NHSL reference 7 (page 4)
[24] REV 07 ww-xx-xx-dc-xxx-001 - signed copy. Environmental Matrix comments, Second Batch, NHSL reference 7 (page 4)
[25] Being the date of approval of the document 'Multi Bed - Ventilation Amendment Proposal to Achieve Room Balance'

supply ventilation at 4ac/hr…"[26] as part of the proposed solution against each of the four-bed rooms. This included rooms located in Critical Care, albeit this was not directly referenced on the document; and

- **February 2019**: As a result of a number of ongoing issues in dispute between NHSL and Project Co, an agreement was signed between the NHSL Board and IHSL on 22 February 2019 (the "**Settlement Agreement**"). The Settlement Agreement states *"The resolution of the Dispute submitted by Project Co through the Schedule Part 8 (Review Procedure) and agreed by the Board, is for 14 No 4 bed rooms to be balanced or negative to the corridor at 4 ac/hr"*[27]*.* This wording was approved by both parties.

Furthermore, we also identified one example of comments provided to the Project Co by Mott MacDonald[28] (on behalf of NHSL) referred to as *"…initial technical comments on draft 1 of the Environmental Matrix"*, dated 13 October 2014[29]. This document included 12 comments, one of which specifically refers to ventilation standards in respect of bedrooms stating *"Bedrooms 4ac/hr, SHTM says 6 ac/hr"* [30]*.* Whilst this comment was not specific to a Critical Care bedroom, this suggests that comments other than those relating directly to 'operational functionality' were raised by NHSL.

c) Role of the Independent Tester ("IT")

The IT advised KPMG that its role was to certify that the design had been built in accordance with what had been agreed between the parties. This is reflected in the IT's scope of work, as set out in paragraph 4.7.2. The EM had been used as the basis for this agreement between the parties and, as such, the IT did not consider that it was responsible for reviewing its accuracy.

[26] Multi Bed - Ventilation Amendment Proposal to Achieve Room Balance
[27] Settlement Agreement, Schedule 1, Part 1, Technical Schedule, Item 7 (page 30)
[28] Attached to an email from Mott MacDonald to Multiplex, among others, dated 14 October 2019. (Document reference: 141014 MM-GC-000399)
[29] Document reference: 141013 Environmental Matrix Comments
[30] Comment 7. Document reference: 141013 Environmental Matrix Comments

Instead, the IT stated that it expected both parties to the Project to have undertaken a detailed review of the EM.

2.4 Professional and technical advice

2.4.1 Our specific instructions were:

To understand what professional and technical advice was given to the NHSL Board, in particular when derogations were proposed, who agreed them and the risk assessments that were undertaken to reach a final decision.

2.4.2 A summary of our observations are detailed below, with further information provided in Section 5 of this Report.

2.4.3 A number of professional and technical advisors were involved throughout the Project. Specifically, in respect of the Issue pertinent to the Delay:

a) From the various documents we have seen, and the discussions we have held, there is evidence that, in arriving at the agreed resolution in the Settlement Agreement in respect of the changes required to the pressure regime to 14 of the four-bedded rooms, advice and support was provided to the Project Team by both technical advisors and internal clinical advisors, which was visible to the NHSL Board; and

b) We have seen evidence that Mott MacDonald was involved in the Project on an ongoing basis, specifically in respect of reviewing and commenting on the EM.

2.4.4 We have not been instructed, and it is not within our area of expertise, to consider the responsibility of external professional or technical advisors to identify this Issue. However, despite the extensive internal and external technical advice received in relation to the Project, the Issue was not spotted.

2.5 Governance arrangements

2.5.1 Our specific instructions were:

To establish the governance arrangements that were in place in relation to the Project and the line of sight of NHSL and SG, along with the escalation arrangements to NHSL and SG.

2.5.2 A summary of our observations are detailed below, with further information provided in Section 6 of this Report.

2.5.3 From the information we have seen, the governance structure surrounding the construction and commissioning of the Hospital was operating in line with that described to us and issues were being escalated through the appropriate channels.

2.5.4 Oversight of the Project had been delegated by the NHSL Board to the Finance & Resources committee (the **"F&R Committee"**), which included four executives from the NHSL Board. The F&R Committee established a Project Programme Board which had day-to-day responsibility for managing the Project (the "**Programme Board**"). The Programme Board did not report directly to the F&R Committee. Instead, any key issues arising on the Project would be reported to the Director of Capital Planning and Projects (the **"DCPP"**) or one of the Project's Executive Leads who would, in turn, escalate this to the NHSL Board and also inform the F&R Committee if the issue had an impact on the financing of the Project or its duration. As there was overlap between members of the various committees and boards, this facilitated the executive leaders of NHSL being kept informed of progress and issues.

2.5.5 Throughout our review, we have seen evidence of these governance arrangements operating in practice and it appears that, at each stage of the Project, personnel with the appropriate technical and clinical skills and experience were involved.

2.5.6 Further, where appropriate, external advice and guidance was sought. An example of such external advice being commissioned is the instruction of an independent third party to carry out checks following concerns raised by the

Infection Prevention & Control team (the "**IPC**") in relation to the reporting format for ventilation checks. A further example is in relation to changes to the design requirements where we have seen evidence of the involvement of technical specialists such as Mott McDonald, as well as clinicians and medical professionals from relevant departments within NHSL.

2.5.7 In addition to the governance processes within NHSL itself, we understand that there was regular dialogue between NHSL and SG throughout the Project, with escalation of issues where required, albeit this was typically more focused on financial rather than technical matters.

2.5.8 The timeframe for moving to the Hospital was set in February 2019 when the Settlement Agreement was signed. At this time, it was known that significant work was still required in order to complete the Hospital, including a number of critical areas which were required to be completed before the building could be considered habitable. Such works continued into July 2019, including a significant amount of post-completion works. As such, the time available for rectification of any identified problems, prior to the scheduled opening date of the Hospital of 9 July 2019, was challenging and left little margin for error. The governance process established in order to implement the required actions, set out in the Settlement Agreement, is discussed in Section 6.4.

2.5.9 Once the Issue which led to the Delay had been identified, steps were taken by NHSL to notify SG of the Issue which led to the decision by the Health Secretary to delay the opening of the Hospital. We note that, due to the urgency of the matter, the ultimate escalation of the ventilation issues was made direct to the NHSL Board and not through the normal governance structure.

3 Background to the Project and the Delay

What decisions were made by NHSL, when these were made, by whom and on what basis these decisions were taken in relation to the air ventilation issues and any other material issues that led to the Delay.

3.1 Introduction

3.1.1 In this Section, in considering the facts surrounding why NHSL made the decision to delay the opening of the Hospital, we set out the chronological background to the Project, based on information communicated to us and documents provided to us.

3.1.2 Whilst this summary provides a high-level introduction to the Project and its timeline, the summary focuses on the timeline of events that led to the Delay and, in particular, the period between the signing of a Settlement Agreement by NHSL and IHSL on 22 February 2019 (the "**Settlement Agreement**") [31] and the planned opening of the Hospital on 9 July 2019.

3.1.3 In preparing this summary, we have considered the decisions taken by NHSL in relation to the air ventilation issues (and any other material issues that led to the Delay), when these were made, by whom and on what basis these were taken.

3.2 Pre-financial close

3.2.1 The NHSL Board approved a capital-funded business case for the Hospital in 2008. This business case was approved by SG for a Children's Hospital only.

3.2.2 In November 2010, SG announced a Non-Profit Distributing[32] (**"NPD"**) funding route, not only in relation to the Children's Hospital but also the

[31] Referred to in the NHSL Annual Audit Report dated June 2019 (https://www.audit-scotland.gov.uk/report/nhs-lothian-annual-audit-report-201819)
[32] A form of public-private partnership procurement programme

Department of Clinical Neurosciences (the **"DCN"**). Various enabling works were required to be performed before construction could commence.

3.2.3 As a consequence of this preparation work, NHSL did not go to the market for a partner for the Project until November 2012. The Project was advertised in the Office Journal of the European Union (the **"OJEU"**), published on 5 December 2012. The NHSL Board proceeded to engage with three bidders during a nine-month competitive process. This process began in March 2013 and ended in December 2013. The winning bidder selected by the NHSL Board would then form an NPD company to deliver the Project.

3.2.4 Supporting the NHSL Board throughout this process were a group of professional advisors which included Mott MacDonald (technical advisors and project managers), MacRoberts (legal advisors) and Ernst and Young (Financial Advisors). The NHSL Board delegated responsibility for oversight of the Project to the Financial & Resources Committee (**"F&R Committee"**) which established the Programme Board which had day-to-day responsibility for managing the Project (the "**Programme Board**") and a smaller team (the **"Project Team"**).

3.2.5 The Programme Board comprised the Project Team as well as representatives from clinical and operational areas, the Director of Finance, the Director of Communications, an NHSL Non-Executive Director and other stakeholders.

3.2.6 In March 2014, the NHSL Board appointed IHSL as its preferred bidder. IHSL's team comprised Macquarie Capital[33], along with IHSL's subcontractors; Brookfield Multiplex (**"Multiplex"**), Bouygues Energies and Services ("**Bouygues**") and HCP Management Services Limited ("**HCP**") (collectively for the purposes of this Report referred to as **"Project Co"**).

3.2.7 The NHSL Board entered into a Project Agreement with IHSL for the design, build, finance and maintenance of the Project on 13 February 2015. It was a requirement for the Project design, installation and operation to comply with

[33] Initially referred to along with IHSL as Project Co

guidance issued by HFS. Further details of the standards issued by HFS[34] is set out in Section 4.2.

3.2.8 The planned scheduled opening date for the Hospital was July 2017.

3.2.9 As required by the Project Agreement, an IT was appointed by the NHSL Board, IHSL, and IHSL's funders, as an advisor to provide certain services independently, fairly and impartially in connection with the Project. Arcadis NV was appointed to this role in February 2015[35].

3.2.10 We understand that, at the time of financial close in February 2015, being the date when the conditions of the financial agreement are fulfilled prior to the funds being made available ("**Financial Close**"), the designs for the Hospital had not been fully developed. This included issues relating to the design of the ventilation systems, including comments on the pressure regime which would be in operation in the Hospital and whether this was in compliance with the relevant standard (Scottish Health Technical Memoranda 03-01 ("**SHTM 03-01**" or the "**Standards**").

3.3 Construction phase

3.3.1 In early 2017, it became clear that the Hospital would not be opening on time, as originally planned in July 2017. Three specific issues were identified at that stage:

a) The design of the high voltage power resilience mechanism;

b) Ventilation issues (pressure regime[36]); and

c) An issue with the provision of a Magnetic Resonance Imaging ("**MRI**") room.

3.3.2 Throughout the remaining period of 2017, discussions with Project Co on a) and b) above, and other emerging issues, continued without resolution. This

[34] The SHTM standards
[35] EC Harris was initially instructed, which was later acquired by Arcadis NV
[36] In relation to four-bedded rooms

ultimately resulted in both parties seeking legal advice and contemplating court action in order to resolve the issues in dispute.

3.3.3 It is our understanding that, in early 2018, the parties entered into a process of negotiated settlement. This included a number of technical workshops held in order that all of the unresolved issues could be raised and resolutions sought. At the workshops, which were held to consider the ventilation issues, there were detailed discussions regarding the required pressure regime in four bedded rooms.

3.3.4 In moving towards resolving this issue, a proposed solution was put forward in relation to the pressure in single bedrooms. This involved an adjustment of the air change rate from 6 air changes per hour ("**ac/hr**") to 4 ac/hr with 2 ac/hr natural ventilation, which we understand from NHSL meant this still achieved 6 ac/hr, but through a 'mixed mode'.

3.3.5 However, an issue remained regarding the pressure regime in multi-bed rooms. NHSL required 14 of the multi-bed rooms to be adjusted to have balanced or negative pressure. Four of the rooms considered as part of this process were located within the Critical Care areas of the Hospital[37]. Reference was made in the proposed resolution of this issue to an air change rate of 4 ac/hr.

3.3.6 During this period, it became apparent that, whilst some of the earlier issues appeared to be resolved or solutions proposed, there were a significant number of other technical issues emerging at the Hospital which required the attention of various project teams.

3.3.7 On 22 February 2019, the Settlement Agreement was signed by NHSL Board and IHSL with the ultimate aim of resolving all known issues and opening the Hospital in July 2019.

3.3.8 The Settlement Agreement set out a total of 76 issues identified by the parties that required resolution. These 76 issues consisted of (a) 73 known issues

[37] Per SHTM 03-01, Appendix 1, Critical Care areas of a hospital require 10 ac/hr

where a solution had been agreed[38] (the **"73 Issues"**); and (b) three technical issues, being:

a) Void detection;

b) Heater batteries; and

c) Drainage.

3.3.9 The Settlement Agreement included an agreed resolution to the ongoing issue relating to ventilation pressure in four-bed rooms (one of the 73 Issues) and also included reference to the agreement made in relation to the single bedroom pressure change.

3.3.10 In the context of achieving the air pressures required by NHSL, this agreed resolution stated *"…agreed by the Board, is for 14 No 4 bed rooms to be balanced or negative to the corridor at 4 ac/hr. The remaining 6No 4 bed wards remain as per the environmental matrix…"*[39]. Of these 14 rooms, four of these 4-bed rooms were located within the Critical Care area of the Hospital.

3.3.11 We discuss the background to this agreed resolution in further detail in Section 5.3.

3.3.12 In relation to the other three technical issues (i.e. not the 73 issues), listed at paragraph 3.3.8 above, solutions were agreed and a programme of work planned to implement the solutions prior to the opening of the Hospital in July 2019.

3.4 Operational phase

3.4.1 The IT provided a "Certificate of Practical Completion" on 22 February 2019. This meant that the construction phase of the Project came to an end and the

[38] The Settlement Agreement contains a table with 81 items, however eight of these stated 'NOT USED'

[39] Settlement Agreement, Schedule 1, Part 1, Technical Schedule, Item 7 (page 30)

Project entered into its operational phase. At this point, NHSL began payment of the annual services payment to IHSL.

3.4.2 During this operational phase, a significant number of outstanding works were required to be carried out by Project Co. In accordance with the Settlement Agreement, these works were performed in parallel with the NHSL Board's commissioning activities[40] for the Project.

3.4.3 Under the requirements of SHTM 03-01, a report on the ventilation system commissioning should be provided to the 'user department', 'infection control (where required)' and 'estates and facilities', following the commissioning[41]. In January 2019, the Project Team provided the Infection Prevention & Control (the "**IPC**") team with a copy of the proposed validation checklists that Multiplex was due to complete in respect of validating the ventilation system in the theatres. This was in order to ascertain if the checklists would be sufficient to meet the report requirements set out in SHTM 03-01[42].

3.4.4 In May 2019, following ongoing correspondence with the Project Team, the IPC confirmed that they were of the view that validation checklists in the format submitted by Multiplex were not sufficient for the purposes of the requirements and instead requested that the Project Team arrange a third party validation of the ventilation systems in order to obtain the required report.

3.4.5 On 30 May 2019, the Project Team contacted the IOM, a third party firm of specialist validation experts with experience in hospital ventilation. The firm that NHSL typically used for validation for hospital ventilation was conflicted from undertaking this testing, as it was used by IHSL[43].

3.4.6 On 5 June 2019, IOM attended a site visit and familiarisation at the Hospital and testing commenced on 17 June 2019. IOM's testing involved the validation of

[40] Commissioning activities were in effect the preparation for receiving patients into the Hospital e.g. ensuring the equipment and relevant supplies were in place, that staff were familiar with the layout and that the Hospital was cleaned
[41] SHTM 03-01, Part A, February 2014, Section 8.65
[42] The requirements are set out in SHTM 03-01, Part A, February 2014, Section 8.64 to 8.65
[43] H&V Commissioning Services Limited

critical ventilation systems at the Hospital, which focused on a list of critical areas provided to them (including theatres, isolation suites, Critical Care areas and recovery areas). We understand that, at the time of testing, some elements of remedial work were still ongoing, which restricted IOM's access to particular areas of the Hospital. Mott McDonald helped to facilitate IOM's testing.

3.4.7 SHTM 03-01 states that an air change rate of 10 ac/hr is required in Critical Care areas[44]. On 18 June 2019, IOM identified that some areas within Critical Care were not achieving 10 ac/hr. This was queried by IOM with Mott MacDonald and further testing was subsequently performed which was completed on 21 June 2019.

3.4.8 On 24 June 2019, IOM verbally informed the Programme Board of the ventilation issues that had been identified, in that the readings in terms of air change rates were not in line with SHTM 03-01, particularly in relation to operating theatres, isolation areas and Critical Care. This was followed by a written report dated 25 June 2019, which was circulated to the Programme Board, incorporating an issues log, which showed:

a) 12 issues with Operating Theatres;

b) 12 issues with air handling units; and

c) One issue with Critical Care (referred to as "HDU" by IOM).

3.4.9 On 25 June 2019, IHSL assured NHSL that all of the issues identified by IOM could be resolved.

3.4.10 Between 25 June 2019 and 1 July 2019, various meetings were held by the Programme Board, together with representatives from the IPC team, Mott MacDonald, IOM, IHSL and Multiplex. These meetings focused on operating theatres and sought to establish:

a) Whether the readings for ventilation found by IOM were correct;

[44] SHTM 03-01, Part A, February 2014, Appendix 1: Recommended air-change rates

b) Whether the readings related to a sample or the whole area;

c) Whether the readings were taken correctly;

d) Whether the issues found could be resolved; and

e) The minimum requirement for compliant operating theatres to allow the hospital to open.

3.4.11 As well as pursuing solutions to operating theatre ventilation, meetings were also held to try and establish, in relation to IOM's first reports regarding the Critical Care ventilation, whether:

a) IOM's measurements were in fact correct;

b) How extensive the results were across Critical Care;

c) What the air handling units could actually deliver if they were adjusted; and

d) The legal and contractual position in relation to these issues.

3.4.12 At 10am on 28 June 2019, a 'Joint Steering Group' meeting was held with NHSL, Multiplex and IHSL to discuss the emerging issues and the detail of IOM's report in relation to operating theatres. We understand that, detail of the Critical Care ventilation issues was not provided for this meeting and that the discussion focused on operating theatres. This was followed by a conference call later the same day to mobilise the necessary engineers to resolve issues with the operating theatres. At 4pm on 28 June 2019, IHSL informed NHSL that the operating theatre issues could be resolved from the following Monday (1 July 2019) but that the work required could not commence until the required engineers were available.

3.4.13 Additionally, on 28 June 2019, we understand that IOM informally provided more detail to the Programme Board regarding the issue of Critical Care air change rates. At this time, IHSL was asked whether Critical Care could, in fact, achieve the required rate of 10 ac/hr and IOM was asked whether the existing ventilation equipment could deliver 10 ac/hr.

3.4.14 On 1 July 2019, IOM provided more detail of the Critical Care ventilation issues it had found which indicated that the equipment was not capable of delivering 10

ac/hr. We understand from NHSL that on the same day, IHSL and Multiplex responded verbally that 10 ac/hr could not be achieved.

3.4.15 At 4:30pm on 1 July 2019, a meeting was held, called by the NHSL executive management team and the Project Team, which included the IPC Lead Nurse and Consultant Microbiologist, the Medical Director, the Children's Services Director and Associate Medical Director, and the Programme Board with two representatives of Multiplex, one representative of IHSL and one representative of IOM, to discuss the air ventilation issues in the operating theatres. Critical Care rooms were not discussed in this meeting as the NHSL Board required the opportunity to discuss this element of the issue internally first given its significance and that IHSL had confirmed that same day that 10 ac/hr could not be achieved using the current system.

3.4.16 Following this meeting, the Programme Board informed a representative of the NHSL Board of the issues with the air change rates within the Critical Care areas of the Hospital. This is the first time that the issue of Critical Care air change rates was escalated to a member of the NHSL Board.

3.4.17 On the evening of 1 July 2019, the issues with Critical Care were shared with other members of the NHSL Board which resulted in an urgent internal meeting being called at 9am on 2 July 2019. The Hospital was due to open only one week later, on 9 July 2019, and it was clear that the issues in Critical Care would not be resolved by this time. As such, attendees were tasked with investigating potential courses of action to address this situation. Attendees reported back at 1pm that day and a list of potential options was generated.

3.4.18 During 2 July 2019, the NHSL Board also briefed the Director General of Health & Social Care at SG and the Chief Performance Officer at NHS Scotland on the situation and the options.

3.4.19 Additionally, a conference call was arranged for 3 July 2019 between NHSL, HFS and Health Protection Scotland (**"HPS"**). HFS and HPS concluded that there was not enough information available to give assurance that the planned move to the Hospital should go ahead on 9 July 2019.

3.4.20 At 2pm on 3 July 2019, the NHSL Board met with the Chief Performance Officer for NHS Scotland in order to discuss the options available. This was followed by an email setting out the respective options.

3.4.21 A communications plan was created by NHSL on 3 July 2019 and press and staff briefings were scheduled for 4 July 2019.

3.4.22 On 4 July 2019, it was decided by SG that in order to ensure consistent and up to date briefings were provided to staff, patients and the wider general public, all announcements would be routed through the Cabinet Secretary.

3.4.23 At 4pm on 4 July 2019, the postponement of the move to the new site was announced by the Cabinet Secretary.

3.5 Summary

3.5.1 Whilst there were significant issues relating to ventilation throughout the life of the Project, the specific issue (being air change requirements in Critical Care areas not complying with the SHTM 03-01 standard) which gave rise to a decision to delay the opening of the Hospital was not identified to the NHSL Board until 1 July 2019. Indeed, this issue only became apparent to any member of NHSL when IOM completed its testing of the ventilation system and reported the issue in relation to Critical Care on 24 June 2019.

4 Design specifications and air ventilation standards

To determine the extent to which the design specifications with regard to air ventilation complied with the SHTM standards, and specifically SHTM 03-01, being the ventilation for healthcare premises standards, at each stage of the Project. It was agreed that KPMG would not undertake a technical review in this respect but confirm that the Standards were included within the design specifications.

4.1 Introduction

4.1.1 In this Section, we have considered the extent to which the design specification with regard to air ventilation included reference to, and complied with, the SHTM at each stage of the Project. Our consideration of this includes:

a) At Section 4.2, we summarise the standards relating to air ventilation which were relevant to the Project and provide the relevant extracts from SHTM;

b) At Sections 4.3 to 4.5, we consider whether the design specifications with regard to air ventilation were referred to at each stage of the key stages of the Project; being:

- Invitation to Participate in Dialogue ("**ITPD**") (the tender process);
- Financial Close, being the signing of the Project Agreement; and
- The Settlement Agreement.

c) At Section 4.6, we detail the process that was to be followed in order to make any changes to the Project Agreement and in turn to designs of the air ventilation;

d) At Section 4.7, we provide details on the ITs role in the Project, specifically in respect of its involvement in monitoring the works for compliance with the BCR, and in effect the design specifications; and

e) At Section 4.8, we provide details of assurances provided by IHSL in January 2019 in respect of compliance with SHTM 03-01.

4.2 SHTM standards

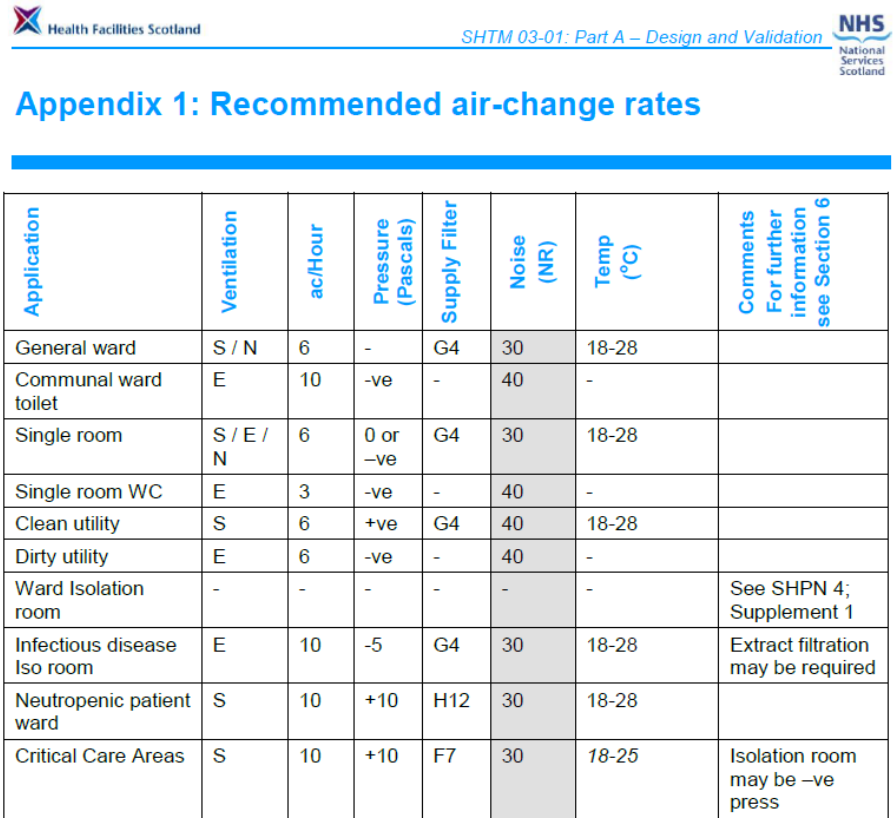
4.2.1 HFS provides operational guidance to NHS Scotland bodies on a range of healthcare facilities topics. As part of its role, HFS issues guidance publications known as "SHTMs". SHTMs give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare. The focus of SHTM guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle.

4.2.2 SHTM 03-01 'Ventilation for healthcare premises' is the relevant guidance which is pertinent to the ventilation issues and the Delay. Part A 'Design and validation', of the latest version of SHTM 03-01[45], provides details of the recommended air change rates for each component of a hospital[46].

4.2.3 Section 7 'Specialised ventilation systems', of the latest version of SHTM 03-01, contains design information for a range of healthcare ventilation applications, listing *'critical areas and high-dependency units of any type'* as being one of the departments that require a degree of specialised ventilation[47]. This section of SHTM 03-01 describes how ventilation systems should be designed for various departments and references recommended air-change rates as being contained within SHTM 03-01 Appendix 1: Table A1 ("**Appendix 1**"). An extract from Appendix 1 is provided below:

[45] Version 2 dated February 2014
[46] Within Appendix 1: Recommended air-change rates
[47] SHTM 03-01, Version 2 dated February 2014, page 82

Figure 1: Extract from Appendix 1: Table A1 of SHTM 03-01



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Appendix 1: Recommended air-change rates

Application	Ventilation	ac/Hour	Pressure (Pascals)	Supply Filter	Noise (NR)	Temp (°C)	Comments For further information see Section 6
General ward	S / N	6	-	G4	30	18-28	
Communal ward toilet	E	10	-ve	-	40	-	
Single room	S / E / N	6	0 or –ve	G4	30	18-28	
Single room WC	E	3	-ve	-	40	-	
Clean utility	S	6	+ve	G4	40	18-28	
Dirty utility	E	6	-ve	-	40	-	
Ward Isolation room	-	-	-	-	-	-	See SHPN 4; Supplement 1
Infectious disease Iso room	E	10	-5	G4	30	18-28	Extract filtration may be required
Neutropenic patient ward	S	10	+10	H12	30	18-28	
Critical Care Areas	S	10	+10	F7	30	*18-25*	Isolation room may be –ve press

4.2.4 It is noted from the above table that 'Critical Care Areas' require 10 ac/hr. As set out in Section 3 of this Report, the source of the Delay was rooms within the Critical Care department of the Hospital not meeting this required 10 ac/hr.

4.2.5 We have been unable to identify any definition of 'Critical Care Areas' within the SHTM. It is therefore unclear, from SHTM alone, if the definition of Critical Care Areas within SHTM 03-01 includes, for example, single rooms and clean utility areas located within Critical Care, or if these fall under the different recommended air change rates shown in the table above. However, we note that the Project Agreement documentation, and specifically the BCR, referred to in paragraph 4.3.8 below, includes clinical output based specifications for each department. The specifications relating to Critical Care (the "**Critical Care Clinical Output Based Specifications**") include references to the areas

included in Critical Care with, for example, references to single cubicles, four bedded bays, isolation cubicles and clean and dirty utilities.

4.2.6 We also note that SHTM 03-01 refers to, *"Specific requirements for hospital departments"* and states *"Specific requirements for individual spaces and departments are included in the Health Building Notes (HBNs) and Activity Database (ADB) A-Sheets, or Scottish Health Planning Notes (SHPNs)* [48]".

4.2.7 As previously mentioned, the Delay itself was as a result of both the 'single bed cubicle' and 'four bedded bays' within Critical Care being identified as non-compliant with the air change rates set out in SHTM 03-01. Individuals at NHSL are of the view that SHTM 03-01 is predominately focused on an adult care environment and does not explicitly consider the different ways in which children's hospitals manage patients in Critical Care, for example, through the use of four-bedded bays to cohort patients with the same infection at times when admission rates are high and Critical Care support required may exceed isolation room capacity.

4.2.8 Without clarity on the definition of Critical Care Areas in the Standards as a stand-alone basis and, in particular, in respect of how four-bedded bays should be classified under SHTM 03-01, the relevant air change rate for particular rooms could be open to interpretation.

4.2.9 NHSL are of the view that such four-bedded bays should be included under 'Critical Care Areas' in the table at Appendix 1 of SHTM 03-01, and included reference to four-bedded bays in their Critical Care Clinical Output Based Specifications. However, an alternative interpretation from the Standards alone could lead to them being classified under a 'General Ward', which carry different recommended air change rates.

[48] SHTM 03-01 V2 Part A paragraph 2.60

Previous standards

4.2.10 The SHTM standard that preceded SHTM 03-01[49] was SHTM 2025. Through review of the documents we have been provided in relation to SHTM 2025, we cannot see any reference to any recommended air change rates for Critical Care areas.

4.3 ITPD stage (March 2013)

4.3.1 The ITPD issued to bidders, dated 11 March 2013, makes reference to the specific room requirements for the Hospital (the **"Room Information**") being detailed in a number of documents, including[50]:

a) The BCR;

b) The EM;

c) The Schedule of Operational/Design Notes;

d) The Equipment Schedule;

e) The Equipment Responsibility Matrix;

f) The Draft Schedule of Accommodation; and

g) The Operational Functionality elements of the Reference Design.

4.3.2 As part of their response to the ITPD, bidders were required to develop 'Room Data Sheets' ("**RDS**") for 11 of the rooms within the Hospital. None of these rooms appear to be located in the Critical Care area of the Hospital[51]. The RDS were to incorporate the Room Information, as detailed above. RDS for the

[49] October 2011 was the date of the first publication of SHTM 03-01
[50] ITPD Volume 1, section 2.5.3 'Room Data Sheets'
[51] On the basis that the EM index refers to the department code for Critical Care being 'B1' and none of the 11 room references detailed in section 2.5.2 of the IPTD have the prefix B1

remaining rooms were to be developed by the preferred bidder prior to Financial Close.

4.3.3 We understand from NHSL that, of the documents listed above, it is only the BCR and the EM that refer to SHTM 03-01 and/or Critical Care. Details of these documents are set out below.

Board's Construction Requirements

4.3.4 The BCR are the NHSL Board's detailed requirements for the Project. The BCR included within the ITPD[52] make a number of references to SHTMs, as detailed in the following paragraphs.

4.3.5 Section 2.3 (NHS Requirements) of the BCR states that, *"unless the Board has expressed elsewhere in the Board's Construction Requirements, a specific and different requirement, the Facilities shall comply with but not be limited to the provisions of the NHS Requirements…"*[53]. These NHS Requirements include the following in relation to SHTM:

> ***"v. Health Technical Memoranda & Scottish Health Technical Memoranda (HTM & SHTM)***
>
> *Project Co shall, in relation to all SHTM and all HTM (except HTM where an SHTM exists with the same number and covering the same subject matter): take fully into account the guidance and advice included within such SHTM and HTM; ensure that the Facilities comply with the requirements of such SHTM and HTM; and adopt as mandatory all recommendations and preferred solutions contained in such SHTM and HTM"*[54].

[52] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013
[53] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Section 2.3 (page 22)
[54] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Section 2.3, part v. (page 24)

4.3.6 The BCR[55] makes direct reference to SHTM 03-01 on a number of occasions within the Project Agreement, specifically in Sub-Section C:

a) Section 5.2 Infection Prevention & Control:

"Project Co shall ensure all aspects of the Facilities allow for the control and management of any outbreak and/or spread of infectious diseases in accordance with the following:

…

f) Ventilation in Healthcare Premises (SHTM 03-01)"[56]

b) Section 8.1 Minimum Engineering Standards:

"The following is a non-exhaustive list of SHTM's, HBN's and HTM's applicable to the Facilities:

…

h) SHTM 03-01: Ventilation in Healthcare Premises"[57]

c) Section 8.5.3 Air Quality, i. Internal:

"Particular attention shall be given to the risk of cross infection within the hospital… Project Co shall demonstrate through submission of information to the Board as Reviewable Design Data for review by the Board…how the proposals facilitate the control and management of an outbreak and spread of infectious diseases, and in particular shall comply with the requirements of SHTM 03-01…"[58]

d) Section 8.7.8 (Mechanical Ventilation & Air Conditioning) also makes direct reference to SHTM 03-01 and how the "*Project Co shall demonstrate how the*

[55] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013
[56] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Subsection C, Section 5.2 (page 68)
[57] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Subsection C, Section 8.1 (page 104)
[58] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Subsection C, Section 8.5.3 (page 104)

proposals facilitate the control and management of an outbreak and spread of infectious diseases in accordance with SHTM 03-01…"[59].

4.3.7 Specific reference is also made to ventilation of 'isolation rooms' as being required to be designed and installed in accordance with SHTM 03-01[60].

4.3.8 Subsection D of the BCR sets out a number of specific clinical requirements, including the Critical Care Clinical Output Based Specifications[61]. We note that the Critical Care Clinical Output Based Specifications refer to *"SHTM 2025: Ventilation"* as containing 'design guidance' for the Project[62], as opposed to the updated standard, SHTM 03-01. As referred to in Section 4.2.10, these previous standards did not specify air change rates recommended for Critical Care areas.

4.3.9 Subsection B of the BCR defines the EM as detailing *"…the room environmental condition requirements of the Board required within each department / unit / space / area…"*[63]. Sub-Section C, Section 8, states that the *"Project Co shall provide the Works to comply with the Environmental Matrix"*[64]. We have provided further details on the EM below.

Environmental matrix

4.3.10 An EM was provided as part of the Room Information within the ITPD[65] (the "**ITPD EM**") from which the bidders were asked to develop their RDS and their design specifications.

[59] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Subsection C, Section 8.7.8 (page 119)
[60] ITPD: Volume 3, Board's Construction Requirements, Rev C, August 2013, Subsection C, Section 8.7.22 (Ventilation and Air Conditioning of Isolation Rooms) (page 124)
[61] B1 Critical Care, Clinical Output Based Specifications, dated January 2013
[62] Section 1.9 Design Guidance, page 15 of the B1 Critical Care, Output Based Specifications, dated January 2013
[63] IPTD: Volume 3 Board's Construction Requirements, Rev C, Subsection B, B (page 9)
[64] IPTD: Volume 3 Board's Construction Requirements, Rev C, Subsection C, Section 8 (page 102)
[65] Entitled the 'Reference Design Envisaged Solution – RHSC / DCN RDS Environmental Matrix'

4.3.11 The bidder's technical submission requirements contained within the ITPD referred to the EM in the following context:

> *"Whilst Bidders are required to undertake their own design, the Board has provided a draft Environmental Matrix as part of the ITPD documentation. Bidders must confirm acceptance of the Board's Environmental Matrix, highlighting any proposed changes on an exception basis"*[66]*.*

4.3.12 The EM details environmental standards (for example, temperature, heating, ventilation) on a room-by-room basis. The EM consists of a cover sheet 'index' showing the different department codes, and references the page on which the associated details can be found. Department 'B1' is listed as 'Critical Care / HDU / Neonatal Surgery'.

4.3.13 Following the index, there is a page of guidance notes which include[67]:

> *"**HDU bed areas** - Design Criteria - HBN 57 gives specific guidance as well as SHTM 03-01 - esp Appendix 1 for air change rates - 10ac/hr Supply…"*
>
> ***"Critical Care Areas** – Design Criteria – SHTM 03-01 – esp Appendix 1 for air change rates – 10 ac/hr Supply…"*

4.3.14 The main body of the EM includes tables detailing, for each department and each respective room, the corresponding environmental standards. These include, among other things, details of the temperature, heating, cooling and ventilation (including supply air change and pressure).

4.3.15 Despite the guidance note, referred to at paragraph 4.3.13 above, advising that all Critical Care Areas should be in accordance with SHTM 03-01 and, specifically, 10 ac/hr supply, we identified that the ITPD EM table for Critical Care

[66] Appendix A (ii) Submission Requirements, Section C8.3 (page 105)
[67] The ITPD EM, entitled 'Reference Design Envisaged Solution – RHSC / DCN RDS Environmental Matrix' version third issue, dated 19 September 2012 (page 2, note 15)) (Document reference: 20120919 Environment Matrix (ITPD))

(Section B1 – page 5[68]) includes the following types of rooms - 'Single Bed Cubicles', 'Open Plan Bay (4 bed)' and 'Open Plan Bay (3 cots)', all of which are detailed with supply air change rates of 4 ac/hr.

4.3.16 The ITPD EM was therefore inconsistent between the guidance notes and detailed content contained within it. The detailed content which stated supply air change rate of 4 ac/hr was also inconsistent with the Critical Care air change rate of 10 ac/hr detailed in SHTM 03-01. We understand the current Project Team are not aware of why the document states 4 ac/hr.

4.3.17 We understand from NHSL that, as part of the process of developing the capital-funded project (see paragraph 3.2.1), documentation relating to the design and build was produced. We understand that an EM was developed by the Design Consultant used for this capital scheme and a version of this was shared as part of the tender process[69].

4.3.18 We have seen a 'first issue' of an EM, which we understand was part of the capital scheme, which is dated 9 September 2010 and is described as 'Royal Hospital for Sick Children – Edinburgh, HK Doc - RDS Environmental Matrix', which within the 'B1 – Critical Care / HDU / Neonatal Surgery' section refers to 'open plan bay (4 beds)' as having 10 ac/hr and balanced pressure[70]. We note, however, that the ITPD EM is entitled 'Royal Hospital for Sick Children and Department for Clinical Neurosciences – Edinburgh Reference Design Envisaged Solution - RHSC / DCN RDS Environmental Matrix'[71]. The version control within the ITPD EM shows the 'first issue' of this document as being dated 3 February 2012 and not 9 September 2010 as referred to above[72]. However, from the dates detailed within them, it would appear that these are two different documents, but

[68] Reference Design Envisaged Solution – RHSC / DCN RDS Environmental Matrix version third issue, dated 19 September 2012 (page 5)

[69] The ITPD EM

[70] Document reference: RHSC RDS Environmental Matrix Sept 2010_iss1_rev-

[71] Document reference: Reference Design Envisaged Solution – RHSC / DCN RDS Environmental Matrix version third issue, dated 19 September 2012

[72] Reference Design Envisaged Solution – RHSC / DCN RDS Environmental Matrix version third issue, dated 19 September 2012

that the IPTD EM could be an iteration of the 'first issue' document[73] provided to us.

Preferred bidder letter

4.3.19 A letter was issued by NHSL to IHSL on 5 March 2014, advising that their final tender, submitted on 13 January 2014, had been accepted (the "**Preferred Bidder Letter**")[74].

4.3.20 As part of the Preferred Bidder Letter, IHSL was asked to *"…use its best endeavours to diligently develop…",* among other things, Project Co proposals and RDS'[75]. These technical schedules were to be *"…finalised in conjunction with the Board to ensure that both parties are satisfied that these technical Schedules robustly address[ed] the Board's Construction Requirements…"*[76].

Period between issue of Preferred Bidder Letter (March 2014) and Financial Close (February 2015)

4.3.21 During the period between NHSL issuing the Preferred Bidder Letter and Financial Close, we have seen evidence of ongoing correspondence between NHSL and Project Co in respect of comments on the EM. We understand from Mott MacDonald and NHSL that, when the 'Board' has been referred to in the below correspondence, this refers to comments from both themselves and the Project Team and not the ultimate NHSL Board. This correspondence includes the following:

a) Comments provided to Project Co[77] referred to as *"…initial technical comments on draft 1 of the Environmental Matrix"*, dated 13 October 2014[78].

[73] Document reference: RHSC RDS Environmental Matrix Sept 2010_iss1_rev-. Dated 9 September 2010
[74] Document reference: 7.1.13 Preferred Bidder Status Letter dated 5 March 2014
[75] Section 4.4 of Schedule Part 1 - Terms of Preferred Bidder Appointment (Document reference: 7.1.13 Preferred Bidder Status Letter dated 5 March 2014)
[76] Section 4.4 of Schedule Part 1 - Terms of Preferred Bidder Appointment (Document reference: 7.1.13 Preferred Bidder Status Letter dated 5 March 2014)
[77] Attached to an email from Mott MacDonald to Multiplex, among others, dated 14 October 2019. (Document reference: 141014 MM-GC-000399)
[78] Document reference: 141013 Environmental Matrix Comments

This document included 12 comments, one of which specifically refers to ventilation standards in respect of bedrooms[79]:

"Bedrooms 4ac/hr, SHTM says 6 ac/hr

Bedrooms have no extract

Bedroom en-suites 10 ac/hr, SHTM says 3 ac/hr

Bedrooms stated as positive pressure, SHTM says 0 or –ve pressure…"[80].

b) IHSL responded to the above comments on 27 October 2014. Specifically, in respect of comment 7 detailed above, IHSL stated:

"The scheme is based on the Reference design throughout which is essentially mixed mode with openable windows and 2/3rds mechanical supply air to all bedrooms. This gives physiological benefits with access to fresh air control by user and obvious Energy benefits. We have amended the environmental schedule to show the room being balanced which is provided by the opening window" 81.

c) An email from Mott MacDonald (on behalf of NHSL) to Multiplex[82], among others, attaching the notes from a meeting held on 11 November 2014. The notes attached state:

"Project Co shall update the Environmental Matrix to reflect the following Board comments"[83].

A specific comment relating to bedroom ventilation was:

[79] Comment 7. Document reference: 141013 Environmental Matrix Comments
[80] Document reference: 141013 Environmental Matrix Comments
[81] Document reference: 20141027 Environmental Matrix Comments
[82] Document reference: 20141111 RE Environmental Matrix NHSL Comments Feedback 3
[83] Document reference: 111114 RDD Part 4 Enviro Matrix comments

"Detailed proposal awaited on bedroom ventilation to achieve balanced/negative pressure relative to corridor."[84]

d) On 19 January 2015, Multiplex emailed sketches of the proposed pressure regime to Mott MacDonald and NHSL[85]. A report was also provided to Mott MacDonald and NHSL detailing Project Co's review of air movement within single bedrooms under various ventilation scenarios[86]. Mott MacDonald responded to the email containing the sketches with a number of comments, including:

"The critical factor from SHTM 03-01 for infection control will be the resultant pressure within the room being balanced with or negative to the corridor"[87]*.*

4.3.22 We note that throughout the above correspondence there is reference to ventilation and SHTM 03-01. However, there is no specific reference to Critical Care rooms and the focus of the discussions appears to have been centred on the pressure regime in the rooms, rather than air change rates.

4.4 Project Agreement stage (February 2015)

4.4.1 The Project Agreement, dated 12 and 13 February 2015, states that the overall responsibility of Project Co is to carry out the works *"so as to procure satisfaction of the Board's Construction Requirements"*[88]. Details of the BCR contained in the Project Agreement are detailed in paragraph 4.4.4 below.

4.4.2 The Project Agreement also includes a list of Reviewable Design Data ("**RDD**") and the status of the approval of such data as at Financial Close. Further details on this are provided in paragraph 4.4.5 below.

[84] Bullet point 4. Document reference: 111114 RDD Part 4 Enviro Matrix comments
[85] Document reference: 150129 MM-GC-000432
[86] RHSC – DCN Edinburgh. Air Movement Report For Single Bedrooms (Draft). Document reference: 13.01.15 20141127 air movement
[87] Document reference: 150129 MM-GC-000432
[88] Project Agreement, Schedule Part 6 (Construction Matters), Section 3 (Board's Construction Requirements), Revision I

4.4.3 The RDD relevant to air change rates is included within the RDS and the EM. We have provided details of the RDS and EM in paragraphs 4.4.8 to 4.4.12 below.

Board Construction Requirements

4.4.4 The references to SHTM 03-01 within the Project Agreement BCR[89] are consistent with those in the BCR provided at the ITPD stage, as detailed in paragraph 4.3.6 above. We note that the reference to SHTM 2025 in the Critical Care Clinical Output Based Specifications also remained in the Project Agreement version.

Reviewable Design Data

4.4.5 The process for RDD is detailed in Schedule Part 8 (review procedure) of the Project Agreement. RDD is classified as either approved or non-approved based on the classification level ascribed by NHSL Board Representatives[90]. Level A (no comment) or Level B (proceed subject to amendment as noted) are in effect approved (collectively "**Approved RDD**"), whereas Level C or Level D are classified as non-approved[91].

4.4.6 Appendix 1, Table A, of Schedule Part 8 (review procedure) of the Project Agreement provides details as to the meaning of the aforementioned approval levels against each category of RDD. The table refers to the Level A and Level B approvals for RDS' as follows:

> *"endorsement of any room data sheet means that Project Co may proceed to construct in accordance with the Submitted Item and that the Board is satisfied that the design and other information in the relevant room data sheet satisfies Operational Functionality."*[92]

[89] Project Agreement, Schedule Part 6 (Construction Matters), Section 3 (Board's Construction Requirements). Document reference: RHSC DCN BCRs A B C Rev I clean 230115
[90] Project Agreement, Schedule Part 8, Review Procedure, Appendix 1 (page 241)
[91] As detailed in Schedule Part 6 (Construction Matters), Part 5, Reviewable Design Data (page 27)
[92] Project Agreement, Schedule Part 8, Review Procedure, Appendix 1 (page 241)

4.4.7 NHSL has advised us that reviewing such documents for 'operational functionality' did not, in their opinion, consist of a technical review as to the extent to which they were in compliance with the Standards.

Room Data Sheets and Environmental Matrix

4.4.8 Relevant design data included within the Project Agreement includes the RDS and an updated version of the EM[93] ("**Project Agreement EM**"). The RDS contain environmental data for each room, including supply air change rates. We understand that the Project Agreement EM was a summary of the RDS.

4.4.9 We note that the Project Agreement EM format and design is similar to the ITPD EM, with the same index and a page of guidance notes. As with the ITPD EM, the Project Agreement EM guidance notes refer to Critical Care Areas design criteria being SHTM 03-01 and *"10ac/hr Supply"*[94]. However, again consistent with the ITPD EM, included within the 'B1' section of the Project Agreement EM[95] (referred to as 'Critical Care / HDU / Neonatal) are rooms referred to as 'Single Bed Cubicles', 'Open Plan Bay (4 bed)' and 'Open Plan Bay (3 cots)', all of which are detailed with a supply air change rate of 4 ac/hr. The Project Agreement EM therefore remained inconsistent between the guidance notes and detailed content contained within it. The detailed content which stated a supply air change rate of 4 ac/hr was also inconsistent with the Critical Care air change rate of 10 detailed in SHTM 03-01.

4.4.10 We note that, whilst the Project Agreement EM guidance notes refer to Critical Care Areas design criteria being SHTM 03-01 and *"10ac/hr Supply"*[96], that a later version of the EM, dated 26 November 2015, contains guidance notes that state *"10ac/hr Supply for isolation cubicles"*[97]. We understand from NHSL that the

[93] Contained within Schedule Part 6, Construction Matters, Part 6 of the Project Agreement. Document reference: WW-XX-XX-DC-001

[94] Document reference: WW-XX-XX-DC-001. Page 2, Note 15. Contained within Schedule Part 6, Construction Matters, Part 6 of the Project Agreement.

[95] Document reference: WW-XX-XX-DC-001. Section B1 – page 5

[96] Document reference: WW-XX-XX-DC-001. Page 2, Note 15. Contained within Schedule Part 6, Construction Matters, Part 6 of the Project Agreement

[97] Document reference: WW-XX-XX-DC-XXX-001 (rev 1)

addition of the words 'for isolation cubicles' in this version of the EM was never flagged as a change to the Project Team. We note that this version of the EM contains other parts of the guidance notes in red. This small change in the text had the effect of removing the inconsistency between the guidance notes and the detail in the matrix, as referred to above.

4.4.11 We note that the Project Agreement EM was classified as 'non-approved' at the date of the Project Agreement, with the Board requesting that Project Co update the EM to reflect a number of comments, including *"Detailed proposal awaited on bedroom ventilation to achieve balanced/negative pressure relative to corridor"*[98]. We have seen initial reference to this comment in November 2014, in an attachment to an email from Mott MacDonald to Multiplex[99] (see paragraph 4.3.21 above). We note that this comment remained in all versions of the EM provided to us, from the Project Agreement EM[100] to the EM included as part of a Settlement Agreement in February 2019[101] (see Section 4.5 for further details of the Settlement Agreement).

4.4.12 Whilst the EM was classified as 'non-approved' under the RDD process at the point of Financial Close, we have not identified any Board comments within the RDD document specifically relating to air change rates and Critical Care.

4.5 Settlement Agreement (February 2019)

4.5.1 As set out in paragraph 3.3.7, on 22 February 2019, a Settlement Agreement was signed by NHSL Board and IHSL. The Settlement Agreement contained a schedule detailing 73 items[102] which had been in disagreement between the parties and the agreed resolutions for each issue.

[98] Bullet point 4. Document reference: 111114 RDD Part 4 Enviro Matrix comments
[99] An email from Mott MacDonald to Multiplex, among others, dated 14 October 2019. (Document reference: 141014 MM-GC-000399)
[100] The document itself was undated but the Project Agreement was dated 12 and 13 February 2015
[101] We understand from NHSL that the version included within the Settlement Agreement was version 11 which is dated 25 October 2017
[102] Schedule 1, Part 1, Technical Schedule of the Project Agreement (Pages 26 to 54)

4.5.2 Two of these agreed resolutions were pertinent to the Delay and related to disputes between the parties as to the extent to which bedroom ventilation was in compliance with SHTM 03-01. Both of the resolutions in effect resolved to deviate from recommendations included within SHTM 03-01. Details of the agreed resolutions for these were as follows:

a) 'Item 7 – 4 bed ventilation': for *"14 no 4 bed rooms to be balanced or negative to the corridor at 4 ac/hr"*[103]; and

b) 'Item 13 – Single Bedroom Ventilation air changes'[104]: to decrease *"the mechanical air change ventilation rate within single bedrooms from 6 air changes per hour (6 ac/hr) to 4 air changes per hour (4 ac/hr)"*[105].

4.5.3 We have commented on the above resolutions further in Section 5.3 below.

4.6 Changes to the Project Agreement

4.6.1 In projects of any nature, it will often become necessary for changes to be made to design plans, which in turn may impact compliance to a contractual requirement. In this Project, the design and build were required to be in compliance with the BCR which refer to SHTM 03-01, among other standards. In effect this makes compliance with SHTM 03-01 mandatory. As such, in order to ensure changes were adequately reviewed and agreed upon, a process to make any required changes was necessary.

4.6.2 During the tender process, bidders could put forward proposed 'derogations', being proposed changes to the proposed project agreement (including the BCR). At Financial Close, any accepted derogations were then incorporated into the

[103] Schedule 1, Part 1, Technical Schedule of the Project Agreement (Page 30)
[104] We understand from NHSL that the details of this agreed resolution were those contained within Project Co notice of change dated 14 May 2018
[105] Project Co notice of change dated 14 May 2018, Section 1.0. Document reference: 180522 Schedule 16 Project Co Change Notice No 051

contractual drafting of the BCR. From the NHSL's perspective, these matters were assumed closed or completed at Financial Close.

4.6.3 Following Financial Close, any deviations from the BCR and the signed Project Agreement, proposed by Project Co, could only be initiated and approved through the Project Co Change ("**PCC**") process. A PCC was defined in the Project Agreement as being, *"a Change that is initiated by Project Co by submitting a Project Co Notice of Change to the Board pursuant to Section 5 (Project Co Changes) of this Schedule Part 16 (Change Protocol)"*[106].

4.6.4 We understand from the Project Agreement[107] and discussions with NHSL that the PCC process was as follows:

a) If Project Co wishes to introduce a PCC, it shall serve a Project Co Notice of Change ("**PCNOC**") to the NHSL Board;

b) The PCNOC shall set out the proposed PCC in sufficient detail to enable the NHSL Board to evaluate it in full. It should specify Project Co's reasons for proposing the PCC, indicate any implication of the PCC, indicate if any savings will be generated by the PCC, and request the NHSL Board to consult with Project Co with a view to deciding on whether to agree to the PCC and, if so, what consequential changes the NHSL Board requires as a result;

c) The NHSL Board shall evaluate the PCNOC in good faith, taking into account all relevant issues, including, among other things, whether the PCC *"may affect the quality of the Services and/or the Works or the likelihood of successful completion of the Works and/or delivery of the Services (or any of them)"*[108];

d) As soon as practicable after receiving a PCNOC, the parties should meet and discuss the matters referred to in it. We understand from NHSL, that on

[106] Project Agreement, Schedule Part 16, Change Protocol, Section1, Definitions (page 389)

[107] Contained within Schedule Part 16: Change Protocol Section 5: Project Co Changes

[108] Project Agreement, Schedule Part 16, Change Protocol, Section 5, Project Co Changes (page 418)

receipt of a PCNOC, the Project Team and its advisors (including Mott MacDonald and MacRoberts) would review and comment on it. Comments and amended versions would then pass between Project Co and the NHSL Board, as required; and

e) If the NHSL Board accepts the PCNOC (with or without modification), the parties shall consult and agree the remaining details as soon as practicable. Upon agreement, the NHSL Board shall issue a notice confirming the PCC, which shall set out the agreed details.

4.6.5 As part of the signing of the Settlement Agreement in February 2019, the resolution of a number of issues was reached. This incorporated a number of changes which had already been raised through the aforementioned PCC process, but had yet to be approved, along with further areas which remained in dispute and which were resolved in the Settlement Agreement. The agreed resolutions which had not been approved prior to the Settlement Agreement were termed 'derogations'. The agreed resolutions included, among others, two which were pertinent to the Delay. We have provided further details of these, and the professional and technical advisors involved in the approval of them, in Section 5.3 below.

4.7 Independent Tester

4.7.1 As part of the ITPD, an IT was required to be appointed as an independent resource to provide inspection review and certify completion in respect of the Project.

4.7.2 The IT was jointly instructed by the NHSL Board and Project Co as part of the Project Agreement. The scope of work of the IT[109] included, among other things:

a) Providing monthly reports and undertaking regular inspections during the works[110];

[109] Project Agreement, Schedule Part 13 'Independent Tester Contract', Appendix 1 'Scope of Services – Independent Tester Contact

[110] Scope item 1.1

b) Providing details of any tests carried out by Project Co, together with results obtained[111];

c) Reporting on the completion status of the Project, identifying any work that was not compliant with the BCR, Project Co Proposals', Approved RDD and/or the Completion Criteria[112];

d) Monitoring the works for compliance with the BCR and Project Co's Proposals and compliance with law[113]; and

e) Monitoring the detailed working drawings and specifications for a sample number and type of rooms which, in their professional judgment, is appropriate to be selected by the IT to verify that they comply with the Approved RDD[114].

4.7.3 In respect of identifying work that was not compliant with BCR, the IT stated that in its view the ventilation flow rates were compliant with the BCR and in particular the EM and RDS. We understand from the IT that, the flow rates are derived by the design consultant from the air change rates specified in the EM and RDS.

4.7.4 We understand from the IT that it reviewed the testing and commissioning results for compliance with the EM and RDS, as required by the Completion Criteria detailed in the Project Agreement[115]. The IT used the EM as the basis for this review process, as this information is the referenced criteria for compliance and it was the IT's understanding that this would have been reviewed by the NHSL Board.

4.7.5 Specifically, in respect of SHTM 03-01 and air change rates, we understand from the IT that, it physically witnessed a proportion of the commission testing of the flow rates, as undertaken by Multiplex's specialist sub-contractors, and reviewed the results of all the tests that were completed. We understand from the IT that,

[111] Scope item 1.3
[112] Scope item 1.2
[113] Scope item 1.9
[114] Scope item 3.2
[115] Contained within Schedule Part 10, Outline Commissioning Programme, Appendix B – Completion Criteria

in accordance with its scope of service, it did not physically test any systems but reviewed the following:

a) That the testing methodology was in accordance with CIBSE[116] commissioning code C;

b) That the equipment that was used for testing flow rate and velocity was within certification/calibration test dates;

c) That the testers were correctly recording the figures; and

d) That the flow rates and pressure were in accordance with the design of the system itself.

4.7.6 The IT advised us that the design flow rates were used as part of the design process and, as such, the IT would not be expected to replicate that design process or reverse it to obtain the actual air change rates.

4.7.7 The actual calculation of air change per hour rates was considered by the IT to be a design function and, as such, outside their scope of work.

4.7.8 Following discussions with the IT, and from reviewing a sample of the monthly reports produced by the IT, we note that, whilst there was reference to other ventilation issues prior to April 2018, there was no reference to any ventilation issues specifically in respect of four-bedded rooms until April 2018. The IT key issues report dated April 2018[117] states that the issue (no. 212) was raised in 2016, details of which are as follows:

> *"The IT understands that NHS Lothian and Multiplex are currently discussing an arrangement by which 14 of the 4 bedded rooms would receive negative pressure to the corridor ventilation systems. The IT is awaiting confirmation of this agreement in a format that would take preference to any other stated requirement."*

[116] Chartered Institute of Building Services Engineers
[117] The Royal Hospital for Children and Young People Edinburgh Key Issues Report No. 37, April 2018, Appendix D Compliance Issues Outstanding (reference nr 212, page 26)

4.7.9 Issue no. 212, as set out above, remains in the subsequent IT reports each month, with the September 2018 report including an additional explanation that Multiplex were *"…going to forward on the Aconex Transmittal document to progress close out"*[118]. We understand that the September 2018 report was the last report issued by the IT and that issue no. 212 was eventually rolled-up as part of the Settlement Agreement.

4.8 Compliance assurance from IHSL (January 2019)

4.8.1 In a letter dated 31 January 2019, a Project Co representative for IHSL, provided their responses to a number of queries raised by the NHSL Board regarding assurances in respect of plant rooms and ventilation systems. Specific assurance had been sought by the NHSL Board for IHSL to provide assurance that *"All critical ventilation systems [to be] inspected and maintained in line with 'Scottish Health Technical Memorandum 03-01: Ventilation for healthcare premises"*[119]. The IHSL's Project Co representatives response to this was "*Construction: - All ventilation systems have been designed, installed and commissioned in line with SHTM 03-01 as required, systems are maintained in such a manner which allows handover at actual completion to meet SHTM 03/01 standards*" [120].

4.9 Summary

4.9.1 Throughout all stages of the Project we have seen references made to the requirements of the Project Co to adhere to SHTM, including specifically, SHTM 03-01 relating to ventilation systems.

4.9.2 Our work has identified issues within the EM, including inconsistencies with SHTM and discrepancies within the document itself. Specifically:

[118] The Royal Hospital for Children and Young People Edinburgh Key Issues Report No. 42, September 2018, Appendix D Compliance Issues Outstanding (reference nr 212, page 25)
[119] Document reference: 10.11.4 31-01-19 IHSL.NHSL Plant Rooms.Ventilation Systems
[120] Document reference: 10.11.4 31-01-19 IHSL.NHSL Plant Rooms.Ventilation Systems

a) The version of the EM document provided by NHSL to bidders as part of the tender process, and referred to in the BCR, as detailed above, included reference to both the single bed cubicles and four-bed rooms in Critical Care as requiring 4 ac/hr. We understand this was not in compliance with SHTM and should have been 10 ac/hr. This reference remained in subsequent versions of the EM; and

b) The guidance note at the front of the document provided at the tender and Financial Close stages of the Project suggested that all Critical Care Areas should be in accordance with SHTM 03-01, being the relevant part of SHTM relating to ventilation, and "*10ac/hr Supply"*[121]. This is inconsistent with the content of the EM as detailed above. We note that, this inconsistency appears to have been removed after Financial Close by the insertion of the words 'for isolation cubicles'[122], suggesting that only 'isolation cubicles' in Critical Care should have an air change rate of 10 ac/hr. However, we were informed by NHSL that this change was made by the Project Co and was not flagged to NHSL by the Project Co (see paragraph 4.4.10 for further details). Despite this change, the EM itself still referred to single bed cubicles and four-bed rooms in Critical Care as requiring 4 ac/hr, which we understand remained not in compliance with SHTM and should have been 10 ac/hr.

4.9.3 We have not been instructed to consider how the inconsistency made its way into the initial EM. However, notwithstanding contractual obligations, it appears that there has been confusion between the parties as to the application of these Standards. This appears to have stemmed from a document which was contained within the tender documentation, a version of which was used throughout the Project, which included details on the environmental specifications

[121] Document reference (tender version): Reference Design Envisaged Solution – RHSC / DCN Environmental Matrix version third issue, dated 19 September 2012 (page 2, note 15)). Document reference (Project Agreement version): WW-XX-XX-DC-001. Page 2, Note 15. Contained within Schedule Part 6, Construction Matters, Part 6 of the Project Agreement

[122] Full wording read: *"10ac/hr Supply for isolation cubicles"* in a version of the EM dated 26 November 2015. Document reference: WW-XX-XX-DC-XXX-001 (rev 1).

of the Hospital, the EM. Elements of the EM were inconsistent with SHTM 03-01 from the tender process (which commenced in late 2012) onwards.

5 Professional and technical advice given to the NHSL Board

To understand what professional and technical advice was given to the NHSL Board, in particular when derogations were proposed, who agreed them and the risk assessments that were undertaken to reach a final decision.

5.1 Introduction

5.1.1 In this Section, we have provided details of the professional and technical advice given to NHSL, which was visible to the NHSL Board through the Project governance structure.

5.1.2 In particular, we have considered when derogations were proposed, who agreed them and the risk assessments that were undertaken to reach a final decision. In seeking to answer this point, in Section 5.3 below, we have focused on one of two changes to the Project Agreement that were pertinent to the Delay.

5.2 Professional and technical advisors

5.2.1 Throughout the Project, a number of advisors assisted NHSL in decision-making from a practical and clinical perspective, as well as from a technical perspective regarding designs and standards.

5.2.2 The Project Team itself consisted of technical and clinical professionals, whom we understand had many years of experience in the health sector. In addition to the Project Team, the other professional and technical advisors involved throughout the Project consisted of[123]:

a) Medical and non-medical experts from within NHSL;

[123] We understand Ernst and Young provided financial advisory support to the Project. We have not commented on their involvement in the Project further in this Section as they were not involved in providing technical advice

b) Mott MacDonald – external technical advisor and project manager;

c) MacRoberts – external legal advisor; and

d) IOM – an independent ventilation tester appointed on 30 May 2019.

Medical and non-medical experts from within NHSL

5.2.3 In order to assist with the development of clinical output specifications and any ongoing queries or changes throughout the Project, the Project Team had access to medical expertise within NHSL, such as the IPC team and clinical care teams for each department.

5.2.4 The IPC team had a nominated individual who worked with the Project Team. This individual was invited to the design meetings, although it was at their discretion if they attended. They were asked to comment on drawings shared with them and ongoing discussions were held with them. The IPC team members were predominantly involved to provide operational functionality advice (as referred to at paragraph 4.4.6 and 4.4.7), rather than to comment on technical elements, such as the specifics of SHTM 03-01.

5.2.5 The clinical care teams were involved in the development of the Critical Care Clinical Output Based Specifications for the Project (as referred to in paragraph 4.3.8 above) and also attended design meetings for their department(s). The Critical Care Clinical Output Based Specifications were initially drafted by the Project Team and then passed to the relevant clinical teams to obtain more specific input and confirmation on, for example, the types of patients going into the wards, what functions the rooms had and the specific requirements of each room. Each ward and department nominated who they were going to involve in these advisory teams. The Critical Care clinical team consisted of a lead consultant, a lead nurse and a charge nurse.

5.2.6 In addition to the clinical care teams and IPC, NHSL also had access to non-medical professionals within its workforce, such as, estates and facilities staff, along with other NHSL contractors, such as the Authorised Engineers. These individuals were available as advisors to the estates team, NHSL-wide, in order to assist with a wide range of technical design elements should the Project Team

feel they required further input. We understand from the Project Team that, such input was not required on a regular basis and would be limited to ad hoc queries.

Mott MacDonald

5.2.7 Mott MacDonald was appointed in 2011 in order to provide project management and design services for the Project[124]. We understand from Mott MacDonald that the design services related solely to 'enabling works'[125]. The 'Post Financial Close Support Services Proposal'[126], prepared by Mott MacDonald, specifies a "*Technical Advisory and Project Management Appointment*"[127].

5.2.8 Mott MacDonald worked alongside the Project Team in order to assist in day to day and ongoing matters, including attending weekly or bi-weekly project management group meetings, as well as meetings relating to proposed PCC.

5.2.9 To this end, Mott MacDonald provided input and assistance with ongoing matters through the RDD process, such as providing comments on the EM and being on hand to support in the drafting of contractual documentation, including those containing health standard guidance, such as the BCR.

5.2.10 We understand from both Mott MacDonald and NHSL that, neither of them ever undertook a detailed review of the EM against SHTM 03-01 and that they responded on an exceptions basis, as and when operational functionality queries came to light[128]. NHSL's understanding of the contractual terms was that it was the Project Co's responsibility to ensure the EM complied with the Standards.

5.2.11 We have seen evidence of the 'Board's' ongoing involvement in the review of the EM both prior to, and after, Financial Close. We understand from Mott MacDonald that, the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board. We have seen specific comments made by the Board (including specifically comments referred to as

[124] Document: Mott MacDonald and NHSL Board contract
[125] Required to be performed before construction could commence (prior to IPTD stage)
[126] Drafted in 2015
[127] NHS Lothian – RHSC + DCN, Post Financial Close Support Services Proposal.
[128] Operational functionality being as described at paragraph 4.4.7

'technical') in respect of air change rates and pressure within bedrooms. An example of this is provided below:

a) Comments provided to the Project Co[129] referred to as *"…initial technical comments on draft 1 of the Environmental Matrix"*, dated 13 October 2014 (being pre Financial Close) [130]. This document included 12 comments, one of which referred specifically to ventilation standards in respect of bedrooms:

> *"Bedrooms 4ac/hr, SHTM says 6 ac/hr*
>
> *Bedrooms have no extract*
>
> *Bedroom en-suites 10 ac/hr, SHTM says 3 ac/hr*
>
> *Bedrooms stated as positive pressure, SHTM says 0 or –ve pressure…"*[131].

b) Comments were provided by Mott MacDonald (on behalf of NHSL) in an email they sent to Multiplex on 17 October 2016[132] stating that:

> *"The Board have reviewed the Environmental Matrix and still has significant concerns on items that do not appear to comply with the BCR's.*
>
> *The Board notes the following general comments:*
>
> 1. *The Board has highlighted cells in blue and red bubble on the hard copy which require PCo review."*

The email went on to explain that *"Whilst the Board has noted general and specific comments above, the Board reminds Project Co that unless the Board has already accepted a derogation, it is Project Co's obligation to comply with the BCR's / SHTMS etc, and*

[129] We understand that both MM and the Project Team reviewed the EM and provided their collective comments to Project Co.

[130] Document reference: 20141027 Environmental Matrix Comments

[131] Document reference: 20141027 Environmental Matrix Comments. Comment 7

[132] Document reference: 161017 MM-GC-002084

the Board not commenting, does not remove that obligation on Project Co."

5.2.12 We note that the version of the EM with highlighted cells in blue and red[133], includes highlighted cells relating to four-bedded bays. Some of the four-bedded bays are included in the matrix part B1 which, as detailed in the index to the EM, is '*Critical Care / HDU / Neonatal Surgery*' (these bays being pertinent to the issue that led to the Delay). The specific NHSL comments included in the EM includes one that states, "*1-b1-063 Stated as supply air 4ac/h, extract via en-suite, this room does not have en-suite facilities"*[134]. We understand from NHSL and Mott MacDonald that, this comment was from a review of the 'operational functionality' detailed in the EM, as referred to at paragraph 4.4.6 and 4.4.7. However, at no point is the fact that the air change rates in this room is not in line with the SHTM 03-01 standard of 10 ac/hr noted. Project Co's response is *"room extract rate added"*[135].

5.2.13 The version of the EM referred to above was subsequently signed off by a member of the Project Team as 'Level B' per the RDD approval process. The covering email from Mott MacDonald (on behalf of NHSL) to Multiplex for the approval at Level B, dated 7 November 2016, states that:

"the Board have serious concerns over the upgrading Environmental Matrix to Status B considering some of the issues raised…being the same as the issues that had been raised since FC… However, as requested by Project Co, the Board has upgraded the Environmental Matrix to status B, noting the Board still does not believe the Environmental Matrix and resultant design complies with the Project Agreement."[136].

[133] Document reference: REV 07 ww-xx-xx-dc-xxx-001 - signed copy from C to D

[134] Document reference: REV 07 ww-xx-xx-dc-xxx-001 - signed copy from C to D. Environmental Matrix comments, Second Batch, NHSL reference 7 (page 4)

[135] Document reference: REV 07 ww-xx-xx-dc-xxx-001 - signed copy from C to D. Environmental Matrix comments, Second Batch, NHSL reference 7 (page 4)

[136] Document reference: 161107 MM-GC-002155

5.2.14 We note that, within this version of the EM, the air change rates included within the bedrooms listed in table B1[137] (relating to Critical Care as per the index to the EM) all remain at a supply air change rate of 4 ac/hr, consistent with previous versions of the EM.

5.2.15 The last version of the EM provided to us (rev 11) was dated 25 October 2017 and signed off at Level B for operational functionality (as referred to in paragraphs 4.4.6 and 4.4.7) by NHSL on 17 November 2017. The covering email from Mott MacDonald to Multiplex notes that:

> *"The Board would also like to note the design for single and multibedroom ventilation design being progressed by Project Co remains non compliant and this non compliance should either be rectified, a PCo change submitted for the Board's consideration or a dispute raised between the parties"[138].*

5.2.16 Mott MacDonald were also involved in correspondence regarding an ongoing dispute as to the bedroom ventilation pressure issues. For example, an email from Mott MacDonald (on behalf of NHSL) to an IHSL representative, cc'ing in Multiplex, on 5 June 2017[139] explains why Mott MacDonald believed a PCC was required in respect of the changes to the pressure within four-bedded rooms and why they were of the view that the proposed design was not in line with the Standards.

5.3 Advice sought in respect of changes to the Project Agreement

5.3.1 As mentioned in paragraph 4.5.2 above, two of the agreed resolutions, which formed part of the Settlement Agreement, were pertinent to the Delay in that they impacted the ventilation regime and in turn its compliance with SHTM 03-01. Details of the agreed resolutions for these were as follows:

[137] Page 5
[138] Document reference: 20171117 MM-GC-003531
[139] Document reference: NEW 170619 R.A.M-GC-000285 Bedroom Ventilation. Contained within email trail.

a) Item 7 – 4 bed ventilation: agreed resolution was for *"14 no 4 bed rooms to be balanced or negative to the corridor at 4 ac/hr"*[140]*;* and

b) Item 13 – Single Bedroom Ventilation air changes[141]: The agreed resolution was to decrease *"the mechanical air change ventilation rate within single bedrooms from 6 air changes per hour (6 ac/hr) to 4 air changes per hour (4 ac/hr)"* [142]*.*

5.3.2 There are interconnectivities in the history and context surrounding both of these agreed resolutions, which is described in the 'background to the agreed resolution' Section below. However, for the purposes of this Report we have focused on the detail of one of the agreed resolutions, Item 7 above, in order to illustrate the professional and technical advice sought in respect of it. Item 7 has not been previously approved through the PCC process and was therefore referred to as a 'derogation'. We have used this terminology when explaining the details of it below.

5.3.3 The Item 7 agreed resolution specifically relates to changes to the pressure regimes in the 14 four-bedded rooms, however the wording used in the agreed resolution also refers to an air change rate at 4 ac/hr.

5.3.4 Of these 14 rooms, four of them were located in Critical Care. These were four of the rooms identified by IOM in their report dated 15 July 2019, along with the single bed cubicles, as not being in compliance with SHTM 03-01, and specifically the required 10 ac/hr rate, ultimately leading to the Delay in the Hospital opening.

5.3.5 All versions of the EM provided to us, which detailed the air change rates being applied to each respective room within the hospital, referred to an air change rate of 4 ac/hr for the Critical Care bedrooms, notwithstanding the guidance note in the IPTD EM and Project Agreement EM versions (referred to at paragraph

[140] Schedule 1, Part 1, Technical Schedule of the Project Agreement (Page 30)
[141] We understand from NHSL that the details of this agreed resolution were those contained within Project Co notice of change dated 14 May 2018
[142] Project Co notice of change dated 14 May 2018, Section 1.0. Document reference: 180522 Schedule 16 Project Co Change Notice No 051

4.4.10) which referred to an air change rate of 10 ac/hr. Therefore this agreed resolution in the Settlement Agreement did not in effect ever change the air change rate that had been detailed in the EM, albeit it was in effect, inadvertently, 'approving' an air change rate in these rooms of 4 ac/hr.

Background to the agreed resolution

5.3.6 As mentioned above in paragraph 4.3.22, we have seen evidence that issues with ventilation in respect of bedrooms, albeit not specific to single or multi-bed rooms, were raised by the Board[143] as far back as October 2014. We understand from conversations with NHSL and Mott MacDonald that, as a result of these comments having been made, there were ongoing discussions relating to ventilation design. From the evidence of the continued correspondence between the Project Team and Project Co that we have been provided, there is no direct reference to four-bedded rooms until September 2016. Prior to this all references had been made to 'bedrooms' or 'single bed rooms'.

5.3.7 Project Co raised two derogation requests, dated May and July 2016 respectively[144], which specifically referred to single bedrooms. Mott MacDonald's response on behalf of the 'Board'[145] in September 2016[146] rejected the derogations and, whilst the derogations referred only to single bedrooms, NHSL's response included a specific reference to a four-bedded room[147]. We note that NHSL's response asked Multiplex if the Project Co could "*confirm how compliance with SHTM in relation to air change rates, balanced ventilation and room heat recovery [would] be met."* It is from this point in time that reference

[143] We understand from Mott MacDonald that the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board.
[144] Document reference (WW014): 03.06.16 Copy of 20160525 Derogation Deliverables - WW014. Document reference (WW015): 26.07.16 Derogation Deliverables - WW015-1
[145] We understand from Mott MacDonald that the 'Board' in this context refers to both themselves and the Project Team and not the ultimate NHSL Board.
[146] Document reference:160922 MM-GC-002006 - Boards rejection of WW014 and WW015
[147] "*4 bedded room 1-L1-100*". Document reference:160922 MM-GC-002006 - Boards rejection of WW014 and WW015.

appears to have been explicitly made to air pressure in multi-bedded rooms[148] as well as single bedrooms.

5.3.8 We understand from NHSL that, in late 2016, following one of the ventilation design workshops to discuss the ongoing ventilation issues, the Project Team highlighted to the clinical team that the air pressure for the four-bedded rooms had been designed to be positive. We understand that due to the Project Team's prior clinical experience, they were aware that this would not allow for patients to be cohorted with the same infection; in direct contravention to the practical requirements of those rooms.

5.3.9 Project Co had classified all four-bedded rooms as 'general wards' in respect of the pressure regime, under the guidance provided in the table illustrated at Figure 1, page 33, and thus felt that the rooms having positive pressure had been designed in compliance with SHTM 03-01 pressure requirements given that no pressure regime was specified in the guidance for 'general wards'. However we understand from NHSL that they and their advisors were of the view they should be classified as having the same function as a 'single room' under the guidance, and should achieve balanced or negative pressure.

5.3.10 We understand from NHSL that the Project Team, including the clinical team members, met with Project Co in order to discuss this issue. Following this meeting, discussions were held with the Children's Clinical Management team which included a Director, Associate Medical Director, Nurse Director and two Clinical Nurse Managers (noting that this was only an issue for the Children's Hospital and not DCN). The basis of these conversations were the implications of not being able to cohort patients and whether this was something they could manage with, without a change being made to the air pressure regime. We understand that the focus of these discussions were on the air pressure regime, and its impact on operational matters.

[148] The terminology 'multi-bedded rooms' and 'four-bedded rooms' is used interchangeably

5.3.11 As the above discussions confirmed that it was not possible to cohort patients and, in turn, use the rooms as needed without a change to air pressure, the clinical team undertook a risk assessment on 5 July 2017. Such risk assessments were required in respect of any proposed changes to the project design which may result in impact to patient care. The risk assessment was in effect an operational review, as opposed to a technical assessment, and required input from the various specialists who were party[149] to the original discussions in order to accurately reflect the discussed risks in the document itself.

5.3.12 The output of the risk assessment was discussed with Project Co. However, Project Co stood by its view that the design as it stood was compliant with SHTM 03-01 and therefore did not agree to a PCC, being the only way to formally agree a change to the design. This was detailed in the Programme Board Paper 'Compliance Issues and Commissioning Delay' dated 24 July 2017[150]:

> "*Ventilation to 4 bedded rooms – PCo design is based on an interpretation of a table contained in guidance where they have applied the ventilation regime for a general ward to the 4 bedded rooms. NHS Lothian, HFS Principal Engineer, the boards Authorising Engineer and Technical Advisors strongly disagree with this interpretation. A risk analysis has been carried out by the Clinical Director and the clinical Project Managers in collaboration with the Clinical Management Team and this work is felt to be essential in order for the new hospital to function safely and at optimal levels. Without the ventilation in the 4 bed rooms being installed correctly these areas will not be able to cohort and safely manage the influx of small children over the winter with infectious respiratory disorders as well as new and emerging conditions and also reduce the future proofing for these services."*[151]

[149] Parties involved are set out in an email dated 6th July 2017 'RE: Risk Assessment re 4 bedded room Ventilation'
[150] Document reference: Compliance Issues and Commissioning Delay 240717 FINAL
[151] Point 5.2. Document reference: Compliance Issues and Commissioning Delay 240717 FINAL

"Two 'without prejudice' meetings have now been held, chaired by IHSL with two of their Directors present, to see if the two parties, NHS Lothian and Multiplex, can come to some agreement on the way forward. These meeting follow numerous meetings between the respective technical teams and copious amounts of correspondence. To date there has been no movement from either side with both sides believing their interpretation/analysis is correct."[152]

5.3.13 In January 2018, given that there had been a number of months without progression on this matter, the Project Team asked the clinical team to revisit the original risk assessment to validate that it remained correct. The outcome of the updated risk assessment remained the same, being that 13 rooms required a change to their air pressure (three of which were in critical care) [153]. This dispute remained and, as such, was brought into the Settlement Agreement (see further details in the Section below).

Approval of the agreed resolution

5.3.14 As part of the Settlement Agreement, Project Co agreed to amend the pressure in 14 rooms[154], with the agreed resolution detailed in the Technical Schedule ("**TS**") of the Settlement Agreement reading as follows:

"The resolution of the Dispute submitted by Project Co through the Schedule Part 8 (Review Procedure) and agreed by the Board, is for 14 No 4 bed rooms to be balanced or negative to the corridor at 4 ac/hr"[155]*.*

[152] Point 5.4. Document reference: Compliance Issues and Commissioning Delay 240717 FINAL
[153] Record of General Risk Assessment, dated 28 January 2018. 13 rooms consisting of 7 for which it was "*essential"* to change, and 6 for which it was "*desirable*" to change.
[154] We understand from NHSL that one additional room was included in the Settlement Agreement, compared to the 13 rooms listed in the risk assessment
[155] Settlement Agreement, Schedule 1, Part 1, Technical Schedule, Item 7 page 30

5.3.15 The agreement was detailed in the document *'Multi Bed – Ventilation Amendment Proposal to Achieve Room Balance'*[156] which showed the 14 room numbers included. Whilst this document did not explicitly state that four of these were Critical Care rooms, the room number prefixes for Critical Care all start '1-B1' as opposed to a different letter. The proposed solution detailed for all four rooms stated "*retain the supply ventilation at 4ac/hr…*". This document was approved at 'Level A'[157] through the RDD process[158] in July 2018, the process for which includes review by Project Co, the Project Team, clinical teams and Mott MacDonald. We have seen no evidence that the air change rate of 4 ac/hr being applied to the Critical Care rooms was questioned during these reviews.

5.3.16 The approved document referred to in the paragraph above was then incorporated into the TS that ultimately formed part of the Settlement Agreement. We have detailed in Section 6.4 the governance arrangements in relation to approving of the Settlement Agreement and associated TS, and the extent of the awareness by the NHSL Board, and associated project committees, of the professional and technical advice sought in approving the content of the resolutions contained in the TS.

5.4 Summary

5.4.1 We have seen evidence of professional and technical advisors being involved throughout the Project. This included specific involvement in relation to ventilation issues.

5.4.2 We have not been instructed, and it is not within our area of expertise, to consider the responsibility of external professional or technical advisors to identify the Issue[159].

[156] Document reference: WW-SZ-XX-DC-XXX-010 Rev 7 Status A
[157] Signed by NHSL and Project Co on 26 July and 27 July 2018 respectively
[158] RDD process – in accordance with the levels as set out in the Project Agreement, Schedule Part 8 (Review Procedure), Clause 4.3 (page 239): Level A: No Comment, Level B: Proceed subject to Amendment as noted, Level C: Subject to amendment as noted, Level D: Rejected
[159] As defined in Section 2.2.1

5.4.3 However, in any event, we have seen no evidence that professional or technical advice identified the Issue prior to June 2019.

6 Governance and escalation arrangements

To establish the governance arrangements that were in place in relation to the Project and the line of sight of NHSL and SG, along with the escalation arrangements to NHSL and SG.

6.1 Introduction

6.1.1 In this Section, we consider the structure of the governance arrangements that were in place for the Project from the point of the Project Agreement onwards, and how matters were escalated through this structure to the NHSL Board and, ultimately, to SG. This is addressed in Sections 6.2 and 6.3 and in Section 6.4 we detail the escalation specifically in respect of the Delay.

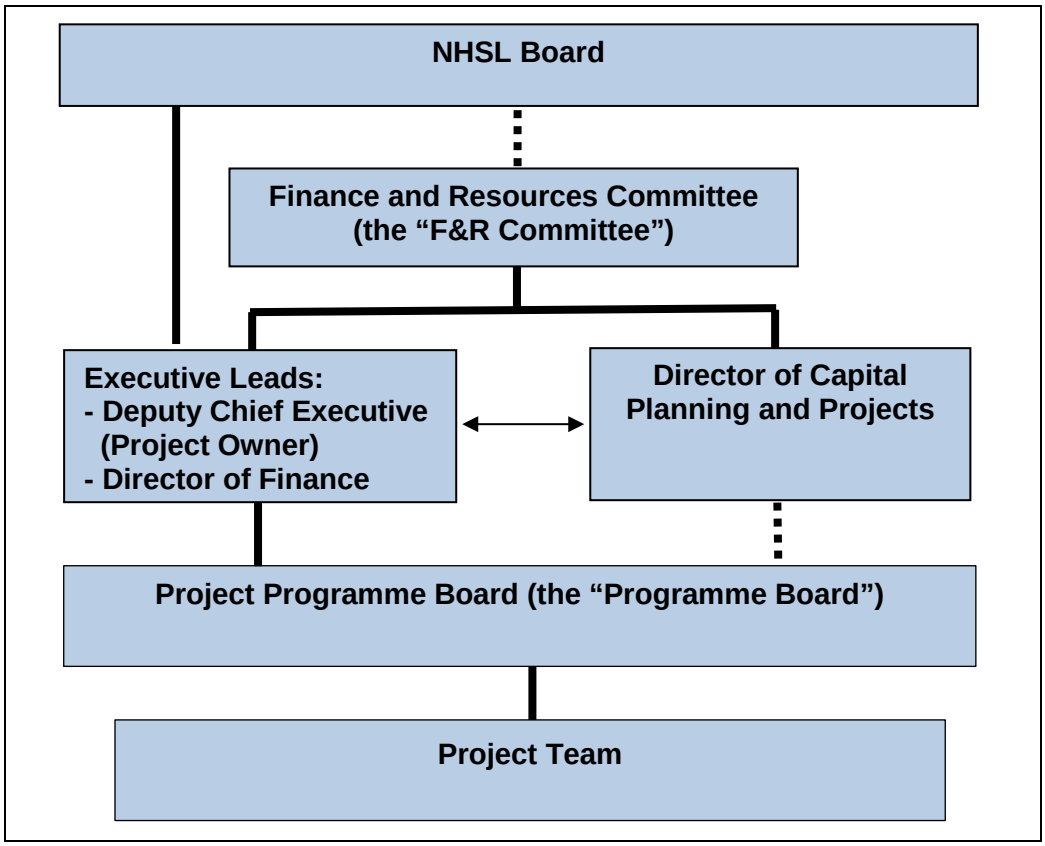
6.1.2 In undertaking our review of the governance and escalation processes, we have, to the extent that the information was available to us allows, sought to obtain evidence that these processes were working in practice.

6.1.3 As set out in Section 5.3, the Settlement Agreement specifically addressed two of the agreed resolutions which were pertinent to the Delay. As such, in Section 6.4, we have also separately presented the governance arrangements which, we understand from our discussions and document review, were in place in relation to the Settlement Agreement and its implementation.

6.2 Governance and escalation structure within NHSL

6.2.1 The governance structure for the Project within NHSL is set out in the diagram below:

Figure 2: Governance structure



6.2.2 We set out further information in relation to each party in the governance structure and their respective interactions with other parties in the paragraphs which follow.

6.2.3 This summary is compiled from interviews performed during the course of our work, together with a review of available documentation, including minutes of the NHSL Board, Programme Board and F&R Committee. The minutes we have

seen indicated that the governance structure was operating in line with that described and issues were being escalated through the appropriate channels.

Project Team

6.2.4 The Project Team, led by the Project Director, is responsible for the day-to-day Project activities and is located at the Hospital site. The Project Director provides a monthly presentation to the Programme Board, detailing progress on the Project and areas of non-compliance, along with next steps in terms of Project activities.

6.2.5 We are advised by NHSL that individuals were selected for the Project Team on the basis of their experience, both in their specialism and involvement in other projects. The Project Team includes individuals with diversified specialisms, including those with engineering, clinical, medical and operational backgrounds. The Project Team also includes technical advisors from Mott MacDonald.

Programme Board

6.2.6 As set out in Section 3 above, the Programme Board comprises of the Project Team as well as representatives from clinical and operational areas, the Deputy Chief Executive, the Director of Finance, the Director of Communications, an NHSL Non-Executive Director, a representative from SG and other stakeholders.

6.2.7 We understand that the Programme Board is responsible for oversight of the Project. Specifically, this involved:

a) Creation of a business case for the Project for approval by the F&R Committee and the NHSL Board;

b) Ownership of the procurement process and tender documentation, and the selection of three bidders (the final selection of the preferred bidder was performed by the F&R Committee); and

c) Oversight of the Project through to commissioning and completion.

6.2.8 The specific Terms of Reference ("**TOR**") for the Programme Board changed over time as the Project evolved from the tender stage, through to the construction of the Hospital and beyond.

6.2.9 The Programme Board meets on a bi-monthly basis, although we are advised by NHSL that ad-hoc meetings were also held during the course of the Project, as required. The Programme Board receives a progress update from the Project Director at each meeting. In our discussions with NHSL personnel, we were informed that any actual or potential issues in respect of the Project (including the technical details) would be discussed and challenged by the Programme Board. Further, we were advised that solutions put forward by the Project Team would also be challenged and either supported or rejected by the Programme Board.

6.2.10 Matters or recommendations that needed to be escalated were typically referred to the Director of Finance as one of the two Executive Leads (the other being the Project Owner (the Deputy Chief Executive)), or the DCPP . Issues escalated would include significant changes to design, cost escalation, issues of non-compliance identified and any matters where an opinion or a decision was required from the Executive Leads. The respective Executive Lead would escalate this to the NHSL Board and also inform the F&R Committee if the issue had an impact on the financing of the Project or its duration.

6.2.11 We were advised by NHSL that, during the course of a project, it is normal practice for the Executive Leads to regularly attend the Programme Board meetings. Due to the nature of the issues that were being raised on this Project, one or more of the Executive Leads attend the bi-monthly meetings, with the Deputy Chief Executive typically chairing the meetings.

F&R Committee

6.2.12 The F&R Committee comprises:

a) Four executive directors (who were also members of the NHSL Board); and

b) Seven non-executive directors.

6.2.13 It is our understanding that the F&R Committee has delegated authority from the NHSL Board in relation to financial governance, property and asset management strategy and strategic capital projects (such as the Hospital). The F&R Committee meets on a bi-monthly basis and its remit is to ensure that value for money is obtained from projects.

6.2.14 In advance of the F&R Committee's bi-monthly meetings, a paper called the Property and Asset Management Investment Programme ("**PAMIP**") is prepared by the DCPP for discussion at the F&R Committee. This document provides an independent view of all projects overseen by the F&R Committee and gives an update on the status of the Project and any issues identified which require the F&R Committee's consideration. The DCPP receives updates from the Programme Board and/or Project director on the status of the Project for the purpose of compiling this report.

6.2.15 We were advised by NHSL that, as the problems with the Project started to escalate around November 2015, supplemental documents were prepared by either the Project Director, DCPP or the Director of Finance, outlining these issues and recommendations which were submitted to the F&R Committee along with the PAMIP.

6.2.16 We were advised by NHSL that the papers submitted by the DCPP for any project should provide a level of assurance on specific individual matters. This level of assurance is determined by reference to NHSL's assurance model. This model provides a rating indicating the level of assurance attributed to the issue or action, being "Significant", "Moderate", "Limited", "None" or "Not Assessed Yet". This rating is included in any recommendations made to the F&R Committee. We have seen examples of this rating being given on some, but not all, of the documents we have reviewed. We understand from our discussions that, the F&R Committee would concentrate its review on those areas where the assurance rating attributed was "Moderate" or below.

6.2.17 A copy of the PAMIP and associated documents, together with a copy of the F&R Committee minutes, are approved by the NHSL Board (although, as noted above,

there is significant overlap between the members of the Programme Board, F&R Committee and the NHSL Board in any event).

6.2.18 A Risk Register is also provided to the F&R Committee. This is completed by the Project Director and uses a "RAG"[160] rating system to assess the risks identified and associated with the Project. A copy of the Risk Register is provided to the F&R Committee for review and to inform its view of the overall level of assurance and/or risk attached to the Project.

6.2.19 As noted above, the Programme Board does not report directly to the F&R Committee. Instead, the Executive Lead for the Project updates the F&R Committee in relation to key issues that have arisen with the Project, such as issues leading to instigation of the Dispute Resolution Process (**"DRP"**) and any significant changes to design. The F&R Committee also approves the business case for the Settlement Agreement, which is discussed in more detail in Section 6.5.

6.2.20 While the Programme Board does not have a direct reporting line to the F&R Committee, the F&R Committee does have clear sight of the operation and status of the Project and the issues that are being identified. We were advised by NHSL that, the F&R Committee provide challenge and ask questions in relation to the Project, which would normally be answered by either the DCPP or the Director of Finance (who is also a member of the F&R Committee). The technical information provided to the F&R Committee is less granular than at Programme Board level.

NHSL Board

6.2.21 As detailed above, the NHSL Board delegated its authority for the Project to the F&R Committee. The F&R Committee does not formally report into the NHSL Board. However, there is significant overlap in terms of membership.

[160] Rating methodology: "Red, Amber, Green"

6.2.22 While the NHSL Board has delegated authority to the F&R Committee, the minutes of the F&R Committee are reviewed and approved by the NHSL Board. As such, the NHSL Board has oversight of the status of the Project and any issues raised.

6.2.23 Issues escalated by the Programme Board to the Executive Leads for the Project are formally discussed with the NHSL Board. The NHSL Board either provide support to help resolve the position, or accept or reject recommendations made to it after discussion of the issue.

6.2.24 The Programme Board submits papers to the NHSL Board containing recommendations for the NHSL Board's consideration. An example of this was the Programme Board suggesting that the DRP should be implemented following issues of non-compliance having been identified on the Project.

6.2.25 The NHSL Board raise challenge and questions on papers presented in respect of the Project. However, this is not a technical level of challenge. The papers submitted to the NHSL Board make reference to the technical advice provided by professional advisors on the Project. We were advised that it is not expected that the NHSL Board will review the technical advice in detail.

6.3 Escalation process for reporting to Scottish Government

6.3.1 We understand that quarterly meetings are held between the DCPP, the Head of Property and Asset Management Finance (both of NHSL) and a representative from SG's Health Finance and Infrastructure team[161].

6.3.2 These quarterly meetings are in relation to all projects being undertaken by NHSL and primarily focus on the monitoring and future expectations for the funding of major projects.

6.3.3 The meetings (together with written correspondence between NHSL and SG) became more frequent when issues arose on the Project (for example, the dispute which arose between NHSL and IHSL and the Delay), in order to allow

[161] Part of SG's Capital Investment team within the Health and Social Care Directorate

the Cabinet Secretary to be briefed on the position, its potential impact on the financial aspects of the Project, and the proposed course of action.

6.3.4 We were advised by NHSL that a representative from SG has a formal role on the Programme Board. However, whilst they rarely attend in person, they receive a copy of the minutes of these meetings.

6.3.5 In addition to the above meetings, NHSL provide an annual report to the Chief Financial Officer (**"CFO"**) for Health and Social Care at SG, giving an update on ongoing and potential future projects, together with a monthly Finance and Performance report. We understand that there was (and remains) open dialogue between the NHSL Board and the CFO at SG to allow any significant issues to be raised and discussed.

6.3.6 In summary, there is a formal process, in addition to an open dialogue, for the NHSL Board to raise issues with SG.

6.3.7 We were advised by NHSL that, following the Settlement Agreement, there were no issues raised to the NHSL Board in relation to the Project that required escalation to SG, or that would prevent the Hospital opening as planned on 9 July 2019.

6.3.8 In Section 3, we set out the background to the ventilation issue which ultimately prevented the Hospital from opening and how this was communicated through NHSL to SG. As set out at Section 3, once the issues which caused the Delay were brought to the attention of the NHSL Board on 1 July 2019, these were escalated to SG within 24 hours.

6.4 Escalation in respect of the Delay

6.4.1 We note that, due to the urgency of the matter, when it became known, the ultimate escalation of the ventilation issues was made direct to Executive Directors (as members of the NHSL Board) and not through the normal governance structure (by-passing the Programme Board and F&R Committee). However, by virtue of their roles in other parts of the governance structure (as described below), members of the Programme Board and F&R Committee were

automatically involved in the discussions of the options that could be available to resolve the issue and not postpone the move into the new Hospital.

6.4.2 It is clear from the minutes that, ventilation issues regarding air pressure, although not specific to Critical Care, were discussed by the Programme Board and contributed to its recommendation to pursue a DRP, which was accepted by the NHSL Board. This issue was escalated through the normal governance process.

6.4.3 We have seen no discussion of, or reference to, issues specific to air changes in any of the minutes for the respective boards and committee. This is in line with our understanding that, the specific issue (being ac/hr requirements in Critical Care areas not complying with the SHTM 03-01 standard), which gave rise to a decision being made to delay the opening of the Hospital, was not known to NHSL until 24 June 2019, when IOM completed its testing of the ventilation system, and subsequently identified to the NHSL Board on 1 July 2019.

6.5 Governance arrangements in relation to the Settlement Agreement

6.5.1 In this Section, we summarise the governance arrangements that were in place in relation to the Settlement Agreement and its implementation.

Approval of the Settlement Agreement

6.5.2 As referred to in Section 5.3, we were advised by NHSL that the Settlement Agreement contained resolutions to a number of issues which had arisen during the course of the Project. We understand from NHSL that these issues had built up over time and came from a variety of sources, including the residual risk register, Project Co Changes, a list of outstanding works and proposed, but not yet approved, Project Co changes.

6.5.3 We understand from NHSL that, depending on how they had arisen, some of these issues had been subject to discussions between the Project Team, Mott MacDonald and Project Co. Such issues were raised with the Programme Board

and discussed and noted at the time they arose (for example, the ventilation issue relating to pressure in four bedded rooms).

6.5.4 The negotiated solutions to these issues became the TS that was incorporated into the Settlement Agreement. The governance around approval for the TS and the Settlement Agreement are detailed below.

6.5.5 As described in Section 6.2 above, pursuing the DRP was proposed by the Programme Board and approved by the NHSL Board. Once the approval to pursue the DRP was given, discussions centred around the content of the commercial proposal put forward by IHSL to resolve the issues and avoid litigation. This proposal formed the basis of the Settlement Agreement. The F&R Committee approved the Programme Board's recommendation to engage with IHSL to discuss their proposal and, consequently, the business case for the Settlement Agreement. The NHSL Board ratified this decision and delegated responsibility to the F&R Committee to authorise the Director of Finance and Deputy Chief Executive to sign the Settlement Agreement on behalf of NHSL.

6.5.6 The negotiations leading up to the Settlement Agreement were conducted by the "Principals Group", which comprised the Deputy Chief Executive and Director of Finance of NHSL, and Directors from IHSL and Project Co. Others were involved, such as the Project Director and DCPP, as appropriate.

6.5.7 We set out further information in relation to each party in the governance structure and their respective interactions with other parties in relation to the Settlement Agreement in the paragraphs which follow. As before, this summary is compiled from interviews performed during the course of our work, together with a review of available documentation, including minutes of the NHSL Board, Programme Board and F&R Committee. These minutes indicated that the governance structure was operating in line with that described and issues were being escalated through the appropriate channels.

Programme Board

6.5.8 We were advised by NHSL that the issues ultimately included in the TS had evolved over a period of time and been considered by the Programme Board as

they arose. We have seen evidence that, in July 2018, the Programme Board was advised by the Project Director that the TS was to be included as part of the Settlement Agreement.

6.5.9 NHSL advised us that a lot of the items in the TS were being negotiated between the Project Team and Project Co and that, as such, the TS evolved over time, with the items to be included in the TS being discussed between July 2018 and early 2019, prior to the Settlement Agreement being signed. We are advised that the TS discussed with the Programme Board included proposed resolutions to issues that were not "ideal" from NHSL's perspective, but were "safe" for the purposes of moving towards an agreed resolution in order to open the Hospital as soon as practicable.

6.5.10 We were advised that the Programme Board was aware that Mott MacDonald (as technical advisor) was consulted in the drawing up of the TS. This was on the basis that the Project Team had been working closely with the technical advisors on the Project. The Programme Board would be provided with details of each item in the TS so they could review this and raise questions on it.

6.5.11 We are advised that the Programme Board supported and approved the content of the TS within the Settlement Agreement, although there was no formal "sign-off" process for this. In addition, in November 2018, the Project Team identified a further three major issues for inclusion in the proposed Settlement Agreement, being the void detection system, drainage, and heater batteries.

6.5.12 The Programme Board minutes in February 2019 evidence that, by that point, the Settlement Agreement had been updated for these three issues, had been agreed between the parties, and would be signed soon.

F&R Committee

6.5.13 We were advised by NHSL that, the business case for the Settlement Agreement was detailed in a paper dated 25 July 2018, presented to the F&R Committee by members of the Programme Board. Challenges and questions by the F&R Committee were answered primarily by the Project Director and DCPP, but also by the Deputy Chief Executive and Director of Finance, as required. As

mentioned in Section 6.2 above, the business case for the Settlement Agreement was approved by the F&R Committee.

6.5.14 In January 2019, the F&R Committee minutes noted that the Settlement Agreement was to go to the NHSL Board for approval in February 2019.

NHSL Board

6.5.15 As described at paragraph 6.2.19, the F&R Committee provided copies of its minutes to the NHSL Board for review and approval as standard. However, a specific briefing and papers were provided to the NHSL Board by the Director of Finance on 6 February 2019 outlining the Settlement Agreement. Again, this demonstrates the escalation of issues through the governance process. We were advised by NHSL that whilst no technical details were provided regarding the proposed solutions, all papers submitted to the NHSL Board contained reference to the legal or technical assurance that underpinned the solutions. Given the governance structure in place, the technical assurance given in respect of the Settlement Agreement and TS was visible to the NHSL Board.

6.5.16 The NHSL Board minutes from February 2019 evidence that the NHSL Board discussed the draft Settlement Agreement, its terms and the potential risks arising from entering into it. Approval for the Settlement Agreement was granted by the NHSL Board on 6 February 2019 and the Deputy Chief Executive and the Director of Finance were authorised to continue negotiations on its behalf, and for either of them to sign the agreement.

Implementation of the Settlement Agreement

6.5.17 The Settlement Agreement was signed on 22 February 2019. The Hospital was due to open 19 weeks later, on 9 July 2019.

6.5.18 We understand that the implementation of the Settlement Agreement was monitored through weekly on-site meetings between the Project Team and Project Co, and that the Project Team was also on-site to observe the progress being made. At these weekly on-site meetings, Project Co were required to provide a plan of the work they were going to perform over the course of the

following week. We were advised that this gave the Project Team the opportunity to challenge or question the Project Co as appropriate.

6.5.19 In addition, we understand that daily "huddles" were held amongst specialist teams, such as with clinical representatives, who would discuss matters with members of Project Co to resolve any issues identified through commissioning, or to determine when access to certain areas could be obtained. We were advised by NHSL that these regular meetings ensured that progress was being made.

6.5.20 We were advised by NHSL that the above process provided assurance to NHSL that the work that had been agreed was progressing as planned.

6.5.21 NHSL advised that the final level of assurance would be given following the sign-off by the IT. The IT would be providing sign-off based on what was contained in the design specifications. The IT would expect that these design specifications had been agreed by both parties, i.e. NHSL and IHSL/Multiplex. NHSL therefore expected that, as the IT had signed off on the building, there would be no issues when IOM performed its testing. As such, NHSL was surprised when the ventilation system was highlighted to not be performing in line with requirements.

6.5.22 We were informed that, once the issue in relation to air ventilation had come to light through the IOM report, an internal Incident Management Team ("**IMT**") was set up by the NHSL Board to investigate the matters raised in the IOM report and to liaise with IHSL going forward in relation to how these matters could be rectified.

6.6 Summary

6.6.1 The governance processes and procedures surrounding the construction and commissioning of the Hospital operated in line with the structure that was put in place.

6.6.2 There was regular dialogue between NHSL and SG throughout the Project, with evidence of escalation of issues where required, albeit this was more focused on financial rather than technical matters.

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gov.scot

[redacted]

Caroline Gardner
Auditor General for Scotland
By email.

19 July 2019

Dear Caroline

Following Ms Freeman's decision, announced on 4 July 2019, to delay the move to the new Royal Hospital for Children and Young People (RHCYP), I am writing to provide you with detail on the reason for the decision, the work that she has instructed to identify the factors that informed the decision and determine the actions required to allow a move. I shall also provide an update on the support being provided to the Board.

On Tuesday 2 July, NHS Lothian informed the Scottish Government of an issue with the ventilation system at the Royal Hospital for Children and Young People in Edinburgh. We were advised that the air change in the ventilation system in the critical care unit did not meet the frequency required to meet the 2014 standard.

In the absence of certainty that the issue could be resolved within the very short timeframe available before services were to move to the new hospital, and given the late notice of the failure in the critical care unit, further assurance was required on all aspects of compliance with standards across the new hospital.

Ms Freeman therefore instructed that the planned move be halted in the interests of patient safety.

Work has been initiated to identify the solution needed to ensure the ventilation in the critical care unit in the new site meets the required clinical and safety standards.

NHS National Services Scotland (NSS) have been commissioned to undertake a detailed assessment of all buildings systems in the new hospital which could impact safe operation for patients and staff, recognising how infection prevention must always be embedded within the design, planning, construction and commissioning activities of all new and refurbished healthcare facilities.

This work will be phased, with assessment of water, ventilation and drainage systems prioritised, including the proposed fix for the ventilation unit. This will determine the timeframe for migration of services to the new hospital and a full report is anticipated in September.

Running in parallel, NSS will also provide assurance that current and recently completed major NHS capital projects comply with national standards. This work will take a risk-based approach and will inform development of the potential expansion of the current function and services provided by Health Facilities Scotland; including providing assurance going forward that NHS buildings meet extant standards.

Where required, additional specialist expertise will be secured by NSS to facilitate their work.

It is also important that we understand the factors, including information flow and timeframes, that led to the decision to delay the move to the new hospital. KPMG have been engaged to conduct an independent audit of the governance arrangements for RHCYP, to provide an external and impartial assessment of the factors leading to the delay. This work began on 15 July and in the first instance will focus on collecting and reviewing all pertinent documentation. This will inform next steps, including interviews with key personnel and timeline for reporting, and further clarity on this is expected within the next week.

I recognise that the cumulative impact of the significant work required to complete the move to the new RHCYP, together with the requirement for improved performance across a number of other areas, including scheduled and unscheduled care, cancer, delayed discharge and mental health, will place significant pressure on the leadership capacity of the Board. Reflecting the significance of this challenge, NHS Lothian have been placed at Level 3 of the NHS Board Performance Escalation Framework.

A formal Recovery Plan has been requested from the Board, setting out clear milestones to address each of the areas highlighted. A package of tailored support will be made available to the Board, in order to develop and implement the Recovery Plan.

Safe, effective and high quality clinical services continue to be delivered from the existing site in Sciennes and my officials are working very closely with the management of the Board and clinical professional organisations to ensure that we take all the necessary actions to allow the move to go ahead as quickly and safely as possible.

Ms Freeman has answered a GIQ yesterday updating Parliament of this information and she has also written to the convenors of the Health and Sport Committtee and the Public Audit and Post-legislative Scrutiny Committee.

I will keep you informed of progress of the reviews being undertaken and the timeframe for moving to the new hospital.

Yours sincerely

Malcolm Wright
Director General for Health & Social Care and Chief Executive of NHSScotland

OFFICIAL:SENSITIVE

Paper no:	**HSCMB/121/2019**
Meeting date:	**11/09/2019**
Agenda item:	**3**

Standing items and Updates

Title:	**NHS Lothian – Consideration of Escalation**

Background and Key Issues:	NHS Lothian was escalated to Stage 3 on 12 July 2019. Whilst there had been improvements in performance in several areas, challenges remained against a difficult financial background. Concern was also expressed over the cumulative impact of these issues and the significant work required to complete the move to the new Royal Hospital for Children and Young People. Since Escalation to Stage 3, an Oversight Group has been established, chaired by John Connaghan, SG Chief Performance Officer, NHS Scotland and NHS Lothian are currently developing a recovery plan which is due in the first week of November 2019. We have also received the two independent reports into the Royal Hospital for Children and Young People (RHCYP). Taken together, and based on advice from the Oversight Board for the RHCYP, our assessment is that there are a broader range of issues that require to be addressed before the building can be fit for occupation. The additional leadership capacity that will be required to deliver this programme may have an impact on the broader capacity of the Board in managing the Stage 3 escalation on a number of performance areas. There are also concerns about the management control of the project in the light of the points raised in the two reports. The issue has been identified in the Scottish Government accounts as a serious control failure.

Action(s) Required:	HSCMB is asked to consider: a) The level of escalation of NHS Lothian, in light of the further information provided in the KPMG and NSS reports and the further delay and related cost. Consideration on escalation should also be consistent with escalation of other NHS Boards; b) What that escalation would be and what specific support would be provided and action taken in response.

Author: **Date:**	**Director: Christine McLaughlin** **Date: 10 September 2019**

NHS Lothian – consideration of level of escalation

Purpose

1. To consider whether the current stage of escalation and associated support provided to NHS Lothian remains appropriate, in light of the two reports from KPMG and NSS which mean that there are more issues to be addressed before the building can be occupied, leading to further delay to the RHCYP project and associated costs.

Priority

2. Routine. Although a decision in advance of the release of the two reports and parliamentary statement would allow greater transparency and clarification of the level of support provided to NHS Lothian.

1.

Background

Escalation to Stage 3: 12 July 2019

3. NHS Lothian was escalated to Stage 3 on 12 July 2019. The reason for escalation as stated in the letter to the Chief Executive was as follows:

2.

3. "Whilst there have been improvements in performance in several areas of NHS Lothian's performance, at our meeting yesterday we discussed a number of challenging areas where further improvement is required and in the context of a challenging financial environment:

i. mental health, specifically at the Royal Edinburgh Hospital, but also the design and delivery of services across Lothian;
ii. cancer waiting times;
iii. scheduled care;
iv. unscheduled care;
v. delayed discharges; and
vi. paediatric services at St John's Hospital

4. I recognise that there are programmes of work already underway in all of these areas and recovery plans in place for scheduled and unscheduled care. A number of improvements are already being demonstrated. I am concerned, however that the cumulative impact of these issues, together with the significant work required to complete the move to the new Royal Hospital for Children and Young People, will place significant pressure on the leadership capacity of the Board and that in order to fully deliver on this challenging agenda for the people of Lothian and beyond, a tailored package of support is required. I have therefore concluded, on the advice of the Health and Social Care Management Board, that NHS Lothian should now be placed at Level 3 of the NHS Board Performance Escalation Framework

5.

6. Stage 3 is defined as 'Significant variation from plan; risks materialising; tailored support required'. Escalating a Board to Stage 3 allows Scottish Government to request a formal Recovery Plan with clear milestones and to provide expert input to support the implementation of that plan as required."

Update since Escalation to Stage 3

4. On the 6 areas of escalation, an Oversight Group has been established, chaired by John Connaghan, SG Chief Performance Officer, NHS Scotland and NHS Lothian are currently developing a recovery plan which is due in the first week of November 2019.
7.
5. Since escalation in July, we have received the two independent reports into the Royal Hospital for Children and Young People (RHCYP). Taken together, and based on advice from the Oversight Board for the RHCYP, our assessment is that there are a broader range of issues that require to be addressed before the building can be assessed as fit for occupation. As such we estimate that the timeframe for full occupation is likely to be autumn 2020 (with DCN potentially moving in spring 2020), although every effort will be made to bring this date forward. The original date at which the unitary charge was due to begin was July 2017. Overall therefore the hospital will be fully occupied 3 years later than originally planned and 1 year later that the most recent date of migration date of July 2019.
8.
6. The KPMG report presents a picture of a confused landscape which led to a lack of compliance with building standards and guidance and missed opportunities to identify and rectify those issues. It does not identify a single responsibility with one individual or organisation, but rather across NHS Lothian, external advisors and contractors.
9.
7. The range of issues identified in the NSS report are broader that the original risk that was identified in relation to critical care and will require actions to be taken in haematology and oncology, to general ward ventilation across the building and to drainage.
10.
8. The estimated cost to the public purse from this delay, including the cost of the earlier settlement agreement reached in February 2019, is in the region of £36.8 million. There are however costs of £24.7 million that will not be incurred due to the original delay to the project which meant that the unitary charge was not incurred as planned in 2017 and 2018. The net impact is therefore £12.1 million. On a project of £230 million this equates to a 16% additional cost or 5% net cost increase. The additional cost of rectification will have a knock on effect on the wider capital programme across the portfolio.
11.
9. The additional leadership capacity that will be required to deliver this programme may have an impact on the broader capacity of the Board in managing the Stage 3 escalation on 6 performance areas. There are also concerns about the management control of the project in the light of the points raised in the two reports.
12.
10. The issue has been identified in the Scottish Government accounts as a serious control failure.
13.

14. Consideration of further escalation

11. Legal advice received in relation to accountable officer status is that there is insufficient evidence to support removal of AO status at this time, primarily due to the dispersed nature of responsibility across the parties involved in the project. The points noted above lead to a consideration of escalation to Stage 4.
15.
12. A summary of levels of escalation is provided below, with details of stage 3-5 provided in Appendix 1.

Stage	Description	Response

Stage 1	Steady state "on-plan" and normal reporting	Surveillance through published statistics and scheduled engagement of ARs/MYRs
Stage 2	Some variation from plan; possible delivery risk if no action	Local Recovery Plan – advice and support tailored if necessary. Increased surveillance and monitoring Scottish Government. SG Directors aware.
Stage 3	Significant variation from plan; risks materialising; tailored support required	Formal Recovery Plan agreed with Scottish Government. Milestones and responsibilities clear. External expert support. Relevant SG Directors engaged with CEO and top team. DG aware.
Stage 4	Significant risks to delivery, quality, financial performance or safety; senior level external support required	Transformation team reporting to Director General and CEO NHS Scotland.
Stage 5	Organisational structure / configuration unable to deliver effective care.	Ministerial powers of Intervention.

13. Stage 4 is described as - Exceptionally where Scottish Government believes that a Board's capacity or capability requires enhancement to address local issues then additional direct management or transformation support can be provided. This will normally take the form of a transformation team led by a Scottish Government Director, Board Chief Executive or other responsible person appointed by the Director General and CEO NHS Scotland to initiate change and support the delivery of a sustainable transformation plan.
16.
14. In the case of NHS Lothian we have formal Oversight arrangements in place for the full programme of recovery and are working towards a recovery plan in early November.
17.
15. Further escalation at this point would be based on the RHCYP programme and our assessment of confidence, given the points noted above, in the ability of the NHS Lothian Board to deliver the programme of work, with its partners, to rectify the issues identified and secure occupation of the building at the earliest possible timeframe in order to mitigate risks in the current sites.
18.
16. Consideration will be given to the appointment of a Senior Programme Director to lead the RHCYP programme, rather than to provide oversight, reporting directly to SG. Such a move could possibly be made on the current stage of escalation, given this relates to one part of the programme. However we have not previously separated out stages of escalation within a board and to do so would require clear agreement of the reason for doing so. Given the level of technical rectification required, we would also want to consider providing additional independent technical advice to the Senior Programme Director.
19.

20. Recommendation

21.
17. HSCMB is asked to consider:
22.

a) Level of escalation of NHS Lothian to Stage 4, in light of the further information provided in the KPMG and NSS reports and the further delay and related cost. Consideration on escalation should also be consistent with escalation of other NHS Boards;

b) If yes, what specific support would be provided and action taken in response.

Christine McLaughlin
Director of Health Finance, Corporate Governance and Value and Chief Finance Officer, NHS Scotland
10 September 2019

35. Minutes of the Private Meeting held on 5 December 2018

35.1 The Minutes of the previous meeting held on 5 December 2018 were approved as a correct record.

36. Matters Arising

36.1 Regional Performance Update – it was agreed to defer discussion on this item until any other competent business.

37. Final Draft Supplementary Agreement RHSC/ DCN

37.1 Mrs Goldsmith advised that the issues around the RHSC/DCN were well rehearsed and she was hopeful that within a few days it would be possible to conclude the negotiations after issues around technical agreements had been resolved.

37.2 In terms of the recommendations in the circulated paper Board members received an update on the progress made in recent weeks on the conclusion of the settlement agreement with IHSL, and the associated commercial and technical agreements. The Board was asked to receive assurance that all negotiations on the terms of this settlement agreement had been supported by the Board's legal and technical advisers. In addition the Board approved the settlement agreement with IHSL and considered a short extension to the longstop date to allow all commercial and technical matters to be concluded. In conclusion the Board approved the terms of the following Board legal minute:

LOTHIAN HEALTH BOARD
BOARD MEETING
RHSC & DCN PROJECT

*Certified true copy extract from the private session of the meeting of the Lothian Health Board (the "**Board**") on 6th February 2019 at The Scottish Health Service Centre, Crewe Road South, Edinburgh (the "**Board Meeting**")*

1. PRESENT

1.1 **Non-Executive Board Members:** Mr B Houston (Chair); Mr M Ash; Mr M Connor; Ms C Hirst; Professor T Humphrey; Mr A McCann; Cllr J McGinty; Mrs A Mitchell; Mr P Murray; Mr W McQueen and Dr R Williams.

Executive and Corporate Directors: Mrs J Butler (Director of Human Resources and Organisational Development); Ms J Campbell (Chief Officer of Acute Services); Mr J Crombie (Deputy Chief Executive and Chief Officer, Acute Services); Mr T Davison (Chief Executive); Miss T Gillies (Executive Medical Director); Mrs S Goldsmith (Director of Finance); Professor A K McCallum (Director of Public Health & Health Policy); Professor A McMahon (Executive Director, Nursing, Midwifery &

SCOTTISH HOSPITALS INQUIRY

Hearing Commencing 26 February 2024

Bundle 13 – Miscellaneous

Volume 3

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