Written Statement

Andrew Peter Seymour Poplett

Introduction

1. My name is Andrew Peter Seymour Poplett and I am an Authorising Engineer (AE) and currently employed as an independent healthcare consultant, where my role is to provide input/expertise to health facilities in relation to ventilation and water. An AE acts 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 the relevant Health Technical Memorandum (HTM). The professional status and role required may vary in accordance with the specialist service being supported. The AE acts as assessor and makes recommendations for the appointment of Authorised Persons (APs), monitors the performance of the service, and provides an annual audit to the Designated Person (DP). To effectively carry out this role, particularly with regard to audit, the AE should remain independent of the operational structure of the healthcare organisation.

Experience and Expertise

2. I started my career as an apprentice engineer in 1985, working for an installation building services company. During my six years with the company I undertook various aspects of design, contract supervision and installation work across a range of industrial and healthcare building services projects. I was later made redundant from this role, however was successful in gaining employment within the NHS as an operational estates officer working at an acute district general hospital.

3. Within this role I began to specialise in ventilation within some of the critical units within that hospital as well as general estate management. Due to my role I moved between a number of NHS trusts, often as a result of trusts mergers. This led to me taking up the role of head of estates for a learning disabilities trust in Northumberland, which later merged to form the then largest mental health trust in England and I took up the role of head of property and planning. In 2010 an opportunity arose for me leave the NHS, which I chose to do and set myself up as an independent healthcare consultant. I now provide independent, impartial and bespoke consultancy services such as system auditing, personnel assessments and awareness training, compliance reviews and action planning to assist and guide clients through the maze of NHS, HSE guidelines, legislation and compliance. I act as an Authorising Engineer, and present my knowledge on subjects such as healthcare ventilation and water system management, service improvements and incident investigations.

4. During the last 12 years as a healthcare consultant, I have undertaken various support consultancy roles for a number of both private and NHS healthcare providers. Following the Health Technical Memoranda (HTM) 00 recognising the role of Authorising Engineer (AE) I began to practise as an AE for specialist ventilation and water, formally registering through IHEEM, which is the Institute of Healthcare Estates and Engineering Management. An Authorised Engineer is independent and appointed (normally by an NHS Trust or PFI Principle Service Provider) to take responsibility for effective management of safety guidance recommended by the Department of Health. Part of the AE role is to undertake an

annual audit of the operation of facilities. The role and remit of an AE is the same in both the HTM and SHTM.

5. I have been peer-reviewed and operate now as a registered AE for both specialist ventilation and for water separately. The peer review process (by the Institute of Healthcare Engineering & Estate Management (IHEEM)) provides a level of assurance that the AE has been assessed by their peers to work and act in a manner and standard which meets the institutes code of practice and conforms to the requirements of the HTM. This role keeps me busy and I currently practice as an independent AE for around 35 to 40 healthcare organisations, principally NHS trusts, but I also act on behalf of trusts for a number of private healthcare providers through Private Finance Inititive (PFI) or Local Improvement Finance Trust (LIFT) arrangements.

6. I'm an incorporated engineer registered with the Engineering Council and a full member of IHEEM. I'm an associate member of the Chartered Institute of Building Services Engineers, (CIBSE) and an affiliate member of the Institute of Fire Engineering. I am currently a committee member of the Northeast Regional IHEEM Committee and Chair of the national IHEEM ventilation technical platform. I am also a founder member of the Specialist Ventilation in Healthcare Society (SVH), which is an independent society that was set up by Malcolm Thomas, the President, who is the lead author of the previous and current ventilation Health Technical Memoranda (HTM), such as HTM 2025, HTM 03-01 2007, and lead author on HTM 03-01 2021. The SVH Society was formed in November 2014 with the aim of bringing together those who were practicing or wished to become Authorising Engineers (Ventilation) (AE(V)) or who have a more general interest in Ventilation in the Healthcare setting. At this time I am only a member of the SVH and have no details on the membership

but know it holds a register of practicing AEs and draws up competencies for prospective AEs. Those interested in ventilation for healthcare can also subscribe to association membership. A significant portion of the Society meetings is given over to discussing and clarifying interpretation of HTM 03-01 and other healthcare ventilation standards.

7. As a member of the SVH Society, I have been lead author and published various guidance or supplementary guidance documents on aspects of ventilation within a healthcare setting. I have also lead authored a couple of guidance notes and supplementary briefing notes for IHEEM's ventilation technical platform, and written numerous articles on ventilation-related issues and the management of ventilation for the Health Estates Journal, which is the magazine of IHEEM and healthcare engineering. Attached at Appendix 1is a summary overview of my work history and involvement with articles and guidance for the institutes and Societies to which I belong;

8. I have been asked to provide a written statement to the Scottish Hospitals Inquiry (SHI) with regards my knowledge and familiarity with the English guidance of the Health Technical Memoranda (HTM) 03-01, on which the Scottish guidance, Scottish Health Technical Memoranda (SHTM) 03-01, is based. I have also been asked to provide my knowledge and experience in design, installation, commissioning and validation of ventilation systems in hospitals. I have been provided with a list of questions from the SHI along with copies of SHTM 03-01. This statement seeks to answer the questions.

<u>General Principles of Hospital Ventilation</u>

9. I have been asked what scientific/professional disciplines underpin the knowledge relevant to healthcare ventilation. All of the principal engineering disciplines within hospitals are covered by a Health Technical Memoranda (HTM), of one variety or another. Generally speaking, there is an over arching HTM 00 standard which provides the framework for all other HTM's and then the engineering disciplines are divided into seven principal areas and an eighth that covers anything that the first seven do not. These areas would be decontamination of reusable medical equipment; medical gas pipeline systems; heating and ventilation; water; fire; electrical engineering; environmental and waste management issues, and then HTM 08 series covering anything that the previous ones don't, for example acoustic treatments, lifts and vertical/horizontal transportation systems and pneumatic tube systems. So ventilation in terms of its importance within healthcare has been covered by various HTMs or Health Building Notes (HBN) in various guises for well over 60 years. Guidance was developed as follows:

- Nuffield - Functions and Designs of Hospitals – 1955
- Operating Department - HBN26 – 1964
- Ventilation in Operating Suites - Lidwell – 1972
- Ventilation in Operating Departments, DV4 - 1983
- Ventilation in Healthcare Premises - HTM 2025 – 1994
- Specialised Ventilation for Healthcare premises – HTM 03-01 2007
- Specialised Ventilation for Healthcare premises – HTM 03-01 2021

The HBN's provide guidance under various clinical and non-specific engineering topics including infection prevention and control.

10. The majority of the evidence-based research specifically for ventilation is based on Dr Owen Lidwell's research paper dating back to 1972, which predominantly looked at the impact and effects of ventilation into hospital-acquired infections in operating theatres. This is where ventilation was identified as a contributing factor in reducing the risk of hospital-acquired infection during surgery. The Lidwell Report in June 1972 was the first published research and guidance into "Ventilation in Operation Suites" was issued by a joint working party from the Medical Research Council and DHSS. This report (frequently known as the Lidwell Report after the chairman of the joint working party), concluded that ventilation in theatres was required to ensure three key principles namely; bacteriological safety, the removal of anaesthetic gases, and comfort. The report still represents the principle research evidence for the current ventilation standards for theatre ventilation in the UK, although the recommendations and standards have been subject to development over time. Key elements of the research established the following standards;

- Bacteriological contamination concentrations (during surgical procedures) should not exceed 180 Colony Forming Units (CFU) per M^3 over any 5 minute period (clause 3.4). A CFU is a unit commonly used in microbiology to estimate the concentration of microorganisms/bacteria in a test sample.

- Airflow Must be maintained from clean to less clean areas even when a door is open (clause 4.3)

- The air change rate should not be less than 20 changes per hour (clause 4.4.4).

- Relative humidity should be controlled between 40 – 60% (clause 6.3.4).

These basic standards were further developed and refined into the first DHSS design guide for ventilation of operating departments issued in February 1983 and cross referenced in both HBN 26 and HTM 2025.

11. The primary driver for ventilating healthcare spaces, particularly within operating theatres, is the dilution of airborne contamination that is generated within the space because of surgical procedures or the people who are present. As well as dilution, you can use ventilation to isolate or control one area from another, so for an infectious patient, the aim is to try and ensure that the air which is being contaminated or potentially contaminated by that infection does not leak into surrounding areas.

12. The use of ventilation will also protect vulnerable immunocompromised or those patients who have virtually no immune system as a result of illness or treatment, so they are not exposed to potential airborne pathogen either from surrounding areas or indeed outside air. This patient group would include those receiving organ transplant, bone marrow transplant as part of their medical treatment. These patients have a reduced immune response so they do not reject the transplanted organ or material, but that makes them susceptible and vulnerable to pathogens that they otherwise might not be vulnerable to.

Role of Ventilation in hospital setting

13. I have been asked if I can explain what is the role and purpose of ventilation in a hospital setting. Ventilation is the provision of air which should be filtered where it needs to be filtered, and tempered into a space either to achieve minimum building regulation compliance for the dilution of contamination and an appropriate indoor air quality or, where certain clinical activities are being undertaken, to provide an

appropriate level of dilution for contamination that is potentially generated within the space to keep it at appropriate levels. The filtering of natural ventilation can be something as simple as a fly screen to prevent insects entering and landing on sterile instruments/areas. Any filtration however does add a degree of resistance to the airflow.

14. In providing an explanation of ventilation within healthcare setting I believe an understanding of contaminants will also assist in understanding why ventilation is important. Contaminants basically fall into three broad categories of airborne risk, these are viruses, bacteria and fungal spores. Each have their own unique properties but can be considered harmful to patients in some circumstances.

15. Viruses are generally very small, generally short-lived outside of the body, but not always, with COVID being an example. They transport or travel within a medium, such as water droplets or droplet nuclei expelled from a person.

16. Bacteria, of which there are many, some harmful, some not, can live for longer periods outside of the body, but they generally travel on something so the most typical example within healthcare is bacteria travelling on skin scales. With every human being constantly shedding skin scales they can carry bacteria on them and travel through an airborne route from one patient to another or from a member of staff to a patient.

17. The third contaminant is fungal spores, probably the longest-lived outside of the body. Anecdotal evidence has shown that aspergillus spores were found in the Egyptian tombs, which were sealed for 3,000 years and were successfully cultured having spent 3,000 years in a sealed chamber. Fungal spores can travel within the air and compared to bacteria and viruses they tend to be larger, but you are still

talking about particles that are between two and five microns typically in size. To put that in context, a human hair diameter is approximately 70 to 100 microns, so these are very small particles. Fungal spores can infect directly and travel for considerable distances in air with evidence suggesting spores can travel at least two miles from point of production.

18. If you have a particularly vulnerable patient who is neutropenic then it's not just about protecting them from the immediate environment of the hospital. For example if there is construction work ongoing around the hospital environment and the wind is in the wrong direction then a concentration of particles could be introduced to that patient environment. Many fungal spores and indeed many bacteria are ubiquitous in nature, they are found commonly all over the place. We probably breathe in aspergillus spores on a daily basis, and they have no impact on us whatsoever. However for certain clinical groups they can be a greater problem, from asthma attacks or respiratory disorder and for a very small minority of severely neutropenic or immunosuppressed patients, they can evolve into invasive aspergillus which can be fatal.

19. Ventilation is used to extract, and preferably at the point of production or generation, any contamination that is done as a result of clinical activity or indeed non-clinical activity. So, from the basics of a cooker hood extracting cooking fumes over the cooker it is extracted at the point of production rather than released into the general atmosphere, or within an operating theatre where point-of-use extraction is not practical or achievable, it provides a general dilution effect to the air from any contamination that's generated in the space.

20. My reminder for this is the phrase “the solution to pollution is dilution”, with the aim to make sure that there is dilution of any contaminant that’s developed within the space to a safe level, so it will not cause health issues for either the patient or indeed staff, visitors, or anybody else within the premises.

21. Ventilation can also be used to separate one area from another and generate clean air paths, so again linked to removing the contamination at the point of production or at least at a point where the contamination does not or is limited to travel through another person’s breathing zone. For example, if it is an endoscopic procedure and you have a patient with potential tuberculosis, part of the endoscopic procedure is to pass the camera down into the lung area and the patient has to cough to pass the camera into there. You don’t want the staff breathing in particles which that person expels as part of the cough if they have, or could have, TB. In this instance the recommendation and advice would be low-level extraction immediately behind the area where the patient is being treated. Any particulate that is expelled gets drawn away to low-level and extracted from the room, rather than passing through the staff breathing zone on its way to an extract grill in the ceiling.

22. Ventilation can also provide appropriate environmental room conditions, so temperatures and in some cases humidity control, which is where ventilation can become air conditioning. Air conditioning is the control of the environmental air within a space by temperature and humidity. So you can get recirculating air conditioning units because the units that you see mounted on the walls or in the ceilings, they don’t provide external fresh air but draw air from the room, heat it and cool it, and can adjust the humidity and put it back into the room. That can be necessary and essential for some clinical areas of activity, burns patients for example.

23. Humidity control is critically important because if you have a large wound site you would not want it to dry out or heal too quickly as it could cause subdermal scarring. So humidity control can be vital within certain clinical areas. In some previous versions of HTM humidity control was also critically important because of some of the anaesthetic agents that were used in sedation or anaesthesiology. These agents had the potential to be explosive or highly flammable and static electricity was a concern where electrical discharge through static discharge could act as an igniter for an explosive anaesthetic agent. Those anaesthetic agents are no longer used, and therefore humidity control, generally, for the control of static electricity, is less of an issue now than it used to be. So ventilation requirements change and evolve as clinical practice changes and evolves and indeed some of the medicines, some of the agents that are used within that clinical practice also change. Ventilation technologies and engineering solutions also change and develop over time.

Parameters of a ventilation system

24. I have been asked to explain what parameters a ventilation system can control, how they interact and their relation to patient safety and care. There are a number of parameters for healthcare ventilation systems. A system can have supply-only, extract-only, supply and extract ventilation and you can have natural ventilation, so it doesn't have to be forced. Opening a window does provide natural ventilation to a space and you can engineer natural ventilation to achieve air-change rates and effective dilution within a space. However, natural ventilation is influenced by the size of opening, the facing of the opening and any prevailing wind direction and most critically outside influencing factors such as temperature differential. If it is very cold outside and very warm inside then you will get more natural infiltration of

air through natural ventilation. If it is very warm outside and warm inside, you will tend to get less natural ventilation because of the thermodynamics of air but you will get natural ventilation.

25. I have been asked that given unpredictability of natural ventilation would there be areas of a hospital that it would not be appropriate. In certain circumstances natural ventilation may be the best option. I would not imagine anyone being comfortable with natural ventilation within a theatre setup but it has been done in the past. It could be used but it would depend on certain climatic conditions for it to work well. If using natural ventilation you would have to have a detailed understanding and assessment of the limitations and the factors that can influence it.

26. You can also get what's called "mixed-mode" ventilation, which is a combination of natural ventilation and some forced ventilation, or you can have full forced mechanical ventilation supply and extract via fans, which is normally ducted. All three groups can be appropriate in some settings within healthcare.

27. When we look at air change rate this is used to describe the volume of air that goes into the room or is extracted from a room to give a number of times that the volume of air within that space is changed per hour. This is a tailored measurement that is governed by the room size or dimensions. Within previous versions of HTM the ventilation rates were specified as litres per second. The problem is that litres per second into a very small room will give a very high air-change rate. If you measure the velocity of the air and you know the cross-sectional area that that velocity is achieving, that will give you a volume of air. That can be defined in a litres per second or metres cubed per hour. An air change rate is derived directly from the litres per second or metres cubed per hour divided by the room volume, because you

are getting air changes per hour. You cannot measure an air-change rate without measuring the volume-flow rate and the volume of the room. Air changes are used as a simplified method to identify the required dilution rate within a given space irrespective of its size.

28. There is a formula which I believe was established as part of Lidwell's original research, which is that one air change, provided that it is distributed evenly across the whole room, is likely or will remove 63 percent of any airborne contamination. Any subsequent air change will remove 63 percent of any residual air contamination. If you had a room with 100 particles of contamination the first air change would clear 63 percent, leaving 37 percent within the space, the second air change would clear 63 percent of that remaining 37, provided no additional contamination was released into the room and provided that the air distribution covered the whole room volume. This formula that is widely used and accepted nationally and subject to the proviso that no additional contaminants are introduced into the room. If it was introduced in the right-hand corner of the ceiling and extracted in the right-hand corner at low level, it is unlikely to achieve full-room air change because the air will short circuit and take the path of least resistance. Air-change rates are a shorthand method for summarising ventilation rates, but they have to be governed or looked at to make sure that they relate to whole-room distribution or dilution/scrubbing. I have been asked if Lidwell's formula and research on air change contamination is still used today and it is.

29. When we look at air pressure this is used to denote air movement from one space to another. So, if something is at a positive pressure, the air provided into the room is greater than the air extracted or leaking from the room and therefore you get a positive pressure. If you have more extract than supply you suck the air out of the

room, you don't necessarily provide air into the room so there's no supply air but air is drawn in through natural leakage, cracks under the doors and creates a negative pressure. Negative pressure is used to contain any airborne contaminant, that could be gaseous, that could be odour, or it could be particulate. Positive air pressure means that you provide that air into that space, and the air is pushed from clean to less clean spaces. And it's a phrase that is used on numerous occasions throughout the HTM, and it's part of this desired airflow path, making sure that air moves from clean to less clean areas to control any potential contaminant risk.

30. When you are seeking to maintain within a space either a positive, neutral or negative pressure it is a specified level of pressure cascade or pascal (a pascal is a standard unit of measurement for pressure) that is used to determine a degree of positivity or negativity. Neutral pressure is intended that if there are no openings and the room is in a normal state, it will not share air to the surrounding area or from the surrounding area into the room. However, that can be impacted and will be impacted when doors are opened because you will get temperature differential and in exactly the same way as natural ventilation can occur, you will get potential air either coming into or out of the space.

31. The pressure that you maintain within a space is governed not only by the ventilation rate but also the air permeability of that structure. For example you will never be able to pressurise a colander as it's full of holes, so it doesn't matter how much air you put in it, you are unlikely to ever achieve a pressure because it will balance naturally through all of the openings. The air permeability also ensures the desired clean air path. The air is drawn out from the area where you want it drawn out from and it doesn't leak out of other surrounding areas. It can be linked to areas such as fire strategy and smoke strategy as well to ensure that areas stay isolated

from another area in the event of smoke transmission. So air permeability is the test method that we use to ensure that spaces can achieve a desired pressure cascade, be that positive or negative.

32. As you introduce air to a space or extract from a space you generate a pressure profile, either positive or negative. If there was no ventilation in a room it would be considered at neutral pressure. If you introduce supply air and don't have forced extract air you will generate a positive pressure within that room provided that room doesn't have too many leaks. If the door is open then it won't create a positive pressure because the air will stabilise between the point where it was introduced and the surrounding area. That's the interaction between pressure and air change, the amount of air that you put in and the amount of air you extract out, linked to the integrity of the construction of the room, the air permeability, will determine the pressure cascade that can be achieved.

33. On looking at air filtration rate this is generally considered to be based upon a desired internal air quality, driven by the surrounding external air quality of the specific geographic area of the hospital. If the location of a hospital is inner city centre with large volumes of traffic, the external air quality is likely to be poorer than if you have a hospital out in the countryside. If you have a hospital sited by a coast or subject to high salt levels, coastal environment, then that again can impact the level and quality of filtration that you have in your system to provide the required indoor air quality of a space.

34. There are times where the filtration is there to protect the equipment, including the air handling equipment. So the initial filter that is fitted, the pre-filter as it is normally called or the return-air filter on an extract system, is generally there to

protect the mechanical engineering device from contamination and blockage. The final filters are then used to provide a finer grade of filteration to a desired air quality that the patient requires. In cases where a patient is neutropenic and susceptible to ubiquitous fungal spores in the air, you would filter to a higher grade standard. If you are manufacturing pharmaceuticals within an aseptic pharmacy suite then your concerns would be that the drugs are not contaminated by any air within the area, and that is where the use of High Efficiency Particulate Air (HEPA) filters or ultra-filters are brought into effect. They filter down to a far finer degree to keep particles out as much as practically possible and can be used in any setting where particulate size or concentration is critical.

35. The ventilation parameters are co-dependent and interlinked and within a healthcare setting they are fundamental in infection prevention control, fire strategy and smoke transmission. The dilution effect of air reduces the concentration of contaminants within the space, depending upon the patient, whether they are infectious or at risk of infection. The pressure cascade is used to provide assurance that there is a positive pressured space so airborne contamination can't enter, or it's a negative pressure space so contamination can't leave through uncontrolled means.

36. If you changed one of the supply or extract air-change rates without adjusting the other proportionally, you would almost certainly have an impact on the pressure cascade because if you put less air in but drew more air out, you could turn an area from positive pressure to negative pressure.

37. When looking at a room that has both supply and extract ventilation and you adjust one and not the other, then you will definitely impact the pressure cascade of that room. It won't necessarily reverse it as it depends upon the scale of the change,

but it will have a more definitive impact. The air-change rate is derived from either the supply or the extract. So if a room has 10 air changes and you wanted positive pressure, and you had both supply and extract within the room, you could put in 10 supply air changes and extract out 8 air changes. That would give you a net positive pressure compared to adjacent areas. However, if you had 10 extract air changes and 8 supply air changes, you would still only have 10 air changes, but you would extract 10 air changes, 8 of them from the supply air that you'd introduced and two air change equivalents through natural leakage into the room. An air-change rate isn't supply plus extract, it's whichever one is the greater that gives you the air change for the room.

Setting Parameters for rooms

38. I have been asked to explain what ventilation parameters are set for specific areas or rooms within a hospital. The HTM 03-01 2021 specifies some areas with recommended ventilation rates within chapter 8 and there is a table listed in Appendix 2 of the document to be used as a guidance for typical spaces. This table shows the air change rate, pressure cascade, filtration grade that's needed, temperature is specified and then there are some additional comments and advisory notes where supplementary guidance may need to be sought. All of these have a fundamental role in patient care and safety., as highlighted in Chapter 2 of Part A HTM 03-01. They were selected because they reflect the typical rooms that are detailed in Chapter 8 of Part A HTM 03-01 and are typical to what you will find in a vast majority of acute hospital settings. The whole of HTM 03-01 is written specifically for acute care medicine but it doesn't require an A&E department to be an acute care facility. If it's a surgical centre it would need to comply to 03-01 because of the operating theatres, critical care, and ward areas. For places like a

dental practice, or GP, or mental health facility, or a care home, or one of the other myriad of healthcare providers, you need to assess the appropriateness of applying HTM 03-01 to the clinical risk profile. Some of them will be similar, some of them will be markedly different.

39. For example an operating theatre will typically require at least 22 air changes per hour, however the final air change rate is derived from the design and what is within the room. If you have a lot of equipment in that room that generates an awful lot of heat, such as robotics, CT scanners, imaging devices then it may be that the air-change rate needs to be considerably higher. It is driven by the minimum air-change rate for infection control, which according to HTM 03-01 is at 22, but it may be that it requires 35 because of the heat gains from within the space.

40. If you have a clinical activity which is not defined within the HTM, what it should be possible to do is for the clinical team to look at similar patient environments and determine the correct minimum level of ventilation requirements. So, for example, there is no renal dialysis unit listed within chapter 8 of HTM, however, there is a listing for invasive treatment rooms. The hospitals will have rooms whereby, clinically, a comparison should be able to be made that if it is an invasive procedure that would typically be done in a treatment room then it would 10 air changes and 10 pascal positive air pressure for the right environment for a renal dialysis room. Ultimately that would be an infection prevention discussion between IPC, Clinicians, and Microbiologists with advice sought from engineers in a collaborative process, discussing what was going to be done in the room, any chemical a:gents or anaesthetising being used. All of these play a factor into the right level of ventilation for that space.

41. The decisions taken on setting these parameters would be driven by the clinical activity within that space. If you have a critical care area then you will have more vulnerable patients than those on a typical medical ward or a daycase ward or another type of patient environment. It's also about the length of time and duration that a patient, or indeed a member of staff, would be exposed to a potential risk. Within an Outpatient department the patient exposure is very limited due to the short duration in which patients are seen and treated. However an in-patient may be in for at least 24 hours, if not longer, so their potential exposure is over a much more extended period and therefore potentially requires different ventilation rates. It's also about the staff exposure, for example those working within dentistry probably see a different patient every 20 minutes but the dentist and nurse are likely to be in the same room for 8 hours, exposed to a number of patients. If these patients all have COVID, then the level of risk to the individual staff working in there is that much higher. The levels of contamination are potentially more concentrated depending upon the air-change rate, but also it's the duration of exposure. That's where legislation such as Control of Substances Hazardous to Health (COSHH) regulations and the work exposure limits, either instantaneous or over an eight-hour shift period, will determine what level of concentration you are trying to manage and that will derive any ventilation rates.

Key Components in Hospital ventilation system (mechanical or forced)

42. I have been asked to describe the key components of a hospital ventilation system and how they operate/control the parameters of air pressure, air changes, temperature, filtration, humidity and others relevant to patient safety and care. When people talk about air-handling unit or a fan, it's actually made up of a lot of separate components, all of which have a role to play. The order in which those components

are positioned is critical to the efficiency of the unit and the condition of the air that you're trying to achieve.

43. The ventilation system starts with the outside air and from where you draw the air in from. It needs to be identified that the air being drawn in from outside isn't providing a source of potential contamination. Therefore even before you get to the air intake louvre, you don't want it drawing in air that's been exhausted immediately from another area. If you have an infectious disease unit and that's exhausting the air then you don't want a theatre air intake immediately beside it as this will draw in anything that's been removed from a potentially infectious area into a theatre air intake.

44. You also don't want vegetation, wildlife or anything else in the immediate area of an air intake because that will host fungal spores and bacteria and will act as a potential source of contamination. The air intake, which is normally a weather-proofed louvre preventing ingress of water, is fitted with a vermin screen to prevent large contamination entering in, such as feathers, vermin, rodents, birds. That then delivers the outside air into an intake plenum or ductwork section prior to the AHU which normally has an automatic shut-off damper, which ensures that if the air handling unit is shut down for any reason the damper will automatically close to make sure that external air pressure or wind does not blow through the unit.

45. Following on from this you have what is described as a fog or frost coil, which is an un-finned heating element designed to ensure that the air entering the air-handling unit does not carry an unnecessary level of moisture which could adversely affect the pre or primary filter. You then have a coarse-grade filter, which filters out large contaminant that's made it through the initial vermin screen but prevents and

protect the equipment of the air-handling plant. This can also be fitted with an acoustic attenuator to cut down noise transmission from the air-handling unit back out into the atmosphere.

46. The next component is a fan unit, which traditionally would been belt and pulley, however under the new HTM, a direct-drive fan is fitted which draws the air into the air intake and directs it to the rest of the handling plant. Following this is a heat-recovery device whereby you recover the energy (either heating or cooling) that was taken from the exhaust air and you put it into to preheat or to precool the air. This facilitates the transfer of energy so you are not wasting all of the energy from the clinical treatment space, throwing it outside and treating raw outside air from external conditions. This is now governed by the European standards and international law, a requirement that air-handling units can't be provided without certain energy efficiency being achieved within the heat-recovery device (EU 1253 (ERP regulations) and EN 1886 (January 2008).

47. Once you've gone through the heat recovery element, you then go through a cooling coil. This will chill the air, but also, as a result of this it will naturally also increase the relative humidity of the air and condense moisture out from it. You will normally have an eliminator plate to stop moisture being carried in the air current beyond the drip tray, which is there to collect the moisture and safely drain it out of the air-handling unit. You then have a re-heater coil which reheats the air. So, if you've cooled it and you've increased the relative humidity and to control this you reheat and dry the air out. If you have to control the relative humidity, you can have a humidifier steam lance where you inject steam in to re-humidify the air without adjusting its temperature. It then goes through a final filter, which is the final finer-grade filter, another automatic shut off damper so it doesn't get backdrafts from the

distribution ductwork, and you can close it off to work on the unit safely. You will then have a distribution attenuator which reduces noise transmission from the unit onto a ductwork distribution system, which delivers it to the area where you are providing air to.

48. If you want separate temperature controls within given areas you can also have trimmer batteries, which can heat or cool to further condition the air if there is a requirement for separate environmental control temperatures within one specific space. The air will then get delivered through grilles into the room. If it's an Ultra Clean Ventilation (UCV) operating theatre, this would have a secondary ventilation recirculation HEPA, with current HTM guidelines stipulating that this should achieve 22 air changes per hour of outside 'fresh' air.

49. From the air being introduced to the room through the supply grilles, you would then have extract grilles, sometimes within the space or sometimes in adjacent spaces depending upon the pressure profile that you're trying to achieve. Those extract grilles go through ductwork back up to the air-handling plant and a coarse filter to take out any coarse particulate contamination that's been generated within the space, such as clothing, skin scales, etc. It will then go through an extract fan and another heat-recovery device, where the energy is transferred from the extract into the supply. Finally it goes through a further attenuator to an exhaust grille, which will be protected with a vermin screen to make sure rats, mice, foxes, birds cannot access into it against the flow of air, from where it is then discharged.

Challenges / Constraints / Compromises

50. Through any large healthcare project there will be challenges and compromises, however it is possible to achieve a known state of ventilation within a

hospital, which should be verified or subject to annual verification of performance, so there is a means to make sure that that performance is maintained. One of the greatest challenges within healthcare from a personal opinion is that hospitals are built to last 50 to 100 years, yet clinical practice and procedures evolve and change every five to seven years. Due to the intensity or nature of the clinical activity they move around within the current space or the nature of the clinical activity is changed and therefore it potentially impacts on ventilation. We rarely reassess on every clinical change the implications to ventilation. For example if a ward was designed as a geriatric ward and its then changed to a respiratory ward, the patient vulnerability profile changes and therefore the ventilation strategy for that area is, in my experience, rarely fully reassessed.

51. One of the silver linings of the Covid pandemic was that it highlighted the requirement for ventilation strategy when moving patients to other wards. Its unlikely to happen now but historically it did. Modifying ventilation within a healthcare setting can be extremely expensive and invasive with ceilings being taken down, moving duct work, it's a huge undertaking. However in the last two years I have noticed through the NHS trusts that I have worked with they look at and consider ventilation far more closely than they did in 2018. In my experience if you are dealing with a particular vulnerable patient group then ventilation is looked at. However if the patient group is non-vulnerable then historically it has been put in the too difficult or too expensive column and possibly overlooked or not given right level of priority.

52. Ventilation is also the largest building service that's installed physically. Ducts are very big and bulky, they take up a lot of space and normally concealed within ceiling voids or loft spaces. They are extremely disruptive to change, modify and adapt. If you suddenly need three extra electrical sockets then it's relatively cheap

and not too disruptive to install on an electrical circuit as long as that it doesn't exceed its maximum working capacity. To change a ventilation system is considerably more challenging and costly.

53. I believe that the pandemic over the last two years highlighted these issues very well. We suddenly had three patient streams where we had patients who we knew had COVID, patients who we knew didn't have COVID and those patients that we didn't know the status of on the point of admission. From a clinical point of view you would want to isolate known COVID positive patients from non-COVID positive patients. This can be achieved through pressure differential and making sure those positive with infection were under a negative pressure cascade, in the same way as someone who was infection free would be under a positive pressure so they wouldn't become infected. If you had three people, positive with COVID, you still wouldn't want them exposed to one another, certainly in the early days, as we were unclear as to whether the severity of illness was directly linked to the level of exposure to the virus.

54. This is where the working exposure limit and viral load came into play. Normally you would want to know what you're trying to achieve and know whether you are protecting the patient from the environment and other patients and staff, or whether you are protecting the environment, staff and other patients from that patient. Frequently wards move around, ICUs expand and contract and they all have different ventilation requirements and this makes it extremely challenging to sometimes practically change in an operational hospital environment.

55. One of the most common areas where compromise or derogation to the standards can be required is if you are modifying or adjusting an existing healthcare

environment. Unlike a new project you are not starting with a blank sheet of paper, you're starting with the confines and restrictions of an existing building envelope or an existing plan brief. Working in this area can be challenging but in my experience I have not had a time when patient safety has been compromised because that is sacrosanct. What can be compromised at times is the location that you would fit an air-handling unit or the type of air-handling unit that you would fit. You cannot compromise on energy recovery because that is now a statutory obligation, but you could compromise on air conditioning or humidification. There are times where you can compromise on location and the practical aspects and configuration of some plant, but in my experience you do not compromise performance which could have an impact on patient care.

Development of Ventilation System

56. I have been asked if I have knowledge or experience in the key stages in the development of a hospital ventilation system. This something that I have been involved with throughout my career in different roles and stages, however as an AE(V) it is a central element of the service which I support and advise on. The ventilation strategy for a healthcare installation starts with the clinical brief or pre-design stage for what the hospital or healthcare facility is intended to do. This would normally be developed by the design team with direct involvement from the clinical and IPC teams with the support of the AE(V) if considered appropriate. Once you have that information, you have an idea of the floorplan or a design output specification that the commissioning body, normally in England an NHS trust, have got as the basis of a business case. This output or performance specification is then used by the design team to undertake the design process.

57. From an early stage ventilation is typically identified as being important, base conformance to building regulation requirements and supplementary guidance up to HTM compliance. The guidance within the HTM and the HBNs recommend which areas need dedicated ventilation and which areas can be fed from general ventilation areas, such as noncritical systems. It should also identify, as the design develops, areas where there might be specific requirements for isolation facilities, local exhaust ventilation systems (LEV), or other elements of critical ventilation. This will assist in creating the ventilation strategy, which should be provided to the design team who develop it based on the requirements from the clinical output specifications. This is then used as a basis of the design moving forwards and should be referred back to at critical points of the design development process, up to final sign off, ensuring it's fully compliant to HTMs, HBNs, and all of the other guidance as stated.

58. The standards are set when agreeing the ventilation strategy and are used as the basis for design. The ventilation strategy and subsequent detailed design are then used to commission the system against the design and its then validated back against the original strategy and agreed design performances to ensure that the design has achieved the standards that they were based upon. That way the NHS trust know what it's getting, how much it's going to cost, and that is the basis that the project is then delivered against.

59. The project will then be commissioned to make sure that all of the individual engineering elements work as they have been designed. The commissioning process is covered in HTM 03-01 2021 under clause 11.1: **"**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 installers. Commissioning of the ventilation system will

normally be the responsibility of the main or mechanical contractor who should coordinate the process". This is supplemented in clause 11.2: **"**Commissioning is often subdivided into sections (for example, air handling unit, automatic controls, air side balance, building fabric and fittings). Each section may be commissioned by its specialist installer, and they are often accepted in isolation". It will then be independently validated against the original ventilation strategy, acknowledging any accepted derogation, ensuring that all of the building engineering services interact with one another as they should. This is outlined in HTM 03-01 2021 in chapter 12 under the following clauses:

12.1 All new and refurbished ventilation systems should be independently validated prior to acceptance by the client.

12.2 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, checking against the HTMs. Validation is not a snagging exercise; see the Note after paragraph 12.30.

12.3 Validation is a process of proving that the system in its entirety 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."

and it can be handed over and put into clinical use.

60. Following on from the commission it would be subject to annual verification for critical ventilation systems to make sure that it continues to operate to an agreed performance level all the way up to when it gets decommissioned. Annual verification is within part B of the HTM, and it is effectively an MOT to ensure that any plant is still performing as it should, and the rooms are performing as they should, to agreed levels as specified within the HTM.

61. For example, an operating theatre should achieve 22 air changes within that clinical space. Every year it will be checked to ensure that it is still providing 22 air changes or an acceptable percentage thereof which, in operating theatres in 03-01 2021, is 80 percent or a minimum of 18 air changes per hour within that space.

62. These levels date back to the original research that Owen Lidwell did which identified the hospital-acquired infection risk increases with air changes during surgery of below 16 to 17 air changes. Depending upon the nature of the operation, depending upon the nature of the clinical activity, and, critically, depending upon the number of people within that space, governs the amount of potential contamination that could be released into that space and therefore that has a direct correlation and impact to the required ventilation rates.

63. At every stage of the process, particularly at the design stage there are frequent discussions about where savings could be made or to duplicate areas served by a single AHU plant, rather than having one area by one AHU plant, value engineering as it's commonly termed. The consequences to resilience and patient safety are considered fundamental at those stages. Some derogations can be driven by economic consideration, but generally, in my experience, they are never put ahead of patient safety.

64. I have been asked if there were an error and a multi-bed room within a critical care area was incorrectly listed as requiring four air changes per hour, would it be expected that it would be identified and addressed through the life of the project. I would like to think so, but it's very difficult to judge on that as it depends on how it's recorded, how often it's referred back to, if it has been signed off and then never looked at again until it comes around to validation. It is possible that it could reach the validation stage with the error not picked up, however I would not expect it to get through validation though as the validator should be sufficiently competent to recognise that's a major deviation and ask why it deviates significantly from the standard. That is one of the reasons why we validate, as it's that final check before we admit a patient in there. There are certain things that need to be checked and double checked. The design of hospitals should be one of those things that are checked and double checked.

Technical Guidance and HTM

65. Throughout England and Wales there are a number of technical guidance documents produced by NHS England and NHS Improvement (NHSEI). These documents include the following:

> Health Technical Memoranda 03-01 (HTM), which provides guidance for anyone involved in the design, installation or operation of healthcare ventilation. It is primarily written by engineers for engineers however it is increasingly contributed to with each production involving infection prevention control specialists. Manufacturers are involved within it and contractors who are used to maintain and verify and validate systems. It's primary focus is an

engineering technical document, however it encompasses a far broader church and a far broader church is involved in its production.

Health Facilities Notes (HFN) and Health Building Notes (HBN), which provides guidance on infection prevention and control, cleaning services frameworks, security, and health and safety and provides a best practice guidance on the design and planning of new healthcare buildings and on the adaptation or extension of existing facilities.

Health Planning Notes (HPN), which provides a comprehensive guidance on planning for in-patient facilities for both adults and children, accident and emergency facilities, and isolation facilities.

Health Technical Notes (HTN), which provides a comprehensive guidance on a range of healthcare specific standards, policies and current best practice. Many of these documents can provide guidance on aspects which impact ventilation.

66. In regards updates of these publications I believe that typically it would be around a ten-year cycle, so what's written is likely to be current for ten years. If a major change happened then an addendum would be issued. For example HTM 04-01 was originally published in two parts and covers use of water. There was an issue with Pseudomonas in Belfast and supplementary guidance was produced, resulting in HTM 04-01 addendum for Pseudomonas being published. When HTM 04-01 was later reviewed and rewritten it became a three-part document, not a two part with an addendum. Now it is possible, and I do not know this for certain but it is possible that as a result of COVID there may be supplementary guidance issued relating to

ventilation. If that is the case then it is likely to be issued as a supplement to HTM 03-01 2021. So part A and part B will be retained but supplement issued for a specific area such as, for example, COVID. The next time that 03-01 would be reviewed and rewritten, then it would be incorporated into the main body of the guidance, if appropriate at that time.

67. There are a number of reasons why the guidance is replaced or updated. This could be due to changing technology and different equipment being available and different clinical approaches. The other major element for change is the need to address energy usage and the environmental impact, given the statutory obligations of climate crisis and to reflect lessons learned over the preceding 10/12 years of HTM 03-01 2007. When you look at the documentation in HTM 2025, it was more prescriptive in its installation standards and so forth. Performance issues and some issues within health care ventilation encouraged a refocus on being more prescriptive on minimum installation standards. Links to climate change issues such as the need to leak test ventilation systems to a higher standard than industry would typically use.

68. The guide does not cover every aspect of clinical activity but the document has adopted and acknowledged new clinical changes in clinical practice such as hybrid and robotic theatres. There has been no change to the minimum standards because it's not yet universal, so the standards have to be written for the typical usage. But as emerging technologies come through they may have an impact on ventilation strategy.

69. Further guidance on ventilation has also been published by Specialist Ventilation in Healthcare Society (SVH), IHEEM and CIBSE. A number of these

documents are highlighted in my CV at Appendix 1. There are other guidance documents relating to ventilation but the healthcare specific guidance is, as far as I'm aware, limited to a relatively small group of individuals who are either generally involved in the drafting of HTM or are members of societies or institutes that help support it.

70. I have been asked which groups and individuals the HTMs are aimed and it is primarily used by designers and healthcare organisations who have responsibility for provision of and maintenance of healthcare ventilation, specifically, HTM 03-01. All HTMs are aimed at designers and operators, which is why you'll find that in the majority of the HTMs they're divided into two parts, part A and part B. Part A is about the concept, the design, the installation, the commissioning and the validation. It is not retrospective and applies to all new or refurbishment projects from the date of publication. In my experience if a project has reached a point of contract signing (i.e an approved business case, fully designed, tendered and contract awarded), then the standard at the time of signing would be used as the basis for the project. However it may be considered appropriate to review the changes to see if they can be adopted after this time, although it will genrally be a contractural issue. There is no hard and fast rule to the best of my knowledge and it is normal that any revision is widely consulted on prior to publication and the impacts can be assessed on this basis if considered appropriate by the contracting authority/client. Part B of the HTM is about the operational, maintenance and the ongoing testing and that is written and designed to apply to all ventilation systems, irrespective of the standard to which they were designed.

71. There are still contracts particularly within legacy PFI contracts where the design has been done according to HTM 2025 and they will work to the criteria of

HTM 2025. If they had read HTM 03-01 2007, and the latest version in 2021, it is in many respects more relaxed than the original HTM 2025. The design standard isn't retrospective anyway. When HTM 03-01 2021 was published, if a system had been designed to 2025, it would still comply. To give you an example, within HTM 2025, theatres were designed to deliver 20 air changes per hour. They had to be tested each year and verified each year and still had to achieve 20 air changes. However, under HTM 03-01 2007 the design of a theatre air change rate was increased from 20 to 25, but under verification and in use, there was a 25 per cent tolerance allowed on that where the theatre was still considered to be compliant and safe to use. So, you could have fewer air changes and still be compliant under 2007 than you would've been under 2025 as there was no tolerance applied then. Under HTM 03-01 2021, the air change rate in theatres has been lowered to 22 air changes with an 80 per cent tolerance, with a minimum performance of 18 air changes.

72. The acceptable performance threshold has been lowered but it's still above what Lidwell's research demonstrated in 1972, that 17 air changes was the cut-off point and that there would be an increase in infection if it was below that. There is still a safety margin, it's just a smaller safety margin, however this is as a result of trying to conserve energy and not over-engineer.

73. I have been asked if compliance with HTM guidance is mandatory. This depends upon the interpretation of the word mandatory and is also dependent on an element of interpretation of the guidance and standards. They can be derogated from provided you record why and the reasons and this can be evidenced and supported. As I understand it the Health and Social Care Act, which is legislative, requires health care providers to conform to various guidance documents and one of those guidance documents, which is I believe expressly stated, are HTMs and

HBNs. So to comply with the Health and Social Care Act you are required to comply to HTMs and HBNs. HTM03-01 - 2021 refers to the “Health and Social Care Act” as placing a duty of care on healthcare providers (para 1.2). It also refers to more particularised duties set out in the Health and Social Care Act 2008 (Regulated Activities) Regulations 2014 (para 3.8 ff)).

74. In all practical sense my belief and interpretation is that the HTMs should be viewed as an approved code of practice and as such should be deemed in elements as minimum standards. In other elements which could be derogated subject to sound recording and reasoning it could also be seen as best practice. It's not black and white and I believe that organisations who choose to derogate from the HTMs have an increased risk of potentially compromising patient outcomes, staff/visitor safety in addition to increased risk of legal, civil and reputational damage/harm.

Derogations

75. I have been asked if its ever acceptable to depart from the terms of the HTMs. From my own point of view I wouldn't depart from any element that had a direct impact on patient, visitor or staff safety, which I would consider to be an absolute red line. If it was a compromise on resilience or quality of installation or engineering, then it would have to be fully documented as to why the derogation was necessary and what justification could be provided for that. I generally as a rule do not accept pure financial reasoning as an acceptable basis for derogation. If it were very time limited or a crisis then there may be acceptable pressures where the risks associated with not providing the service is greater than the risks associated with providing a derogated service. However it should never impact on patient or staff safety and is a judgement call that needs to be taken by a multidisciplinary informed

group, it's not down to an individual. An engineer can't decide to derogate on an engineering topic in isolation, they must consider what potential implications that engineering derogation may have from a clinical perspective or an Infection Prevention Control perspective.

76. The new HTM 03-01 2021 is explicit on this and no derogation should be made by an individual. It must be made as a collective discussion, collective responsibility through the Ventilation Safety Group. The HTM 03-01 2007 version did not include a requirement for a Ventilation Safety Group, so it was silent on derogation in terms of approval. The implication, if you read the whole document, is that you would have to seek the approval of all interested parties, you cannot derogate in isolation and it would need to have Clinical Director or Director of Infection Prevention Control to sign off on it. As an Authorising Engineer one of my remits is to steer people in making sure that all aspects are considered when considering a derogation.

77. This would also apply to the parameters within ventilation, such as air change rates, air pressure and open and closed door protection. There needs to be a minimum volume of air applied to a room if it's got a single door and more air if it has a double door. This ensures that when that door is opened, if the airflow is designed to be from this room to the next room, i.e. positive pressure, it will remain that way when the door is opened and someone passes through it and then closes the door behind them. For example you could have a room with 20 air changes, but only 100 litres a second going into it. If that had double doors then there wouldn't be sufficient airflow to make sure when you open the double doors air didn't travel from the surrounding area into that room.

78. If you choose to derogate or not comply with an HTM and it can be demonstrated that as a result it has compromised patient safety, then I believe you would be in breach of the Health and Social Care Act, which is the umbrella the Regulations come under, so if you breach the regulations then you breach the Act. The directors of an organisation would potentially face corporate manslaughter charges and the associated penalties of that. If you have breached the Health and Safety at Work Act or any of the subsequent regulations, COSHH regulations, workplace regulations, then that would also be a breach and would carry the penalties associated with a material breach of the Health and Safety at Work Act.

79. If you had not complied with one of the more subtle areas of HTM, for example the new HTM 2021 stipulates that within a multi storey building, the lift should go all the way up to the plant room level. If that was derogated, so the lift stopped at the top occupied level and didn't go up to the plant room level, then it would be a breach of HTM. However, if it was adequately recorded and derogated and an adequate explanation as to why it was done, such as planning restrictions, or costs and you could demonstrate that safe access for maintenance staff, plant and equipment replacement could be achieved by another route, I don't believe that would be a breach of law. It would technically be a derogation against the HTM however ay future validation would note the agreed derogation and if it did not affect patient safety then it could be potentially accepted.

80. There are still a number of older hospitals, Victorian buildings which are often described as Nightingale wards, with windows that open on both sides of the ward, which normally didn’t have any forced mechanical ventilation. When it comes to natural ventilation, it is pretty much an ideal design because you can open the upper windows on one side, the lower windows at the other and you will get a good cross

flow of air across the ward, which is the most efficient natural ventilation through that design. However with that layout what you don't have is any privacy and dignity, there is no separation of patients other than by curtains and social distancing of bed spacing. The sources of infection can be far higher, but the opportunity to naturally ventilate, if you ignore patient dignity and privacy and all of the other infection risk, is probably better in the Nightingale Hospitals in some respects.

81. As we move towards a more modern approach and layout of wards you will see individual bedrooms with private en-suites. This significantly improves the patient experience and many aspects of healthcare, but because you now have multiple smaller areas you make ventilating the space far more challenging to achieve.

82. There are always difficulties whenever you are working within an older existing building envelope as you've gone from a potentially naturally ventilated solution to requiring a forced ventilation. The services are constrained by the physical space that you have available and unless you turn the hospital into something like the Pompidou Centre, running all the services on the outside, you are limited by the space available and ceiling heights of an existing healthcare facility.

83. Another significant issue with older hospitals is maintenance access to plant areas. We don't want plant, particularly mechanical plant, that requires inspection and maintenance in the patient area, because any maintenance team would then be working within a clinical area, which could cause clinical disruption and potential infection risk. I wouldn’t want those services above the ceilings either because that would equally involve taking out ceiling tiles to gain access to do maintenance. The ideal solution would be to maintain the plant in a plant room environment on the floor

above the area that it serves. No matter the age of the building you cannot derogate the minimum legal standards.

84. The difficulty you face is space, particularly within urban areas, as you can't have a hospital that's only two stories tall, the ground floor being the patient space and the first floor all being plant. It would be an ideal layout but expensive and a hospital like that could require a very large say 100-acre site. So due to existing healthcare facilities, which are often of a vertical design, you end up with lots of floors of clinical practice, service ducts and distribution infrastructure throughout the building. All of the plant, whether that's the boilers at low-level or the air handling plant at roof level are usually contained within an area that can be accessed by maintenance staff, without needing to enter the clinical environment.

85. What tends to happen is that the clinical areas are limited by the number of bays or beds they can accommodate, because the amount of space that has to be taken up by plant. Anything is possible, but it can take extremely complex engineering solutions and it may be that instead of having an eight-bedded ICU, you end up having a four-bedded ICU. At which point you either need twice the area to accommodate the same number of beds, or it financially doesn't economically make sense. It is possible to do but in my experience I have never been asked to compromise patient safety issues on the basis of achieving a bed capacity.

86. Working within an existing envelope of a building significantly increases the challenges. Starting with a blank sheet of paper and a green field site you can design as much as anything, with departmental interactions, because one of the biggest issues with healthcare isn't just having the right spaces, but it's having the right adjacencies. So ideally your recovery area needs to be beside your theatres

that need to lead on to ICU, which in turn goes to HDU and then to general wards, with the patient journey dictating the interactions. All the diagnostic and imaging equipment needs to be beside accident and emergency to diagnose patients and know which part of the health stream to put them into. That's when the strategic planning of hospitals comes into play and why it becomes a significantly greater challenge when you have an existing site.

87. To summarise, you cannot derogate from minimum standards. If a ward or room is designed to do ten air changes and you have an eighty per cent tolerance within the current HTM, and it falls below eight air changes, it's non-compliant and should be shut. The recommended air-change rates are the required standards to minimise the risk of adverse health impact patients and staff.

88. The HTM also states that hospitals should not have any ventilation plant that hasn't been subject to a major refurbishment every 10 years and replaced every 20 years (HTM 03-01 Part A - Expected service life (13.32) & HTM 03-01 Part B Lifecycle of ventilation systems (1.53/1.54)). However, if that was enforced to the letter then you would shut almost every single hospital in the country overnight. That's when you have to take a sensible approach and risk assess. If the performance is safe and appropriate then you can schedule and plan capital investment when it can be afforded and achieved, but you wouldn't instantly take it out of operation if it was old but still functionally suitable.

89. I believe what is required and in my own personal opinion, is that the process for managing, recording and monitoring derogations should be formalised. When a derogation is made it should be kept as a live document and kept under constant review. A decision to derogate taken at the time of a capital project may have been

justified at that time but could have consequences for how the building is then later developed as clinical activity changes. So a decision to derogate needs to be recorded accurately at the time and kept under review to ensure that that decision remains appropriate throughout the life of that installation. So while some aspects of the guidance may reflect a legal obligation which cannot be departed from without breaking the law the guidance itself does not have any inherent legal status.

90. There are circumstances where just complying with the HTM wouldn't automatically mean that you'd also comply with minimum legal standards. For example a post-mortem room has to have ten supply air changes and twelve extract. If you suddenly had to do a post-mortem on a patient who died from viral haemorrhagic fever, you wouldn't carry this out in a normal mortuary because of the potential risk of a release of a Category 4 pathogen. So the HTM is right, however it’s set for normal usage. For a given circumstance that the HTM is defined for then it should achieve legal compliance but could not necessarily be deemed to cover every circumstances, which a hospital may be engaged in. The guidance only makes recommendations, albeit ones which are informed by a wide range of appropriate technical knowledge.

91. It follows that appropriate professional judgement will still be required when designing, installing and operating ventilation in hospitals. It should not therefore be assumed that following the letter of the guidance will be sufficient in all circumstances to produce an acceptable ventilation installation which is compliant with the law, and that in any event, such judgement will be needed when ventilation is needed in circumstances for which the guidance does not provide. This is one of the drivers between the 2007 guidance and the 2021 guidance and why the new HTM draft includes a requirement for a multidisciplinary ventilation safety group.

HTM 03-01

92. I have been asked if I have had any involvement in the latest iteration of HTM 03-01 2021, which is intended to ensure that those responsible for commissioning and operating hospitals, such as health boards, meet their various legal obligations relating to ventilation. I was approached by Malcolm Thomas, who was the lead author for 2007 version of HTM 03-01 and the current 2021 version. He had been brought on-board by a company called Archus, healthcare consultancy, who had secured the bid to draft HTM 03-01. He was looking for me to contribute to HTM 03-01 (2021) and sit on a panel of specialists who contributed, debated and discussed the content and update of the revision of HTM, which commenced in 2017. This group included Microbiologists, infection prevention control professionals and clinicians. I believe the draft was finished and ready for publication in early 2019 but was delayed as a result of the global pandemic, until June 2021.

93. My contribution to this document saw me authoring draft text for some sections, such as the function and role of a ventilation safety group. I was also part of the group collective where we discussed and reviewed all of the various iterations and all of the contributions that everyone made until Malcolm Thomas pulled together the final version. It was a lengthy process, however I think the process was driven by the scope of the technical topic. There was a large group who contributed to the draft of HTM 03-01 2021 and Malcolm Thomas kept notes and comments received from the last date of publication, with suggestions or areas where people feel that something was missed, areas of potential error. These areas would be revisited and covered in any future draft. The scope of the review would also have to meet the parameters set by the Department of Health.

94. Once we were approaching what we hoped would be the finalised document it was circulated out to wider institutes for comment. I believe that several thousand comments were received by Malcolm. He then sifted through all of those comments where they were consolidated and it was then reviewed by the wider group, discussing their relevance and if it needed to be included in final draft. This gave Malcolm sufficient information to produce the final document. The final document was then sent to proofing and to the Department of Health for approval and ratification because there was, as I understand it, a financial cost benefit analysis required. So if changes had been suggested that would have a financial impact, the Department of Health had to be satisfied that the financial consequence was sufficient or the benefit outweighed the cost. The draft was subsequently agreed and published.

95. The document is written in language that a layperson should be able to comprehend, but it boils down to the definition of competence and my definition of competence is to know when you're not. So, if you read something and you fully understand it and you understand the principle and you understand what it's saying, then you can act on that and take it as the right answer. If you read something and you are unsure then you shouldn't plough on regardless, you should stop and consult with others to make sure that you are right in your interpretation.

96. I have been made aware that I am acknowledged as a contributor to the interim SHTM 03-01 2021, which is being published. I had no communication or discussion with anybody prior to that document being published. Now, it is pretty much identical to HTM 03-01, which I did contribute to and I'm perfectly happy having my name attached to it as is Malcolm Thomas, however he also has had no discussion with anyone from National Services Scotland.

97. It has been issued as interim guidance and I do not know what NHS Scotland's intention is as to whether they will issue a completely revised SHTM at a future date. It may revolve around COVID, or other influencing factors. I was a little surprised when it came out as I would expect to be contacted if I'm named in the document as a contributor before releasing the document. I'm aware that the devolved administrations were party to the drafting of the HTM and I suppose it depends upon the nature of the HTM as to whether it gets a Scottish equivalent or whether it gets completely rewritten. My understanding from others I have spoken to is that there are less than a dozen words that have been changed unless they relate directly to legislation which, because there's different legal structures, was necessary. But generally, the content is near identical.

STATEMENT OF TRUTH [to be signed by witness once statement is finalised]

I, Andrew Poplett, confirm that:

(i) The contents of this statement is the truth to the best of my knowledge and recollection;

(ii) I am willing for this statement to form part of the evidence before the Scottish Hospitals Inquiry.

(iii) I am willing for this statement to be published on the Scottish Hospitals Inquiry website.

Signature: Andrew Peter Seymour Poplett

Date*:* 13.04.2022

Appendix 1

Resume of Andrew Poplett – IEng, MIHEEM, MSVHSoc, ACIBSE, AffIFE

Summary Employment History

Trained and qualified as a mechanical building services engineer (BTec HNC) (1985-89)

September 1985 to September 1991 : Haden Young Limited Newcastle upon Tyne

Worked as a specialist project engineer (commissioning & snagging) 1992 started work for the NHS as an operational Engineer

January 1992 to April 2000 – Newcastle General Hospital / Newcastle City Health NHS Trust

Following the completion and implementation of the Newcastle Services Review (NSR) became an Operational Engineer (Specialist Services) Newcastle General Hospital within the newly formed Newcastle City Health NHS Trust, where through internal promotion became Acting Estates Manager.

Lead engineer on Aspergillus “outbreak” in Newcastle (1998) helped develop containment precautions for Aspergillus control standards (NDSC Ireland)

April 2000 to March 2006 - Northgate & Prudhoe (NHS) Trust

In 2000 became Head of Estates for Northgate & Prudhoe NHS Trust

April 2006 to May 2009 - Northumberland Tyne & Wear (NHS) Trust

Due to a merger of three existing NHS Trust’s became Head of Property & Planning for Northumberland Tyne & Wear (NHS) Trust

May 2009 to present - Andrew Poplett Enterprises Ltd

Left NHS in 2009 to become an independent healthcare estates consultant and AE for specialist healthcare ventilation and water.

Over 35 years of experience in healthcare engineering

Chair of the IHEEM Ventilation Technical Platform, Member of IHEEM Regional Committee, & Member of the Water Technical Platform AE(W) Peer Review Panel.

Founder Member of the SVHSoc, Associate member of CIBSE, and Affiliate member of IFE

Lead Author of the following Supplementary Guidance Notes

IHEEM Ventilation Technical Platform (VTP)- Briefing Note - VTP/BN/001 - Potential Increased Risk of Aspergillus Infection due to COVID-19 & the Associated Essential Precautions & Control Measures to Consider

IHEEM Ventilation Technical Platform (VTP)- Guidance Note - VTP/GN/001/V1.0 March 2021 - Design Output and Performance Specification Guidance for the Ventilation Strategy / Systems for Dental Care Facilities

SVH Society - Updated Briefing & Guidance on Considerations for the Ventilation Aspects of Healthcare Facilities for Coronavirus – Revision Number 03-V5 8th June 2020

SVH Society – Guidance Note - Air Handling Unit Condition and Risk Based Monitoring Briefing Document

SVH Society - Guidance on Critical Ventilation System Risk Assessment Process and Factors

SVH Society - Fire Damper Briefing Document

SVH Society - Cryptococcus Briefing for AE(V)’s, AP(V)’s & Estates Professionals

Contributing Author of the following Supplementary Guidance Notes

Health Technical Memorandum (2021) 03-01 Specialised ventilation for healthcare premises;

Part A: The concept, design, specification, installation and acceptance testing of healthcare ventilation systems

Part B: The management, operation, maintenance and routine testing of existing healthcare ventilation systems

National Guidelines for the Prevention of Nosocomial Invasive Aspergillosis During Construction/Renovation Activities via production of the Newcastle-upon-Tyne City Health Trust Estates Department – Operational Policy for Aspergillus Management EOP53 (Version 1 updated 2nd February 2000)

Author of the following Health Estate Journal (HEJ) Articles & IHEEM Presentations

Aspergillus fumigatus – a ubiquitous foe – October 2014

L8 – Consider the ventilation aspects – November 2014

Fire Safety – Importance of Regular Inspection stressed – January 2015

Who should appoint AE's & AP's – April 2019

The Estates Manager's Guide to Cryptococcus in Healthcare Ventilation - June 2019

When to seek derogation, and the best approach – September 2021

AE's & AP's – Jack of all trades but masters of none? March 2022