Health Technical Memorandum 03-01:
Specialised ventilation for healthcare premises

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

Draft for technical engagement
December 2019
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Executive summary

Preamble

Health Technical Memorandum 03-01 – ‘Specialised ventilation in healthcare premises’ is published in two parts: Part A deals with the design, installation and initial acceptance of ventilation systems; Part B covers the operational management aspects.

The document gives comprehensive advice and guidance on the legal requirements, design implications, maintenance and operation of specialised ventilation in healthcare premises providing acute care. The use of these premises is very intense, the occupancy level high and the patients may be particularly susceptible to airborne infection risks. Their condition may also require close control of the environment.

The ventilation of non-patient facilities within the hospital curtilage should be designed to suit the application and specific guidance relating to the activity should be followed e.g. pharmacy, sterile supply unit, etc. However, as they are on the hospital site the means of providing ventilation should not adversely impact upon the hospital, e.g.; evaporative cooling towers should not be installed, sound levels should be appropriate and if the facility is within or attached to an area accessed by patients, their needs and the risk of airborne contamination should be considered.

In other types of healthcare facility that are outside of the hospital curtilage, e.g. GP practices, health centres, minor injuries units, dental, ophthalmic & podiatry clinics, mental health facilities, respite care, long stay care homes and hospices, etc. a risk assessment of the nature of the treatment being delivered, condition of the patients and intensity of use needs to be undertaken in order to determine the extent to which this guidance will be applicable.

The guidance contained in Part A of this Health Technical Memorandum applies to new installations and refurbishments of existing installations.

The guidance contained in Part B of this Health Technical Memorandum applies to all ventilation systems installed in healthcare premises irrespective of the age of the installation.

1 Healthcare ventilation concepts

The needs of the building occupants

1.1 Ventilation is used extensively in all types of healthcare premises to provide a safe and comfortable environment for patients and staff and control odours. More specialised ventilation is provided to help reduce airborne infection risks in areas such as operating departments, critical care facilities, isolation rooms and primary patient treatment areas.

1.2 The Health and Social Care Act places a duty of care on healthcare providers. Increased health risks to patients will occur if ventilation systems do not achieve and maintain the required standards. The link between surgical site infection and theatre air quality has been well-established. If the ventilation plant has been installed to dilute or contain harmful substances, its failure may expose people to unacceptable levels of risk. Proven breaches of the statutory requirements can result in prosecution and may also give rise to a civil suit against the operators.

The building environment

1.3 Healthcare buildings are visited and used by large numbers of people. Many will be unwell or anxious so a well-ventilated environment with a fresh feel and an absence of noxious odours is essential.

1.4 Ventilation may also be installed:

- to ensure compliance with the quality assurance requirements of items processed in pharmacies and sterile services departments;
- to protect staff from harmful microorganisms and toxic substances e.g. in laboratories and anaesthetic rooms;
- to contain the spread of smoke between fire compartments as part of the fire strategy.

1.5 Healthcare buildings are continuously occupied, intensively used and because of the specialised nature of the facilities it may be extremely difficult to provide the service elsewhere if the ventilation fails. In order to ensure continuity of service, ventilation systems should be designed and installed so that they can be quickly and easily maintained. The resilience of the proposed system in the event of service outage should also be considered.

1.6 The ventilation of healthcare facilities consumes a significant portion of their energy load so wherever possible natural ventilation is the preferred option. Where mechanical ventilation is used, sustainable design concepts allied to good quality installation and the provision of controls that accurately maintain the desired environment when the facility is in use will result in the minimum energy input for the maximum benefit.
Airborne risks to staff

1.7 Most healthcare staff are no more at risk from airborne hazards when at their workplace than they are when not in a healthcare environment; however, certain groups as detailed below may be exposed to a variety of airborne contaminants.

- Staff who administer anaesthetic agents or who work in areas where they are routinely used will be at risk of casual exposure to these agents.
- Staff who routinely work in areas where they may come into close contact with patients who have respiratory symptoms will be at risk of exposure to the microorganisms causing the symptoms.
- Staff who routinely work in areas where they may come into close contact with patients that have skin lesions, an infectious disease or a dermatological condition will be at risk of exposure to the microorganisms causing the condition.
- Staff who routinely process with pathology specimens
- Staff who decant, mix and/or process chemicals used as reagents for the setting or processing of pathology specimens
- Staff who routinely harvest pathology specimens for subsequent analysis
- Staff who handle the ingredients of drugs
- Staff who may be routinely exposed to airborne hazards listed in EH40 issued under the Control of Substances Hazardous to Health Regulations (COSHH) e.g. woodworking dust, welding fume, chemical vapour, etc.

1.8 A well-designed ventilation system can mitigate the airborne risks to staff. It should:

- Supply sufficient unvitiated air to dilute the possible contaminants
- Have air terminals located to efficiently scour the ventilated space
- Move the air from the clean to the less clean space and/or out of the building
- Supply the air at high level and remove it at low level so that the breathing zone of staff is in a clean airflow path.

1.9 Adoption of these principles will be sufficient to control the general risk to the staff identified above in their particular working environment. More specific airborne hazards will need to be captured and removed by local exhaust ventilation (LEV) systems provided under the COSHH Regulations. (See para ## below)

Airborne risks to patients

1.10 In general terms an environment that is satisfactory for staff will be satisfactory for patients. There are, however, exceptions as below:

- Intensive treatment units of any type
- Haematology/oncology units
- Transplant units and units treating patients who have had their immune system compromised.
• Bone marrow transplant units (BMT)
• Burns units
• Cystic fibrosis units.

Patients described above will need an environment supplied with good quality filtered air that is maintained at a positive pressure with respect to surrounding areas.

**Note**

Patients who are particularly at risk from airborne microorganisms will normally be placed in an isolation room or suite that is maintained at a positive pressure. Patients who have a condition that could be transmitted to others are normally placed in a negative pressure isolation suite. When the patient’s exact condition is unknown they may be placed in a neutral pressure isolation suite (see HBN04 for detailed guidance).

1.11 A more general airborne risk will result from poorly designed and constructed air handling units (AHUs) that allow water to stagnate inside; they can become a source of microorganisms such as *Legionella*. If their intake is badly sited or housekeeping in the area is poor, then fungal spores such as *Aspergillus* can be drawn in. The ventilation system will then become a means of spreading these microorganisms and fungal spores around the healthcare building.

1.12 All ventilation systems should conform to the principles set out in the Health and Safety Executive’s (HSE) Approved Code of Practice and guidance document ‘Legionnaires’ disease: the control of Legionella bacteria in water systems’ (commonly known as L8), and Health Technical Memorandum 04-01 – ‘Safe water in healthcare premises’.

**Specialist equipment environment**

1.13 Imaging and other non-invasive scanning equipment will require stable environmental conditions to stay within calibration and provide accurate repeatable results. HBN 10 (2020) gives detailed guidance.

**Medicinal products environment**

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 legislation about their operation in addition to that mentioned above.

1.15 There are specific requirements under the Medicines Act 1968 to maintain accurate records of plant performance, room conditions and maintenance events. Such records would need to be preserved for up to 25 years as part of a quality assurance audit trail.

1.16 Specialised ventilation plants installed in laboratories dealing with research, development or testing, whether involving drugs, animals or genetically modified microorganisms, may be subject to legislation regarding their operation in addition to that mentioned above.
Fire and smoke control fundamentals

1.17 The fire regulations require that, if ventilation ductwork penetrates the fabric of a building, it should be designed and installed to contain the spread of fire (see Health Technical Memorandum 05-02 – ‘Guidance in support of functional provisions for healthcare premises’ for further guidance).

1.18 When ventilation systems are originally designed, they will conform to an agreed fire strategy. This will determine the compartmentation, provision of fire-rated ductwork, fitting of sprinklers, the siting of fire and smoke dampers and an agreed control action for the ventilation in the event of a fire. The agreed fire and smoke control strategy must be clearly set out as part of the design specification.

1.19 It is management’s responsibility to ensure that the fire strategy applied during the design and installation of a system is not reduced during the subsequent operation and maintenance of the equipment.

1.20 If a ventilation system is upgraded or altered to suit a change of use, it will be necessary to reassess the fire strategy.

1.21 Note that in developing a fire and smoke containment strategy, the design of ventilation for infection prevention and control should not be ignored. Over-compartmentation and poorly chosen fire lines can prevent air moving from clean to less clean areas and thus increase the infection risk. This can be a particular problem in operating departments where the desire to create a protected escape route can be at odds with the need to cascade air through a suite of rooms and out into a corridor in order to control the airborne infection risk.

1.22 The number and location of fire and smoke dampers can also be problematic. Fire-rated ductwork within fire zones will reduce the need for fire and smoke dampers. It will eliminate the need to provide access for routine damper testing and the infection-control problems associate with reversed airflow paths resulting from damper failures and nuisance tripping. (See also Chapter # for ventilation control, in the event of fire.)
2 The user requirements

Patient treatment falls into four basic categories:

Surgical – Physical interventions to repair, remove or rebuild damaged or infected tissue

Medical – The administering of drugs or various forms of practical, non-invasive treatment to cure or reduce the severity of an infection or condition

Mental Health – The use of counselling often in conjunction with drugs to control or alleviate abnormal behavioural or false perception issues in patients.

Palliative care – Treatment to temporary or partially relieve or mitigate long-term conditions.

Surgical

2.1 It is believed that up to 25% of infections that occur as a result of a surgical intervention are caused by the airborne route. The source of these infections are predominantly as a result of organic material, typically skin scales, liberated during the surgical procedure becoming airborne and landing in the wound or on surgical instruments. These then become a means of inoculating the patient with the contaminant. There are five possible routes that may result in airborne infections:

- Skin scales liberated by the surgical team during the procedure.
- Organic material liberated from the patient as a result of the procedure.
- Organic material remaining from a previous use of the space becoming airborne
- Organic material liberated outside of the space entering during the procedure.
- Organic contamination in the supply air from a ventilation system that has been contaminated with biological material.

2.2 The level of airborne organic material present or biological burden (bioburden) is typically defined in terms of the number of colony forming units (CFUs) present at the wound site during the procedure. It will be dependent on:

- The number of persons present
- The completeness and effectiveness of their gowning
- The duration of the procedure
- The type of procedure
- The use of air-driven power tools
- The possibility of any patient contribution to the bioburden in the space
- The general cleanliness of the space
- The discipline of the surgical team
• The measures that have been taken to prevent or control contaminants from outside sources entering the space
• The quality and volume of the incoming supply air
• The efficiency of the incoming air to “scour” the space.
• The means of removing contaminated air from the space.

2.3 Good surgical discipline, effective patient preparation, the cleanliness of the space and control of the entry and exit of personnel during the procedure will all contribute to reducing the bioburden present.

2.4 A well-designed ventilation scheme that provides a suitable quality of air and efficiently scours the space will further reduce the bioburden. If the ventilation maintains the space at a positive pressure to adjoining areas, the risk of contaminants originating outside of the space from entering will be reduced.

2.5 In addition to controlling the bioburden, ventilation should provide comfortable conditions for the staff and patient.

2.6 The ventilation system should also control the risks to staff from anaesthetic agents and other hazardous fumes and emissions typically found in surgical facilities. (See Chapter 1; Airborne risks to staff.)

Medical

2.7 In general the main requirement will be to ensure that staff and patients are kept in comfortable conditions.

2.8 There are specific instances where staff can be at risk of contracting an illness by the airborne route from a patient. This is the case in infectious disease units where the ventilation will be designed to maintain the unit and individual patient rooms at negative pressure relative to adjacent areas. This will protect persons outside of the unit from infection by the airborne route but not staff entering and working in the unit who may need to take additional precautions to protect themselves.

2.9 The opposite problem occurs when patients are neutropenic, that is they have a reduced or extremely low resistance to infection. They are then at risk of infection by the airborne route from other persons such as staff and visitors. This will be the case in cancer/oncology units, critical care facilities, and bone marrow and general transplant units. The ventilation in these areas will need a higher air quality and be set to maintain a positive pressure to adjacent areas.

Mental health

2.10 The main requirement will be to ensure that staff and patients are kept in comfortable conditions.

2.11 After assessment, the fire risk may be considered greater and therefore additional steps may need to be taken to mitigate these risks.
Palliative care

2.12 The main requirement will be to ensure that staff and patients are kept in comfortable conditions. Temperature control may be more stringent for patients with long-term and/or end-of-life conditions.

2.13 Difficulties with evacuating patients in the event of fire may need to be considered.

Other professional groups

Imaging and interventional imaging

2.14 There are major advances in diagnosis and minimally invasive treatment involving imaging. It may be necessary during these invasive or non-invasive procedures to provide sedation or general anaesthesia to help with anxiety or pain. This may involve the use of inhaled anaesthetic agents and/or N₂O. Staff working in these areas may be exposed to these anaesthetic agents when they are administered or subsequently when they are exhaled as the patient is “recovered”.

2.15 A similar situation occurs in the maternity unit where Entonox, a mixture of nitrous oxide and oxygen (N₂O/O₂), is used as an inhaled analgesic.

2.16 In both of the above cases, ventilation should be designed to provide a clean airflow path, dilute any casual spillages of the gas and control the exposure of staff to the anaesthetic agent (see COSHH; Chapter #).

Post-mortem and pathology

2.17 Staff who harvest organs and specimens at a post-mortem and place them into preservative solutions may be exposed to the microorganisms present and fumes from the preservative.

2.18 Staff who section organs and prepare specimens for analysis may be exposed to the microorganisms present and the chemicals used for staining and fixing the specimens.

2.19 In both of the above situations local exhaust ventilation (LEV) in the form of down flow benches, safety cabinets and fume cupboards need to be provided to control the risk.

Pharmacy

2.20 Exposure to the active ingredients of drugs represents a hazard to pharmacy staff who are involved in their production. These activities are carried out in an aseptic preparation facility to ensure that the drugs themselves are not contaminated. The actual production typically takes place inside an isolator so that there is a physical barrier between the hazard and the operator.

2.21 Alcohol sprays are used and staff exposure is normally controlled by the provision of LEV systems to remove the hazard.
Comfortable conditions are essential for staff working in aseptic preparation facilities as they need to be fully gowned, and entry and exit is restrictive.

_Estates and facilities_

Staff may be engaged in welding, soldering, machining wood or paint spraying. They may also decant chemicals in quantity, for example, for boiler treatment or hydrotherapy-pool dosage. LEV systems are routinely used to control the hazards arising.
3 Legal requirements to provide ventilation

Health and Safety at Work Act

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

3.2 The Act places a duty of care on ALL to provide and maintain a safe workplace. This includes designers and suppliers of goods or services. Those trading as competent designers or suppliers are therefore liable to provide outcomes that meet the clients’ needs and are without hazard to staff, patients and others who may be affected by the work activity.

Control of Substances Hazardous to Health Regulations

3.3 The Control of Substances Hazardous to Health (COSHH) Regulations 2002 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 microbiological safety cabinets.

3.4 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 COSHH requires that the system be examined and tested at least every 14 months by a competent person (P601 certified) and that management maintain comprehensive records of its performance, repair and maintenance.

3.5 Certain substances have workplace exposure limits (WELs) set out in the Health and Safety Executive’s (2005) Guidance Note EH40 – ‘Workplace exposure limits’ contains the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended)’. If specialised ventilation systems are provided in order to achieve these standards, they will be subject to the COSHH Regulations as above.
Workplace (Health, Safety and Welfare) Regulations

3.6 These Regulations state that all enclosed workplaces must be ventilated by natural or artificial means.

3.7 Any plant provided under this legislation must include an effective device to give an audible or visual warning of plant failure where necessary for health and safety.

3.8 The Regulations require that ventilation systems are maintained in an efficient state, in efficient working order and in good repair.

Building Regulations

3.9 Apply to domestic and non-domestic buildings.

3.10 Clarify satisfactory methods of providing ventilation and give ventilation rates.

3.11 Set minimum standards for:
   
a. The protection of the supply position

b. Precautions against Legionella

c. The purity of recirculated air

d. Access for service and maintenance

e. Documentation and proof of performance

Health and Social Care Act 2008 (Regulated Activities) Regulations 2014

3.12 Regulation 12(2)(h) of the Act decrees that registered providers must assess the risk of, and prevent, detect and control the spread of, infections, including those that are healthcare associated.

3.13 Appropriate standards of cleanliness and hygiene should be maintained in premises used for the regulated activity. The Department of Health (2015) issued ‘The Health and Social Care Act 2008 Code of Practice on the prevention and control of infections and related guidance’ (the HCAI Code of Practice), which contains statutory guidance about compliance with regulation 12(2)(h) (x-ref to paragraph on HCAI code of practice).

3.14 Regulation 15 of the Act states that:

   (1) All premises and equipment used by the service provider must be:

   a. clean,
b. secure,
c. suitable for the purpose for which they are being used,
d. properly used
e. properly maintained, and
f. appropriately located for the purpose for which they are being used.

(2) The registered person must, in relation to such premises and equipment, maintain standards of hygiene appropriate for the purposes for which they are being used.

**Note:** The “registered person” means, in respect of a regulated activity, the person who is the service provider or a registered manager in respect of that activity. A “service provider” means a person registered with the CQC under Chapter 2 of Part 1 of the Health and Social Care Act 2008 as a service provider in respect of that regulated activity.

### The Medicines Act 1968 & Human Medicines Regulations 2012

**3.15 Tim Sizer supplying clause**

3.16 Pharmacy aseptic preparation facilities should conform to the requirements of the European guide to good manufacturing practice ([https://ec.europa.eu/health/documents/eudralex/vol-4_en](https://ec.europa.eu/health/documents/eudralex/vol-4_en)) and the requirements of the Medicine Inspectorate if a licensed manufacturing unit.

### Indoor air quality (IAQ)

3.17 The World Health Organization has produced a paper on IAQ and the Department for Environment, Food & Rural Affairs (Defra) has a website that gives data for outdoor air quality by postcode for the UK ([https://uk-air.defra.gov.uk/air-pollution/daqi](https://uk-air.defra.gov.uk/air-pollution/daqi)). These enable designers to choose suitable filter grades by location and application. (See document SVHSoc-02-V1.3 for further information.)

### Other relevant standards and sources of guidance

3.18 The Chartered Institution of Building Services Engineers (CIBSE) guides are the principal source of general ventilation design guidance. Note that the actual guidance contained in this HTM may differ from the CIBSE guidance due to healthcare-specific issues.

3.19 ISO 14644 provides information on clean rooms used in pharmacy aseptic preparation facilities and the inspection, assembly and packing (IAP) rooms for the processing of medical devices in sterile services departments.
3.20 BS EN 15780 Ventilation for buildings – Ductwork – Cleanliness of ventilation systems

3.21 HSG258 issued by the Health and Safety Executive provides guidance on the design of local exhaust ventilation (LEV) systems.

3.22 Other relevant guidance is listed in the references section of this document.
4 The design and specification process

Definition of a critical system

4.1 Ventilation systems serving the following are considered critical:

- operating suites and their recovery areas of any type, including rooms used for interventional procedures
- airborne isolation facilities
- critical care areas
- invasive treatment, endoscopy and bronchoscopy rooms
- containment level 3 laboratory
- pharmacy aseptic preparation facilities
- inspection, assembly and packing (IAP) room in a sterile services department
- MRI, CAT and other types of emerging imaging technologies that require particularly stable environmental conditions to remain within calibration
- any system classified as a LEV system under the COSHH Regulations
- any other system that clearly meets the definition that “a loss of service from such a system would seriously degrade the ability of the premises to deliver optimal healthcare”.

Resilience and diversity

4.2 When planning the ventilation of healthcare facilities, it is important to consider how the service will be delivered if the installed ventilation system fails or the area served must close due to the effects of fire, flood, power loss or an outbreak of infection.

4.3 Resilience in critical healthcare areas can be provided by splitting the ventilation load between two or more AHUs and / or employ a design that allows two or more AHUs to feed a common plenum with isolation dampers on individual branches to each critical zone. The objective will be to ensure a continuity of service to each critical healthcare area. For example, a large ITU should be split into two sections with an AHU for each. A small ITU cannot easily be split so a CCU should be provided with ventilation to the same standard. In the event of a major failure, the ITU could decant to the CCU and the CCU patients be decanted to a ward with enhanced ventilation.

4.4 Diversity can be achieved by having several facilities each served by its own AHU. For example, in an operating department if each theatre suite is fed from its own dedicated AHU, the loss of one suite – while inconvenient – will not shut the department. The same scenario applies to isolation rooms if there are several of them each independently ventilated.
Note: Providing twin ventilation fans in an AHU merely delays the time at which the system needs to be completely shut down in the event of a fan failure. It does not in itself provide resilience in terms of delivering healthcare. (See Chapter 9 for further guidance.)

New build facilities

4.5 New-build healthcare facilities should be fully compliant with the recommendations of this HTM and the legislation in force at the time.

Assessment of service requirements: selection of design criteria

External design conditions

4.6 The most accurate data that is available for the summer and winter conditions at the site should be used. The Meteorological Office supplies data for the UK; data is also available from CIBSE and other sources. It is essential that the designer agrees with the client as to which source of data is used and the design risk associated with the chosen external design conditions.

Note: CIBSE publish design summer year weather files that are also morphed to reflect future climate change.

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

Internal design conditions

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

4.9 Recommendations for the dry resultant temperature and humidity of individual spaces are given in activity data A-sheets (see Chapter 8 for specific requirements). Particular departmental requirements are given in the respective HBN and its room data sheets.

Minimum fresh air requirements

4.10 In general areas and wards within healthcare premises odour control is the main reason for providing ventilation. In the absence of other guidance, 10 litres/second/person should be taken as the minimum ventilation requirement. Healthcare ventilation systems will normally be “full fresh air” either by natural, assisted natural or mechanical means, with energy recovery from the extracted air.

4.11 A limited number of applications, e.g. clean rooms, will utilise recirculated air systems. In these cases, at least 20% of the recirculated air should be fresh and additional filtration will be required to remove airborne particulate contamination and, if necessary, odours. (See also Chapter #; Clause # (UCV systems)
4.12 Smoking is generally not permitted in healthcare premises, so no allowance need be made. Reference should be made to local national policy guidance.

4.13 In treatment and support areas the overriding requirement may be due to airborne infection control, hazard containment, the stability of specialist equipment or relate to a specific department’s function. Each case should be considered independently in order to determine the overriding minimum requirement for ventilation (see Chapter 8 for specific guidance).

Limiting supply air conditions

4.14 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: −8K
- winter heating: +10K

4.15 Supply air humidity should be kept below 70% in order to minimise risks associated with condensation and mould growth. There is no lower limit in unoccupied spaces.

4.16 Some types of diagnostic imaging technologies require close control of both temperature and humidity as well as the rate of change of conditions to ensure clarity of the image and accuracy of the data generated. The manufacturer’s guidance should be followed.

Air purity

4.17 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 centralised food preparation facilities;
- protect finishes, fabrics and furnishings; to reduce redecoration costs;
- protect equipment either within the supply air system, i.e. to prevent blocking of coils, or in the space itself to prevent dust accumulation.

4.18 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, an ISO Coarse µ55% filter will be suitable. More critical areas will require an ISO ePM10 µ50% filter. HEPA filters will only be required in ultra clean systems and designated “clean rooms”.

4.19 In some inner-city areas, the local airborne particulate level may be particularly high. In those special cases filters to ISO ePM2·5 µ50% may be required to achieve the required indoor air quality. (Reference Defra website and SVHSoc. filter document.)
### Humidity control requirements

4.20 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.

4.21 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 (see Chapter 8 and associated HBNs).

4.22 The humidity within a building can be allowed to float but should not exceed 70%.

### Maximum noise levels

4.23 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.

4.24 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 airflow.

4.25 Plant noise should not be greater than 85 dB(A) within the plantroom 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.

4.26 Attention should 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.

4.27 The values recommended in Table 4.1 are for the total noise environment of space. In general, there will be noise transmitted into the space and noise generated within the space. 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.
4.28 In Table 4.1 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 which should be considered in the overall design, that is, in specifying the attenuation of walls, partitions, ceilings, etc.

4.29 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.

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

Calculation of building loads

Air infiltration

4.31 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.

4.32 CIBSE guide A; Section 4 and TM52 provide 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 Regulations Part L1 A – Airtightness minimum requirements - must be met. Note Jez Beals to amend.

Summertime temperatures
4.33 Thermal modelling should be undertaken to ensure that internal temperatures in all areas do not exceed CIBSE Guide A: 2013 guidance. Thermal modelling should be carried out by a competent software user.

4.34 Where thermal modelling indicates internal temperatures will exceed the recommended levels defined in CIBSE Guide A: 2013, additional measures should be explored to achieve compliance such as reducing solar and casual gains, improving building fabric performance, etc.

**Peak heating load**

4.35 Peak heating local calculations are necessary on all mechanical supply systems to establish the size of heater-batteries and subsequently the central plant. Note that with the introduction of the requirement to fit energy recovery set out in EU 1253, the heater-battery size will be reduced. If the energy recovery value is ignored the heater-battery and its control valve will be oversized and the system when put to use will be unstable and liable to hunt.

4.36 Where ventilation systems provide tempered air to spaces which have supplementary LPHW to offset the building fabric losses, the AHU 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).

4.37 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 that recommended in Clause 4.14 and the ventilation supply volume increased to suit.

**Peak cooling load**

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

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

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

4.40 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.
The cooling loads for all plants on the chilled water system should be calculated at each of the individual peak times in order to accurately establish the required (diversified) capacity of the chiller.

Note that as with heating, the introduction of the requirement to fit energy recovery set out in EU 1253, the cooling coil size will be reduced. If the energy recovery value is ignored the cooling coil and its control valve will be oversized and the system when put to use will be unstable and liable to hunt.

Annual energy consumption

Annual energy consumptions of simple heating-only ventilation systems are simple to calculate, based on supply-to external air temperature rise, and frequency of occurrence of external temperature data (CIBSE Guide).

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 paragraphs on “Calculation of plant requirements”.

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

The nature of air-conditioning operation, that is 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.

The concept of load and plant operation charts is outlined in the CIBSE Guide. 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.

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, the annual energy consumption of individual elements, and thus the air-conditioning system, can be established.

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.

Where this would require excessive ventilation levels, the designer should consider removal of the moisture at the source of the evaporation via an exhaust hood or similar device.
In intermittently heated buildings, it is necessary to consider the condensation risk at night set-back conditions as well as during normal operation. Calculation methods for this assessment are given in CIBSE Guide.

**Calculation of plant requirements**

**Air supply volumes**

4.52 The minimum air supply volume for a room is determined by the greatest of:

a. The minimum fresh air requirement.

b. The air required to achieve the room differential pressure and provide open door protection at the key door.

c. The minimum supply volume for the room load as determined by the maximum heating or cooling supply temperature differential.

d. The desired air change rate.

e. The make-up air for a local extract e.g. cooker hood or LEV system.

**Plant sizing**

4.53 Once the design airflow has been established the cross-sectional area of the air-handling unit can be calculated based on the specific fan power (SFP) for the fans and a maximum coil face velocity of 2.5 m/s. The fan duty should be calculated by adding the resistances of all elements that contribute to the pressure drop of the index circuit.

4.54 In order to establish the length of the AHU, it will be necessary to refer to manufacturers' literature, ensuring all necessary access panels and components are included as detailed in Chapter 9.

4.55 The designer should ensure that an allowance has been made for “dirty filter” conditions and confirm whether the fan pressure quoted is the total or static pressure.

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

Typical fan volume and pressure margins:

Criteria: Low and Medium/high-pressure systems

- Volume flow rate margin for leaking and balancing requirements = +5%

- Total pressure loss margin:
  - a. for increase in volume flow rate (above) = +5%
  - b. for uncertainties in calculation = +5%

- Combined total pressure loss margin = +10%
Refurbishment of existing facilities and fitting out shell schemes

4.57 When refurbishing existing facilities or fitting out “shell” schemes, every effort should be made to achieve full compliance with this HTM and current Health Building Notes (HBNs).

4.58 The physical constraints of the building may mean some derogation in terms of layout and room dimensions are unavoidable, but it is vital that the infection control aspects, clean airflow paths, cascade of air from clean to less clean areas and fire & smoke requirements are not compromised and the complete facility its fit for purpose.

4.59 A new AHU fully compliant with current standards will normally be required. The existing AHU should only be retained if it is not more than 10 years old and is (or can be made) fully compliant with current standards.

4.60 The most commonly used original standard operating theatre design solutions from previous versions of this HTM have been revised and updated (See Appendix #). They have been retained in this guidance as they will remain applicable to older theatre suites that are being refurbished within their original footprint. They may also be applicable where a pre-built “shell” is being fitted out.

Change of use of existing facilities

4.61 When a change of use of existing facilities is contemplated, the ventilation requirements should be completely revised to suit the new use (see also paragraph 4.59).

4.62 A new AHU fully compliant with current standards will normally be required. The existing AHU should only be retained if it is not more than 10 years old and is (or can be made) fully compliant with current standards.

4.63 If the ventilation load is reduced and the existing system is retained, then its output should be reduced to suit. This will necessitate a recalculation of the heater and cooler loads and resizing of the control valves to match the new loads. It may also necessitate a change in fan size. Failure to carry out this exercise will carry an energy penalty and loss of control function.

4.64 The area / zone fire strategy will need to be reassessed to suit the new layout and purpose.
5 Ventilation strategies

In order to reduce energy costs and provide a more sustainable healthcare estate, ventilation selection should be as follows:

• First choice – Natural ventilation
• Second choice – Mixed-mode ventilation
• Final option – Mechanical ventilation

Natural ventilation

5.1 The airtightness of new buildings has improved to the point that infiltration through building leakage can no longer be relied upon to provide sufficient airflow. Attention should 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.

5.2 Internal partitions, fire compartment walls and closed doorways can often impede the flow path; 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, which would prejudice safety, security or comfort.

5.3 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.

5.4 Current guidance restricts the opening of windows for safety reasons; also, 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.

Note: Natural cross-flow ventilation is able to give reasonable air distribution for a distance of up to six metres inwards from the external facade, 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.

If natural ventilation is single-sided, it will usually only be effective for a three-metre depth within the space. Beyond that it will need to be supplemented by mixed-mode or mechanical ventilation.

5.5 Planning constraints caused by a building’s shape and/or the functional relationships of specific areas will invariably result in some measure of deep planning, thus reducing the opportunity for natural ventilation.
5.6 Ventilation costs can be minimised by ensuring that, where practicable, core areas are reserved for those rooms that need to have mechanical ventilation. Examples are:

- sanitary facilities, dirty utilities and those rooms where clinical or functional requirements have specific environmental needs; and
- those rooms where – for reasons of privacy, absence of solar gain, etc. – windowless accommodation is acceptable.
- Other spaces appropriate to core areas are those which have only transient occupation and therefore require little or no mechanical ventilation (for example, circulation and storage areas).

5.7 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 a 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.

5.8 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. However, in most healthcare applications, internal subdivisions will restrict or prevent this effect.

5.9 It is almost impossible to maintain consistent flow rates and ensure that minimum ventilation rates will be achieved at all times. However, this variability is normally acceptable in such areas as office accommodation, staff areas, library/seminar rooms and dining rooms, where opening windows (of a design that facilitates natural ventilation) should be provided.

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

5.11 Further information can be found in Health Building Note 00-10 Part D – ‘Windows’, BS 5925 and CIBSE’s Applications Manual AM10 – ‘Natural ventilation in non-domestic buildings’.

**Mixed-mode ventilation**

5.12 Mixed-mode ventilation is an assisted form of natural ventilation. Fans are fitted in purpose-made damper-controlled ventilation openings. Alternatively, a separate draw or blow-through ventilation unit may be installed. In both cases the dampers and fans are controlled by temperature and occupancy sensors to ensure a minimum airflow rate while taking advantage of natural ventilation effects when present.

5.13 Where natural or mixed-mode ventilation is adopted with complex air paths, the designer should produce an airflow diagram in order to ensure correct provision of air-transfer devices. CIBSE’s Applications Manual AM13 – ‘Mixed-mode ventilation’ gives guidance.
Mechanical ventilation

Central versus local plant

5.14 Mechanical ventilation is expensive so it should only be provided when the space being served requires close control of its environmental conditions.

5.15 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, so the condition or quantity of supply air to different areas or zones of the building should be varied accordingly. This can be achieved by either providing individual plants to each zone or providing separate controls for each zone such as provided by a variable air volume (VAV) system. 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.

5.16 In large buildings, a choice between a small number of large systems located in centralised plant areas and a larger number of smaller locally distributed systems may arise. Large distribution systems and their plant can have the advantage of lower operating costs, but require more space for vertical shafts. 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 may lead to a more expensive class of ductwork.

5.17 Decentralised AHUs feeding multiple smaller distribution systems may be more expensive in capital costs but as they avoid long runs, large ducts and vertical shafts, 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. See also Chapter 4 and Chapter 9.

Horizontal and Vertical AHUs

5.18 AHUs may be configured as horizontal or linear units that are single- or double-stacked in the case of combined supply and extract units. They may also be configured more compactly as vertical or cabinet-style units. Selection will be dependent on the plant space available and where the unit is to be located. Whichever style is selected, good access for service and maintenance is essential.

Chilled Beams

5.19 Chilled beams should not be installed in clinical areas.

Note:- Patient bedrooms are classed as clinical areas as treatment is often delivered at the bedside rather than in a designated treatment room.

5.20 Passive chilled beams may be installed in non-clinical areas, but they should be positioned to ensure that cold draughts are avoided. The control settings should
ensure that all elements of the beam are always above dew-point. Manufacturers of these devices are able to provide specific advice on the siting and design limits of their equipment.

5.21 Chilled beams require regular cleaning if they are to remain efficient. They should be easily accessible for maintenance and should not be installed above fixed items of equipment which would make access difficult.

Note: Maintenance access to chilled beams will require the use of pulpit steps or wheel-around access equipment. The use of such equipment in a working hospital is very restricted.

Standalone air-conditioners

5.22 Split comfort air-conditioners, room conditioners or cassette units recirculate air which affects indoor air quality and may increase the risk of healthcare-associated infections (HAI). Therefore they should not be installed in clinical areas.

Note:- Patient bedrooms are classed as clinical areas as treatment is often delivered at the bedside rather than in a designated treatment room.

5.23 Split comfort air-conditioners, room conditioners or cassette units may be installed in non-clinical areas, but they should be positioned to ensure that cold draughts are avoided. The control settings should ensure that the external elements of the units are always above dew-point. Manufacturers of these devices are able to provide specific advice on the siting and design limits of their equipment.

5.24 Standalone air-conditioners merely recirculate air so a primary fresh air supply of at least 20% of the room air change rate, or that required by the Building Regulations, or 10 l/s/person, whichever is greater must be provided.

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

5.26 Split-comfort air-conditioners, room conditioners or cassette units require regular cleaning if they are to remain efficient and not become a source of airborne bio-hazards. If they incorporate an open water drainage system they should be risk-assessed under L8/HSG274 as part of the Legionella assessment. They should be easily accessible for maintenance and should not be installed above fixed items of equipment which would make access difficult.

Note: Maintenance access to split comfort air-conditioners, room conditioners or cassette units will require the use of pulpit steps or wheel around access equipment. The use of such equipment in a working hospital is very restricted.

N.B. Traditional refrigerants are being phased out because of their effects on the environment and are becoming ever more expensive. Their replacements at the time of writing have a degree of flammability. Both these factors pose serious
consideration as to whether split-comfort air-conditioners, room conditioners or cassette units are suitable devices to choose. In scanning and control equipment rooms the use of chilled racks, shelves and embedded panels supplied with water above dew-point would be a more suitable option.

**System selection**

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

**Zoning of the building**

5.28 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;
- the fire and smoke control strategy for the area.

5.29 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 of internal loads;
- level of control required.

5.30 For single-zone plant in staff areas, local control (with a run-on-timer if required) is recommended as the system can be turned off when the space is not in use, thus saving both thermal and electrical energy. Most clinical zone 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.

5.31 The control of individual plant items is covered in Chapter 9, with examples of typical control strategies in Chapters 6 and 7. For control of particular critical ventilation and air-conditioning systems, see Chapter 8.

5.32 On rare occasions a duplicate standby air-handling plant may be justified. If installed, it should be provided with a gas tight damper (see BS EN 1751) at its junction with the supply distribution duct so that no backflow can occur. Standby plants can become sources of contamination if warm moist air is allowed to dwell within them. Their design and control system should ensure that this cannot happen.
**Fire and smoke control**

5.33 Within a designated departmental fire zone, the total mechanical supply and extract ventilation volumes should be approximately equal so that in the event of a fire, smoke is neither drawn into nor blown out of the zone. Note that individual sub-zones within the departmental zone may be positively or negatively pressurised to suit the clinical need (e.g. isolation rooms, operating theatres, etc).

Note: In atria and stairwells, dedicated smoke clearance fans may be installed to keep evacuation routes clear in the event of a fire. These together with associated damper-controlled openings do not form part of the building’s general ventilation system and their operation will be automatically initiated by the building’s fire detection system.

**Air-conditioning**

5.34 Due to capital and running costs, air-conditioning should only be used in essential areas. These include operating departments, critical care areas, manufacturing pharmacies and areas with particularly sensitive equipment. Information on system performance requirements for individual departments is given in Chapter 8.

**Local exhaust ventilation**

5.35 Wherever the escape of chemicals, toxic fumes, biological materials or quantities of dust into the general area would present a hazard to the occupants, LEV must be provided. This is a statutory requirement under COSHH and the system should be designed to the standard set out in HSG258.

**Ventilation for general areas**

5.36 Chapter 8 provides recommended air-change rates, temperatures and pressures for general areas requiring mechanical ventilation in healthcare buildings.

**Acceptable methods**

*Mechanical extract ventilation*

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

5.38 Replacement air is provided by either a central supply system or enters the building through gaps in the structure or purpose-made openings. 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.

5.39 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).
5.40 If general exhaust systems are used, filtered and tempered replacement air should be 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.

5.41 Information on specialised extract systems is given in Chapter #.

Mechanical supply systems

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

5.43 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 (LPHW) heating system should offset any fabric loss so that set-back room temperatures can be maintained during unoccupied periods without the need for the ventilation system to operate.

Balanced ventilation

5.44 A balanced ventilation system is a combination of both a supply and an extract system of equal volume; either a single space or a whole building may be considered to be balanced.

5.45 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

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

5.47 In negative pressure facilities, it will be necessary to provide make-up air in order to promote the correct pressure cascade.

Recirculation systems

5.48 Air recirculation systems are normally used in HEPA-filtered clean rooms where the return air is significantly cleaner than the outside supply and where odour levels are not significant.

5.49 Recirculation is also routinely used in the canopy section of ultra-clean operating theatre ventilation systems. The recirculated air is HEPA-filtered to ensure that biological contaminants released by the surgical team are not discharged back into the clean zone.

5.50 Where the designer is considering the installation of an air recirculation system, due account should be taken of:

- A 20% minimum fresh air supply volume or that required by the Building Regulations or 10 l/s/person, whichever is greater;
- 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 automatic control dampers (ideally 5–6 m/s) where fitted, to provide suitable authority and good shut-off;
• modulating control of mixing to provide optimum on-plant conditions;
• the use of “free cooling” by cycling the dampers to minimum fresh air when the enthalpy of the outside air is greater than that of the extract air under conditions when cooling is required.

Note: Recirculating air can create particular problems when its ductwork breaches fire compartmentation. Designers should ensure that the system complies with the fire strategy in all modes of operation.

Dilution ventilation and clean airflow paths

5.51 In the past dilution ventilation has been used as the sole means of controlling levels of hazardous airborne hazardous substances in a space. This approach in itself is no longer considered acceptable. COSHH requires that known hazardous substances should be substituted by safe alternatives. If this is not possible, they should be controlled at source by using a closed system (such as an anaesthetic gas scavenging unit) or a protective enclosure (such as a fume cupboard). A good level of background ventilation will assist in diluting any casual release of the substance.

5.52 The casual exposure of staff to leakage or spillage of substances such as anaesthetic agents 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 airflow path – from the air-supply point, to the staff, on to the patient, and out via a low-level extract – would also apply in recovery rooms and birthing rooms. A suitable air-change rate will provide background dilution ventilation as an additional safeguard. This approach ensures that “all reasonable steps are taken to prevent or control exposure (of staff) to the hazardous substance” as required by COSHH.

Note: In these areas the supply air should be 100% fresh and not recirculated.

5.53 In operating theatres, patients 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.

Displacement ventilation

5.54 Displacement ventilation is used in areas that have a large casual gain from people or equipment e.g. atriums, central dining rooms, central kitchens, hydrotherapy pools, lecture theatres, etc. As the supply will be located at low level it is essential that the terminals are located where fixed or movable equipment and devices cannot obstruct them. Extract will be at high level either through temperature controlled vents or an active extract system.
6 Energy control strategies

6.1 The basic objective will be to provide the necessary service utilising the least amount of energy possible. To this end switching a system “off” when not required is the most energy efficient policy.

6.2 If the system is needed to maintain a minimum background condition then reducing its output “setting back”, to the minimum necessary to achieve and maintain the desired condition is the next best option.

Note on “Set back”: In previous times when fan motors only had two speeds, turning the system to “Set back” meant switching to the lower fan speed. With modern fans the speed is infinitely variable so “Set back” is not a fixed fan speed but rather a control strategy that reduces the system output in order to maintain a desired minimum condition. This may be related to the air velocity at a fixed point, air change rate, pressure differential, temperature, humidity or a combination of any of these parameters. Providing a dew-point sensor in an internal space that brings the system on to “set back” is a simple way of maintaining a minimum condition.

6.3 The system should only run at full output when needed to achieve and maintain the defined “in use” operating condition

6.4 Care should be taken when specifying plant to discover the true “in use operating condition”. Overstating the condition will lead to oversized plant, unstable control and excessive energy consumption.

6.5 The design and selection of set points for an AHU and associated extract system will have a significant impact on the overall energy consumption and efficiency of the system as a whole. (See Chapter 9 for detailed information)

Timed control

6.6 The AHU should be switched “on” and “off” at fixed times using a time clock or BMS programme. The AHU needs to come on early enough in the morning to bring the space up to temperature by the normal start time.

6.7 As above but with an “optimum start” control that uses the outside temperature to determine the start time. In winter, the lower the outside temperature, the earlier the AHU starts. In summer, the higher the outside temperature above that desired, the earlier the AHU starts.

6.8 As above but link the AHU to a temperature sensor in the space. If out of hours the temperature inside drops to dew-point, typically 16°C in winter, or rises above 25°C in summer, the AHU will start and run at “set back” (see definition above).

6.9 Any combination of the above or any other appropriate and applicable method that uses the least energy to maintain the specified condition. Various options
for the control of single and multi-zone air-conditioning systems are given in CIBSE Guide B3 – ‘Air conditioning and refrigeration’. [correct ref??]

**Occupancy control – user triggered**

6.10 The ventilation system output should be linked to occupancy detectors. These may take the form of movement, CO₂, PIR or other sensing technologies that can detect that the area served is in use and switch the system “on” or “off” and/or adjust the ventilation output to suit the actual load.

6.11 In intermittently used spaces such as operating departments, movement sensors (e.g. passive infra red [PIR] or similar) should be installed in the space with a double-knock detection programme so that if movement is detected twice within 10 minutes the AHU will switch “on” to full speed. If no movement is detected for 30 minutes, the AHU switches “off”. Double-knock detection prevents the system from switching on in situations where a person has briefly accessed the space when it is not in use.

6.12 The above can be combined so that if there is no movement for 15 minutes the AHU switches to “set back” (see definition above) during the working day and “off” outside of normal hours.

6.13 In operating departments, the AHU control should be linked to the lighting. If the theatre general lights are switched “on” the AHU switches “on” in “set back” mode. If the main operating lamp is then switched “on”, the AHU goes to “full speed”. If all the lights are out, the AHU goes “off”.

**Note:** There are occasions when this approach may need to be used with caution e.g. if the type of surgical procedure requires the lights to be “Off” during a part of the operation then an override timer will be needed.

**User control**

6.14 Some applications require intermittent mechanical ventilation, frequently at a high air-change rate, for example in certain types of treatment rooms (e.g. for odour control). Local controls to facilitate this mode of operation if required should be placed in a prominent position to encourage economical use. Specifying timers that shut the system down after a suitable operating period and which need to be reset manually will reduce energy waste.

6.15 Local controls that enable the user to select more than one mode of operation should be clearly labelled to identify the particular mode selected.

6.16 Where the system allows different room pressures to be selected, a direct-reading pressure gauge should be fitted within the eye line of the users, 1·5 m above floor level, adjacent to the selector control unit to provide an independent confirmation of the resultant mode of operation. A permanent notice giving a clear description of the selectable modes of operation should be mounted adjacent to the control unit.
7 Environmental control

Building construction factors

Objectives of the control system

7.1 The primary objective of a ventilation control system is to keep 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.

7.2 Control of most systems will be via a Building Management System (BMS). This will enable the operating conditions and control tolerances to be set and monitored. It is often not possible to accurately predict building load variation at the design stage. Information provided by monitoring the operation of the plant via a BMS will enable optimum set-points to be established and energy consumption reduced. The BMS 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.

7.3 A BMS incorporating self-adaptive control algorithms that automatically adjust the set-point to suit the usage and load is preferred. The provision of movement sensors within the controlled space in order to determine the actual occupancy will facilitate this process.

7.4 The failure of ventilation systems serving critical areas can have grave consequences for the delivery of healthcare. Control systems should therefore be simple, robust and reliable.

7.5 Computer-software-driven control systems are becoming the norm in building services. However, healthcare ventilation systems need to be available for operation 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 restarting critical systems in the event of a software failure is provided (see also paragraphs 4.4–4.4).

7.6 Where BMS are used, the outstations at the various AHUs should default to a safe set of operating parameters and be capable of independently controlling their AHU should the BMS link be lost.

Location of controls

7.7 Whether within the plant, duct or room, sensors should be located to provide accurate measurement of the condition of the air being monitored.

7.8 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.

7.9 Where there is a requirement for close control of air-conditioning parameters in a number of zones (for example 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. The control of most multi-zone systems within healthcare premises is based on off-coil control within the central plant, with trimmer heater-batteries on individual zones.

**Note:** In modern buildings the cooling load is often significantly greater than the heating load and may exist year round. Whenever possible, the design should take advantage of free cooling when available.

7.10 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).

7.11 Many ventilation systems may be completely shut down when the area served is not in active use (for example operating theatres). Alternatively, where there is a need to maintain a background condition, the ventilation output can be reduced by “setting back” the system (see para # and associated Note:). This will significantly reduce energy consumption and extend the life of filters and other system components.

7.12 There will also be a need to specify the control strategy in the event of a fire either within the zone being served or within an adjoining zone. This should be agreed with the client and / or their nominated fire officer and set out in the fire cause and effect statement.

**Multi-zone control methods and application.**

7.13 Close control of all air-conditioning parameters may be difficult to achieve with multi-zone systems, since each zone will in theory require a reheater and humidifier to give total control of humidity, if that is what is required. In reality, such close control is rarely required. 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 a minimum condition within one zone.

7.14 Designers 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 airflow is established within the extract system, or vice-versa depending on the required pressures within the rooms being served (see also Chapter 8).

7.15 The sequence switching of units in order to prevent transient reverse airflows will be particularly important in laboratories and pharmacies that contain fume cupboards, safety cabinets and other LEV systems.
7.16 Alarms should be provided in the estates maintenance department to show “filter fault” and “low airflow”. The “filter fault” alarm should be initiated by a predetermined increase of pressure differentials across the filter. The “low airflow” alarm should be initiated when the supply-air quantity falls to 80% of the design value.

Fire aspects (To be revised)

7.17 A fire control panel should be mounted at the main entrance of the area that the ventilation serves. Access to the panel should be restricted to the fire officer and appointed site AP(V). It should include independent on/off controls and an indication of the status of the supply and extract systems.

Note: In certain critical care areas, it is preferable to maintain the supply ventilation in case of a fire within the area e.g., 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 they can be safely evacuated if necessary.

7.18 In all critical care areas, the ventilation system should continue to operate unless smoke starts to enter the AHU. A notice should be affixed to the fire control panel stressing the need to liaise with departmental staff before switching off fan units.

7.19 All supply AHUs should have a smoke sensor linked to the fire control panel and 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.

User requirements

Room temperature control

7.20 The limits for room temperature set-point are generally between 18°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.

7.21 The selection of temperature set-point for each room or zone may be by a control facility in the room/zone or be carried out remotely at the control panel or BMS. Where the control device is mounted within the room / zone and is 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 ±1 K. All other control set-points should be selectable either on the control panel or at the BMS interface.
7.22 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 control panel, with the signal repeated on the main system control panel or BMS. It is important that this indicator displays the actual measured temperature and not the selected temperature.

Alarms and indication

7.23 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 override should be provided.

7.24 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 (for example isolation suites).

For specific departmental control parameters see Chapter 8.

For plant controls see Chapter 9.
8 Specific healthcare departmental requirements

Note to consultees: This section to be a list of requirements and is still under development. Suggestions are welcomed.

What goes on in the department?

What is the prime need that will be met by the ventilation?

- Infection control
- Hazard removal
- Comfort
- Stability of medical equipment
- Specific fire risk?

How will the ventilation need be met?

- Airflow direction
- Clean airflow paths
- Air change rate
- Pressure cascade
- Air velocity at a specific location(s)
- Supply air filtration standard
- Temp
- Humidity
- Noise

How should it / they be controlled

Any other healthcare factors

Additional explanatory notes if needed
General considerations

Special healthcare ventilation applications

8.1 This section contains design information for a range of healthcare ventilation applications.

8.2 The following departments will require a degree of ventilation appropriate to their function.

- The Operating department
- Treatment rooms, Endoscopy and Minimum invasive suites
- Diagnostic and Interventional imaging and Cardiology suites
- Obstetrics
- Isolation facilities
- Infectious disease unit
- Bone marrow and other transplant units
- Chemotherapy and Oncology units
- Sterile Supply and Disinfection Units
- The Pharmacy department
- The pathology department, mortuary and post-mortem suite
- Physiotherapy unit
- Burns unit
- Tissue bank and Emerging specialties
- Estates Infrastructure

8.3 Design information for many of these applications is given in Table # and in the following Chapters within this section.

General information

8.4 The foregoing sections of the document contain general information on healthcare-specific aspects of ventilation system design and specification. This section gives generic information relating to the design of ventilation within healthcare facilities.

8.5 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 minimised
- to control the temperature and if necessary, the humidity of the space
- to assist with the removal of and dilute waste gases and odours

8.6 It is not possible to give definitive guidance for every healthcare ventilation application however the section on operating theatres contains much
information that is common to other applications. Where no specific guidance is
given, then the principles set out below should be followed:

- The CIBSE guide contains 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,
  e.g. 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 #.
- 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 #.
- 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 #.
- A methodology for calculating a design solution for a non-standard suite of
  operating rooms is given in Appendix ##. This may be adapted as necessary
  to suit other less complex applications where air is required to cascade from
  clean to less clean areas.

8.7 There are four routes that 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.
  
  o Particles entering with the supply air can be controlled by the selection of suitable
    filter grades.
  o 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 air change rate.
  o 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.
  o The transfer of particles from adjacent spaces can be controlled by:
    – A differential pressure between spaces when doors are shut.
    – Airflow paths flowing from clean to less clean spaces.
When designing ventilation for a healthcare application, the sources of airborne contamination, their degree of hazard to patients and/or staff and the ability of ventilation to control them should be taken into account.

8.8 The supply air volume flow rate for any particular application will be that required to:

- achieve the applications recommended air change rate
- provide closed- and/or open-door protection
- achieve comfort or application specific room conditions
- replace that removed by an installed extract system
- meet the fresh air requirement relating to the number of people anticipated to be present
- achieve the minimum fresh air requirement if air is recirculated.

Whichever is the greatest amount.

Note: Air-change rates are given in Table #. These figures have been found to give sufficient dilution of airborne contaminants, provided the mixing of room air is reasonably uniform. Closed- and open-door protection volumes are given in tables # and #. Fresh air requirement is 10 l/s/person. Minimum fresh air if recirculated is 20%.

8.9 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 airflow path (see paragraph 8.64 and Chapter 9 for additional guidance on supply terminals). For example, in an operating room the ceiling should be divided into four quadrants and a supply terminal positioned at the centre of each quadrant and along the lines that join them as necessary to ensure that all parts of the room are actively supplied. This will help create in ventilation terms a well-mixed space. Extract and air-out paths via door gaps, transfer grilles, pressure stabilisers and low-level active extract should be evenly distributed to encourage efficient scouring of the room. In an anaesthetic room, locating the supply terminal on the ceiling in a position behind where the anaesthetist will normally stand, and the extract terminal at low level adjacent to the medical gas pipeline terminals will encourage a clean airflow path past the breathing zone of the anaesthetist, thus reducing their casual exposure to airborne anaesthetic agents.

8.10 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.

8.11 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 airflows when personnel move...
between rooms. They may also result in doors being held partially open by air pressure.

**Temperature and humidity control**

8.12 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 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.

8.13 Temperature differences of up to 10 K for winter heating and 7 K for summer cooling should not be exceeded.

8.14 Supply air humidity should be kept below 70% in order to minimise risks associated with condensation and mould growth. There is generally no lower limit in unoccupied spaces; however, see application-specific guidance in paragraphs ##.

**Removal and dilution of waste anaesthetic gases**

8.15 Anaesthetic gases are subject to workplace 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 airflow path.

8.16 In 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.

8.17 The design primary air supply to an operating theatre anaesthetic room that is equipped with a N₂O terminal or in which an anaesthetic agent is delivered to the respiratory tract of a patient using a carrier gas or an operating department recovery room should be 15 air changes per hour.

8.18 The primary air supply to any other room that is equipped with a N₂O or N₂O/O₂ (Entonox) terminal or in which an anaesthetic agent is delivered to the respiratory tract of a patient using a carrier gas or in which the patient is subsequently recovered should not result in less than 10 air changes per hour.
Fire aspects

8.19 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

8.20 Air should flow from the cleaner to the less clean areas as shown in Table 2. There are several factors that affect the likelihood of a reverse airflow 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 1.4 m wide doorway may allow the transfer of 0.19 m³/s of air in each direction when there is no temperature difference, but when the temperature differential increases to, say, 2 K, the volume transferred may increase to 0.24 m³/s).

8.21 In order to reduce the likelihood of contamination of a clean area by a reverse airflow from a less clean area, two methods of door protection are used:

- 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 # gives details of closed door leakage rates for a range of differential pressures.
- Open door protection – The pressure differential drops (See Table #) 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 # gives airflow rates for open door protection related to door/opening size and classification of the adjoining areas.

8.22 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.

8.23 The recommended airflow rates to achieve this are given in Table #. Provided that the dilution criteria in Table # 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.

8.24 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**

8.25 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 airflow patterns do not occur.

8.26 Extract grilles should be sited and balanced to promote air movement in the desired direction.

**Operating department**

8.27 The information given in this section relates to General also known as Conventional 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.

8.28 Additional information for UCV theatres is given in Section #.

8.29 A method of obtaining a design solution for non-standard theatres from first principles is given in Appendix 4.

**General**

8.30 The supply of air to an operating room has four main functions:

a) to dilute airborne bacterial contamination

b) to control air movement within the suite such that the transfer of airborne contaminants from less clean to cleaner areas is minimised

c) to control the temperature and if necessary the humidity of the space

d) to assist the removal of and dilute waste anaesthetic gases

The amount of air supplied to the operating room will normally be determined by the number of doors and desired air change rate.

8.31 The detailed considerations upon which the supply airflow rate is based are as follows:

a) **Dilution of airborne microbial contaminants**

8.32 There are four routes that airborne microbial contaminants may appear in an operating room:

- Through the supply air
- Shed by operating staff
- Produced by the surgical activities
- Transferred from adjacent spaces
8.33 Supply flow rates for the main rooms of the operating suite are given in Appendix #. For the other areas where room sizes and activities vary from site to site, air change rates are given in Appendix #: Table #. These figures have been found to give sufficient dilution of airborne microbial contaminants, provided the mixing of room air is reasonably uniform.

8.34 The design primary air supply to a conventionally ventilated general operating room or “lay up” preparation room should provide not less than 22 air changes per hour in the room or the required level of door protection whichever is greater. Note the volume of the theatre to be calculated using the method given in Clause 8.51.

8.35 For general conventionally ventilated operating theatres, the air supply would be filtered in the AHU. Terminal or HEPA filters are not generally required.

8.36 Air extracted from operating suites should not be recirculated, as it may contain malodorous contaminants.

b) Control of air movement within the suite such that the transfer of airborne contaminants from less clean to cleaner areas is minimised

8.37 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.

8.38 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 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.

c) Temperature and humidity control

8.39 In an operating theatre the temperature should be adjustable within the range 18°C to 25°C by the staff at the surgeon’s panel. The ventilation system should be capable of maintaining an internal temperature of 20°C at summer outside design and 22°C at winter outside design in all but the most extreme outside conditions. There may instances where these temperatures may not be appropriate e.g. children and patients with a low body mass. The internal design temperatures should then be agreed in writing with the client.

8.40 Supply flow rates to achieve the required room conditions, are calculated conventionally, taking account of all heat and moisture gains and losses. Temperature differences of up to 10 K for winter heating and 7 K for summer cooling should not be exceeded. Humidity should not exceed 70% saturation.
In most applications the base heating load will be provided by a radiant panel heating system in the surrounding corridors.

d) Removal and dilution of waste anaesthetic gases

The design primary air supply to an operating theatre anaesthetic room that is equipped with a N\textsubscript{2}O terminal or in which an anaesthetic agent is delivered to the respiratory tract of a patient using a carrier gas, or an operating department recovery room should be 15 air changes per hour.

Anaesthetic gases are subject to workplace exposure limits. The air movement scheme should ensure that staff are in a clean airflow path (see Chapter # paragraph #).

Fire aspects

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. 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 airflow 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 subcompartment. (See also Chapter 9 clause #)

Door protection

Air should flow from the cleaner to the less clean areas as shown in Appendix 2; Table 2. The factors that affect the likelihood of a reverse airflow through doorways are discussed in paragraphs 8.20–8.21.

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 airflow through any open doorway is sufficient to prevent any serious back-flow of air to a cleaner area.

Provided that the air change rates in Appendix 1 Table 1 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.

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.
8.50 Scrub – this may be a part of the operating room, often in a bay. 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.

Note: If the Scrub is in effect a separate room or corridor that is open (no door) to the Theatre and it has a pressure stabiliser discharging onto a corridor or an active low level extract at its far end so that air has to travel through the scrub to leave the theatre, then the volume of the scrub will not be counted as being a part of the operating room for the purposes of calculation the theatre supply air volume. If the scrub is a trough on the wall of the operating room, the volume of space it occupies will be considered part of the operating room for the purpose of calculating the theatre supply air volume.

8.51 Preparation room - 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.

8.52 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 fitted with a stand-off baffle plate on the theatre side. The air may also be directed into a corridor.

8.53 Dirty utility – the room is kept at negative pressure with respect to the theatre so that contaminants contained in the waste do not re-enter the theatre. A utility opening onto a clean corridor is considered to pose a greater risk than one opening onto a service corridor and so has a greater differential pressure. A utility can be shared between two theatres or be centralised to serve a group of theatres.

8.54 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 and provides a heated envelope around the theatre suite thus obviating the need to run the theatre ventilation out of hours to maintain its temperature above dew-point.

Standard air movement control schemes

8.55 In the previous versions of this guidance (DV4 and HTM 2025) 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 layout. Guidance on operating suites
contained in HBN 26 (2004) increased the recommended size of operating
room from approximately 35m² to 55m². 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.

8.56 Four new standard solutions were developed to reflect the current guidance on
theatre suite layout and room sizes given in HBN26 (2004) as well as the
general increase in air change rates.

8.57 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 standard. 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.

8.58 It is important to recognise that in any situation where a “non-standard” room
size or theatre suite layout is being considered, the designer should 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
- Barn and semi barn theatres

Appendix # contains a methodology for assisting the designer to arrive at a suitable
solution.

8.59 The revised standard design solutions are as follows:

N° 1 – Typical Conventional theatre – room sizes as HBN26
N° 2 – Typical UCV theatre – room sizes as HBN26
N° 3 – HBN26 illustrated Conventional theatre
N° 4 – HBN26 illustrated theatre with UCV terminal fitted
N° 5 – Pre 2006 Conventional theatre, single corridor (HTM2025; 1b)
N° 6 – Pre 2006 UCV theatre, single corridor (HTM2025; 1a)
N° 7 – Pre 2006 Conventional theatre, two corridor (HTM2025; 5b)
8.60 Details of these standard solutions are given in Appendix #. 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 #. 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 be the case in the anaesthetic room to help maintain the patients core temperature, and the preparation room when designated as a lay-up.
- The preparation room (SPS) / 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) / corridor 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 microbial dilution within the scrub room; the air is then exhausted to the corridor via a pressure stabiliser or by an active extract. No mechanical supply 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.

8.61 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 gaps approximate to those given in Component Data Base, see Table in Appendix 2 and the comment below.
- Casual heat gains are accounted for.
- A trimmer battery is installed in the air supply system to the anaesthetic room.
- Leakage through the structure is kept to a minimum. Note that theatre suites will be subject to an air permeability test at 1st fix and final validation (see Chapters 10 and 12)
NB: - 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 be 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.

8.62 It is recommended that every effort should be made to adopt one of the schemes described above.

Operating theatre air terminals and air distribution

8.63 The selection and sighting of air diffusers will be critical in establishing an efficient pattern of mixing. The theatre ceiling should be divided into quadrants and a supply terminal positioned in the geographical centre of each quadrant and along the line that joins the centres of the quadrants as necessary. In a large theatre, additional terminals around the centre point may be necessary to promote efficient scouring and achieve satisfactory air movement at the operating table level. Supply terminals should be ceiling mounted circular “air master” style, square “four way blow” or perforated plate style that produce a downward displacement, turbulent airflow. (See8.10 and Chapter 9; Clause ##)

Note: In order to ensure correct air distribution it is essential that the supply terminals locations are not displaced by light fittings or ceiling mounted pendants and articulated booms. Ideally the supply terminals should alternate with light fittings along the quadrant lines described above.

8.64 Plenum style “laminar” flow 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.

8.65 Horizontal flow distribution should not be used in new installations however space constraints may force its retention when refurbishing existing installations. Where fitted the supply grilles will require a means of directional adjustment and should be lockable in position to prevent casual alteration in future when being cleaned.

8.66 The diffuser equipment chosen should not cause “dumping” and provide a velocity 1 m above floor level at the operating position of between 0·1 m/s and 0·3 m/s.

8.67 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 and preferably four air out paths, approximately equally spaced should be provided.
**Automatic control**

8.68 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 are 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 [Section 6; Clause 11](#)).

8.69 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 (1.5 m above finished floor level) and be accessible for cleaning and the removal of fluff and lint. Alternatively, they could be mounted in one of the operating rooms low level extract ducts.

8.70 Wall-mounted passive temperature and humidity sensors are not recommended.

8.71 Controls should be provided to enable operating department ventilation plants to be closed down when the operating suites are unoccupied. (See also [Chapter 9 Clause #](#))

8.72 When in the “off” mode, the control system should ensure that the ventilation plant is automatically reinstated if the space temperature falls below 16°C.

8.73 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. (See also [Chapter #, Clause #](#)). Theatre ventilation plant status indication should also be located at the staff control base. (See SVHSoc. 01-V1.3 “Operating Theatres – Energy Control Strategies and the Surgeon’s Panel” for further details)

8.74 The humidity within the operating department should fall within the range 35% to 60%. Where it is considered necessary to fit a humidifier, it should be selected to humidify to 40% saturation at 22°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.

8.75 Each operating suite should be served by an independent supply and extract plant. The plants should be interlocked so that the supply starts up first and shuts down last thus preventing reverse airflows. If the extract plant fails when the theatre is in use, it can continue to be used but a warning should show on the surgeon’s panel. If the supply fails when the theatre is in use the extract should shut down to prevent reverse airflows and an alarm sound and show on the surgeon’s panel.
Ventilation of operating department ancillary areas

General
8.76 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
8.77 Table 2 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 4 for the operating suite are not necessary for other areas of the department, however, the airflow directions should be maintained from the clean to the less clean areas.

8.78 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
8.79 The design of the ventilation system for the ancillary rooms depends on the overall configuration of the department. The ancillary rooms plant may need to be interlocked to the theatre suite plants so that reverse airflow patterns do not occur.

8.80 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).

Central sterile pack store
8.81 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
8.82 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 airflow.

8.83 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 (COSHH).
Ultra-clean ventilation system

General requirements

8.84 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 significantly reduce post-operative sepsis following certain orthopaedic procedures.

Note: The number of microorganisms 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/m³.

8.85 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 which 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.

8.86 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. Notwithstanding any variation in their design philosophy, all UCV systems will be required to completely achieve the performance standard set out in the “Validation” section of this document.

8.87 As with conventional theatres, each UCV operating suite should have its own dedicated air handling unit (AHU) to the standard set out in Chapter x. To ensure operational flexibility and permit routine maintenance, air handling units should not be shared between suites.

8.88 In retro fit 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 airflow rate reduced so that either suite can be taken out of use without detriment to operating conditions in the other.

8.89 An inherent feature of a UCV system is its large airflow so it is essential to recirculate the air supplied to the operating theatre and/or to recover its energy in order to optimise operating costs.

8.90 The primary fresh air volume supplied to an 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.

8.91 Laying up in the clean zone is preferable microbiologically. Where a sterile pack store (SPS) preparation room is provided, a transfer grille will be required in the prep/theatre door.

8.92 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 baffle to prevent air transfer interfering with the ultra-clean airflow distribution.

8.93 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.

8.94 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

8.95 In a remote plant system, all the air-conditioning equipment is located outside of the operating room, except for the uni-directional airflow terminal, terminal filter, air diffuser and the return air grilles. (see Figure ##).

8.96 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 airstream.
- 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 airstream. 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**

8.97 Vertical flow modular units comprise a ceiling mounted canopy 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.

**Vertical Flow UCV Systems**

8.98 Vertical flow systems are effective at reducing infection risks. Some systems have no walls and use auxiliary fans to create an air curtain around the clean zone. Partial wall systems have side screens that terminate 2 m above floor level and full wall UCV have side screens that terminate 1 m above floor level.

8.99 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 should be not less than 1 m from the operating room walls and terminate at least 2 m above floor level. Full wall systems provide a physical barrier between the operating team and other theatre occupants and guide the air down to the operating table level. They can therefore work at a lower air velocity.

8.100 Siting the return air grilles around the periphery of the theatre at low level will help control short-circuiting 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.

8.101 Vertical systems should have a clean zone large enough to encompass the operating site and all the instrument trays likely to be needed for the surgical procedures to be undertaken. Ophthalmic and minor hand surgery would typically require a 1·4 m circular or rectangular terminal. For major orthopaedic procedures, a minimum size of 2·8 m x 2·8 m 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. Having a contrasting coloured area on the floor delineating the extent of the clean zone will assist staff and is therefore essential.

8.102 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. However, issues of cooling coil
drainage, condensate removal and maintenance access within the space
constrains of the module may make this option impracticable. The additional
cooling load should then be catered for by conditioning the primary air to
compensate.

8.103 If an existing AHU is to be retained, it may require modification to ensure that
it achieves the minimum standards set out in Section ## 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 increase 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.

8.104 A factor affecting the airflow pattern is the supply/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.

8.105 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. For all vertical UCV systems, the design
discharge velocities will be as follows:

Air velocity 2 metres above floor level:

- No side wall system = 0·38 m/s average
- 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 section gives details of the method of measurement.

8.106 Variable speed recirculation fans with differential pressure control may be the
most suitable solution for maintaining consistent performance and energy
saving.

UCV Filters

8.107 The AHU primary and secondary filters should be to the standards and in the
location set out in Section 9.

8.108 Terminal filters should be provided within the UCV canopy 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.

8.109 In some modular UCV units their manufacturers state that the terminal filter is used as a pressure equaliser to balance airflow so a grade higher than H10 is fitted. 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.

8.110 The final filters should be installed in a leak-proof housing in a manner which 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.

8.111 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, non-electronic pressure gauges should be fitted.

8.112 The UCV system will require a return air filter to capture the relatively coarse particles which would otherwise significantly reduce the life of the final filter. This should be at least an ISO 1689 Coarse 60%. 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

8.113 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.

8.114 The maximum noise level in an operating room fitted with a UCV terminal of any type should not exceed 50 dB(A). Chapter 12; Validation; gives details of the method of measurement.

Lighting and operating Lights

8.115 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.

8.116 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 retro fitting UCV systems.

8.117 In vertical UCV installations a minimum of 2.75 m from floor to the 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.

**Note:** The traditional means of light support is a central column that passes through the UCV canopy and is rigidly fixed to the building structure. The position of the support therefore prevents air being supplied at the centre of the canopy. Separate supports displaced from the centre of the clean zone would lead to improved airflow. This approach was advocated in the 1994 version of this guidance but at the time of writing no UK manufacturer has chosen to adopt this solution. Alternatively providing the operating team with battery powered headsets incorporating lights will remove the need for traditional operating lamps and their supports.

**Controls and instrumentation**

8.118 The functions of the supply AHU and extract ventilation should be continuously monitored by a BMS control unit. The controls and instrumentation for the main plant are set out in Chapter 9.

8.119 UCV systems will additionally require:

- A set-back facility that can reduce the air supplied through the UCV canopy to a volume that equates to not less than 22 air changes per hour of the operating room gross volume or that required for door protection whichever is greater, whilst still leaving the supply AHU operating at full speed.
- A readout sufficiently large (25 mm) to be clearly visible from the operating table that shows the temperature of the air being supplied by the UCV canopy.
- A readout sufficiently large (25 mm) to be clearly visible from the operating table that shows the relative humidity of the air being supplied by the UCV canopy.
- A red indicator light that will illuminate when either the supply AHU or the UCV canopy fails, or either or both are switched off.
- An amber indicator light that will illuminate when the UCV canopy is at set back and the supply AHU is running.
- A green indicator light that will illuminate when both the supply AHU and UCV canopy are operating at full speed.
- A blue indicator light that will illuminate when the UCV canopy airflow, as detected by a differential pressure sensor, falls below 80% of the design flow rate.

8.120 The switching devices and indicators should be incorporated in the surgeon’s panel and their functions clearly labelled. In retro fit 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. (See SVHSoc. 01-V1.3 ‘Operating Theatres – Energy Control Strategies and the Surgeon’s Panel’ for further details.)
8.121 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.

8.122 The UCV unit manufacturers 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.
# Treatment facilities

Editor’s note – These tables are only examples of a format for application specific guidance.

<table>
<thead>
<tr>
<th>Critical application: Treatment facilities</th>
<th>Area / zone</th>
<th>Reason for ventilation</th>
<th>Specific design factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bronchoscopy treatment room</strong></td>
<td>Control of exposure of staff to airborne pathogenic material discharged by the patient e.g. MDRTB during the procedure being undertaken. (COSHH Regs.)</td>
<td>Establish a clean airflow path – Supply terminal at high level at foot end of patient’s chair / couch and extract terminal at patient’s head level behind the chair / couch. Design parameters Air change – 10 per hour Pressure regime – -5Pa to corridor Noise level – 40d(B)A Temp range – 20 to 24°C BMS control Humidity – Floating; max 70%RH Supply filter – ISO ePM10µ50% Extract discharge – Discharge in safe position away from people or open windows. If no suitable position available treat the discharge in the same way as an LEV with a discharge stack 3m above the roof line.</td>
<td></td>
</tr>
<tr>
<td><strong>Endoscopic procedure room</strong></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dental treatment room</strong></td>
<td>Control of exposure of staff to airborne pathogenic material discharged by the patient during the procedure being undertaken. (COSHH Regs.) Control of exposure of staff to waste anaesthetic agents when used. (COSHH Regs)</td>
<td>Establish a clean airflow path – Supply terminal at high level and extract terminal at low level near patient’s chair / couch. Design parameters Air change – 10 per hour Pressure regime – Neutral to corridor Noise level – 40d(B)A Temp range – 20 to 24°C BMS control Humidity – Floating; max 70%RH Supply filter – ISO ePM10µ50%</td>
<td></td>
</tr>
<tr>
<td><strong>General treatment room</strong></td>
<td>Comfort conditions only</td>
<td></td>
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</tbody>
</table>
# Critical care facilities

Editor’s note – These tables are only examples of a format for application specific guidance.

<table>
<thead>
<tr>
<th>Critical application: critical care</th>
<th>Area / zone</th>
<th>Reason for ventilation</th>
<th>Specific design factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: ITU and CCU should be treated identically in terms of service provision. Their only difference is the staff to patient ration. This provides resilience as ITU can decant to CCU and CCU to a ward with enhanced ventilation in the event of a ventilation failure.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive care / Continuing care individual room</td>
<td>Protection of patients from airborne organisms and fungal spores</td>
<td>Supply only in patient’s room and cascade air out via door undercut, transfer grille or pressure stabiliser through rooms of a lower classification.</td>
<td></td>
</tr>
<tr>
<td>Intensive care / Continuing care open bays</td>
<td>As above</td>
<td>Design parameters Air change – μ10 per hour Pressure regime – +5Pa to general area Noise level – 35d(B)A Temp range – 20 to 24°C BMS control Humidity – Floating; max 60%RH Supply filter – BS EN 1822 – H10</td>
<td></td>
</tr>
<tr>
<td>Bone Marrow Transplant (BMT) unit</td>
<td>Protection of patients from airborne organisms and fungal spores Note: Patient(s) will have a very poor immune system (neutropenia) so will be particularly vulnerable to infection by the airborne route.</td>
<td>Supply only in room and cascade air out via door undercut, transfer grilles or pressure stabilisers through rooms of a lower classification. Design parameters Air change – μ20 per hour Pressure regime – +15Pa to corridor Noise level – 35d(B)A Temp range – 20 to 24°C BMS control Humidity – Floating; max 60%RH Supply filter – BSEN 1822 – H12</td>
<td></td>
</tr>
<tr>
<td>Haematology / Oncology ward</td>
<td>As for BMT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transplant ward</td>
<td>As for BMT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Maternity facilities

**Editor’s note – These tables are only examples of a format for application specific guidance**

<table>
<thead>
<tr>
<th>Critical application: Maternity</th>
<th>Area / zone</th>
<th>Reason for ventilation</th>
<th>Specific design factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstetrics Theatre</td>
<td>Protection of patients from airborne organisms and fungal spores. Control of exposure of staff to waste anaesthetic agents. (COSHH Regs)</td>
<td>Ventilation design parameters as for a conventional operating suite. System should run at &quot;stand by&quot; with a minimum temperature of 18°C and be able to attain full operating conditions within 5 minutes of triggering the system</td>
<td></td>
</tr>
<tr>
<td>Delivery room</td>
<td>Control of exposure of staff to waste anaesthetic agents. (COSHH Regs)</td>
<td>Establish a clean airflow path – Supply terminal at high level at foot end of bed and extract terminal at low level at head end of bed. Design parameters Air change – 10 per hour Pressure regime – Neutral to corridor Noise level – 35d(B)A Temp range – 20 to 25°C local control Humidity – Floating – max 70%RH Supply filter – ISO ePM10µ50%</td>
<td></td>
</tr>
<tr>
<td>Delivery room with birthing pool</td>
<td>As for standard delivery room above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specials delivery room</td>
<td>As for standard delivery room above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery</td>
<td>Comfort conditions only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal intensive care unit or Special baby care unit (SCBU)</td>
<td>Protection of neonates from airborne organisms and fungal spores. Neonates are kept in incubators but may be removed for feeding, changing etc. so local temperature control and ensuring a draft free environment is essential.</td>
<td>Standard supply and extract Design parameters Air change – 10 per hour Pressure regime – +5Pa to corridor Noise level – 45d(B)A Temp range – 20 to 28°C local control Humidity – Floating – max 70%RH Supply filter – ISO ePM1µ65% - 90% (Filter grade depends on ODA Category – See SVHSoc.02-V1.3 document)</td>
<td></td>
</tr>
</tbody>
</table>

**N.B. This is a critical healthcare facility and consideration should be given to system resilience or how suitable alternative accommodation could be provided in the event of a ventilation system failure.**
## Pharmacy facilities

Editor's note – These tables are only examples of a format for application specific guidance

<table>
<thead>
<tr>
<th>Area / zone</th>
<th>Reason for ventilation</th>
<th>Specific design factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean room</td>
<td>Protection of product during and after compounding. EUGGMP standards apply and the Medicine Act if the facility is licensed. Control of exposure by the airborne route to staff of substances during and after compounding products. (COSHH Regs.) Note: While this application is a critical facility, it is usual to have a plan in place to decant to another site in the event of a ventilation system failure.</td>
<td>Supply only in clean room and cascade air out via pressure stabilisers through rooms of a lower classification. Note: thimble extract may be provided for Class 3 safety cabinets depending on the location of room within the building. Design parameters Air change – μ20 per hour Pressure regime – +15Pa between unclassified rooms and +10Pa between classified rooms Noise level – 45d(B)A Temp range – 20 – 24°C BMS control Humidity – Floating – max 60%RH Supply filter – BS EN 1842 – H14</td>
</tr>
<tr>
<td>Radiopharmacy clean room</td>
<td>As for standard clean room with additional requirements of the Radiological Protection Act and Regulations.</td>
<td>As above</td>
</tr>
<tr>
<td>Non-sterile stores and support rooms</td>
<td>Comfort conditions only</td>
<td></td>
</tr>
</tbody>
</table>
Hydrotherapy - general requirements

8.123 In a hydrotherapy suite, heat recovery via a heat pump.

8.124 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.

8.125 A recirculation plant is recommended, with fresh-air make-up to the standard required by the Building Regulations Part F – Non-domestic Buildings. In practice this may need to be increased to control condensation.

8.126 As far as practicable, recirculated 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.

8.127 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.

Control of hydrotherapy pool installations

8.128 The supply and extract fans should be interlocked so that the supply fan does not operate until flow is established within the extract system.

8.129 Time-clock control should be provided, with a local override switch to extend the normal operating period as required.

8.130 Night set-back temperature (in the range of 21-25°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.

8.131 A remote indication panel should be provided in the pool hall, giving a visual display of the pool water and pool air temperature.

Extract systems

8.132 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.

8.133 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 wood working machinery or large centralised pathology laboratories housing multiple safety cabinets, cut up benches, fume cupboards and specimen stores.
8.134 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 containment level 3 rooms
- Fume cupboards
- Welding fume extracts
- Wood working 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
- Dental furnaces, grinders and polishers.

8.135 LEV systems are statutory items that will be subject to an independent inspection every 14 months.

**Hood extract systems**

*Special requirements*

8.136 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.

8.137 Perimeter drain gulley’s and corrosion-proof grease eliminators should be provided on kitchen hoods.

*Typical arrangements*

8.138 The airflow rate should 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 m/s;
- vapour of gases 5 m/s to 6 m/s;
- light dusts 7 m/s to 10 m/s.

Excessive velocities will be wasteful of power and generate noise.

8.139 The lowest edge of the canopy should be 2 m above finished floor level, with a minimum of 300 mm overhang beyond the edge of the equipment on all sides.

8.140 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.
8.141 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.

8.142 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 airflow, and constitute a maintenance problem.

Control of hood extracts

8.143 Provided that it does not interfere with the operation of the department when not in use, the ventilation system for the hood extract any associated supply can be shut down. To this end, local control should be provided.

Bench extract systems

Special requirements

8.144 Bench extract ventilation is required in departments such as pathology and mortuary, where activities involve the release of malodorous or toxic fumes which should not be inhaled.

Typical arrangements

8.145 Each ventilated position will usually be accommodated in a continuous run of benching, which should not be more than 650 mm from front to rear and which should be provided with a continuous upstand at the rear. Each position should have a 1200 mm x 150 mm 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 75 mm 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

8.146 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 supply can be shut down. However, a run-on timer with a minimum setting of 30 minutes should be provided. To this end, local control should be provided.

8.147 Processes that use produce hazardous vapours, fumes, dusts or noxious vapours should be enclosed or semi enclosed in a suitable cabinet or exhaust protected work station.

Safety cabinet and fume cupboard extract systems

8.148 Safety cabinets and fume cupboards are devices that have 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 LEV systems under the COSHH Regulations. The make-up air system to a room that
contains an LEV system may also be considered as an essential part of the system and be included in the LEV classification.

**Special requirements**

8.149 The supply air system should not distort the uni-directional 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 airflow 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.

**Arrangements for safety cabinet installations**

8.150 The manufacture and installation of microbiological safety cabinets should be in accordance with the relevant national standards and guidance issued by the Advisory Committee on Dangerous Pathogens (ACDP).

8.151 A Class 1 microbiological safety cabinet should be specified for routine work involving Group 3 pathogens. It should be housed in a containment level 3 room. Specific design information on containment rooms is issued by ACDP in conjunction with the Health and Safety Commission.

8.152 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 uni-directional airflow 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.

8.153 Microbiological safety cabinet extract is HEPA filtered prior to being discharge to outside. The extract ductwork should as far as practicable be kept under negative pressure while inside the building.

8.154 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.

8.155 The discharge from the cabinet should be fitted with a back draught damper. In multiple installations where several cabinets discharge into a common extract and discharge duct, it should be possible to isolate each cabinet from the system when not in use.

8.156 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 separate 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 3 m high terminal.

8.157 Where this is impracticable, discharge into the room via a double HEPA filter has been accepted; the preferred method however is to discharge above the roofline as per the clause above and the similar standard for fume cupboard designs.

Arrangements for fume cupboard installations

8.158 The manufacture and installation of fume cupboards should be in accordance with the relevant national standards and associated guidance.

8.159 The primary factors which 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.

8.160 The air velocities through sash openings should 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 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 should be maintained irrespective of whether the sash opening is varied, or whether doors or windows are open or closed.

8.161 The possibility of a fire or explosion which may not be contained by a fume cupboard should 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.

8.162 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.

8.163 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.

8.164 Fume cupboards for certain processes should 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.

8.165 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 change-over and be fitted with a flow failure alarm.

8.166 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

8.167 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.

8.168 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.

8.169 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.

Plantroom ventilation

General requirements

8.170 Plantrooms are required to be ventilated in order to maintain acceptable temperatures for satisfactory operation of the plant and controls, and for maintenance activities. Natural ventilation through louvred openings protected from infestation by a mesh of 6 to 12 mm is preferred. Powered plantroom ventilation should only be required if the plantroom lacks an outside wall.

8.171 Ventilation requirements should 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.

8.172 Air handling equipment should not be located in a fire compartment that houses combustion equipment.

8.173 Statutory regulations for plantroom ventilation are contained in the Building Regulations, and further guidance in Section B13 of the CIBSE guide.
9 Equipment selection factors

General requirements

The following gives detailed guidance on the design and selection of ventilation equipment, the distribution system, terminals and control aspects. Designers should take note of the supporting information given in Chapter 10 – Installation standards and Chapter 12 - Validation and acceptance process. Failure at the design stage to make due allowance for the standards to be achieved may mean that the installed ventilation system will not be acceptable to the client at handover.

Location and access

9.1 The plant should 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.

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

9.3 Air handling units (AHUs) should be located in an accessible area secured from unauthorised entry. They may be grouped together in dedicated plantrooms or distributed around the building with AHUs located adjacent to or within the area that they serve. In the healthcare setting, mounting units in ceiling voids above occupied spaces is not permitted.

9.4 Wherever possible AHUs should be located in purpose-built plantrooms or designated service spaces within a building. This will allow for routine service and maintenance (which is a statutory requirement) to be carried out at any time of day and regardless of weather conditions. It will also protect the plant from contamination by bird droppings so reducing the risk of fungal spore contamination of the air supplied by the AHU. Control of pests and vermin will be simpler and while not in themselves a source of airborne contamination, their corpses can become a reservoir of biological material that may lead to fly and wasp infestations within the AHU.

Note: In a new building it is not envisaged that there will be any need to locate AHUs outside. The design of the building should incorporate central or distributed plant spaces, sufficient for the services to the building.

9.5 When refurbishing or changing the use of an existing building, plant space will need to be created to house the ventilation plant and other services. If located on a roof, they should be enclosed in a plantroom with a safe means of access. If located at ground level, they should be secured within a plantroom to prevent unauthorised access. Measures should be taken to exclude vehicles from the vicinity (min distance 4 m) to ensure that exhaust fumes will not be drawn into intakes. Ideally intakes for ground level AHUs will be extended to a height that allows them to draw in unvitiated air.
9.6 In the unlikely event that an internal or external plantroom cannot be provided, and ventilation units have to be located outside, they will need to be fully weatherproof to IP65 standard and secured from unauthorised access. Protection against the elements should also be provided for personnel carrying out routine inspection and maintenance activities. As an example, when two units are outside, and they are installed with their access doors facing each other, if the gap between them is roofed over and the open ends capped, then the AHUs themselves create what is in effect a plantroom.

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

Note: Plantrooms should be provided with a sink so that glass drainage traps may be cleaned out and staff can wash their hands after handling contaminated / dirty filters. A source of domestic hot water (DHW) with a valved hose connection point will also be required so that AHUs can be washed out internally as part of their routine maintenance.

9.8 Fire precautions should be incorporated in accordance with HTM 05. Guidance is available in Section 3 of this document.

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

Standard requirements

Identification and labelling

9.10 All ventilation systems should be clearly identified with a permanent label in accordance with the requirements of Chapter # para ###. The label should identify both the AHU and the area that it serves. The lettering should be at least 100 mm high and be mounted in an easily visible place near the fan of the unit adjacent to the local electrical isolator. Any subsystems and the principal branch ducts should be similarly labelled.

Note: The AHU identification code should conform to the plant identification system at use in the premises. (See Chapter 13 – System information)

9.11 The direction of airflow should be clearly marked on all main and branch ducts (see BS1710).

9.12 All airflow test-points should be clearly identified with a permanent label and the design information given. (e.g. TPS 1 – anaesthetic supply; 400 x 300; design 185L/s).
9.13 Plants should comply with the minimum standards set out in the table below.

<table>
<thead>
<tr>
<th>AHU Element</th>
<th>Minimum Standard</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>Double metal skin with sandwiched insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smooth internal surface without channels or ridges</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No projecting spire screws inside the unit.</td>
<td></td>
</tr>
<tr>
<td><strong>Note:</strong></td>
<td>Capping projecting spire screws is not acceptable.</td>
<td></td>
</tr>
<tr>
<td>Internal surface finish</td>
<td>Powder coat or equivalent</td>
<td>Not surface galvanised</td>
</tr>
<tr>
<td>Thermal transmittance</td>
<td>BS EN 1886; Class T2</td>
<td>Manufacturers declaration</td>
</tr>
<tr>
<td>Thermal bridge</td>
<td>BS EN 1886; Class TB2</td>
<td>Manufacturers declaration</td>
</tr>
<tr>
<td>Deflection</td>
<td>BS EN 1886; Class D2</td>
<td>Manufacturers factory test</td>
</tr>
<tr>
<td>Factory airtightness test</td>
<td>BS EN 1886; Class L2</td>
<td>Test at +700Pa and -400Pa</td>
</tr>
<tr>
<td>– pre delivery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site airtightness test</td>
<td>BS EN 1886; Class L2</td>
<td>+700 / -400 Pa</td>
</tr>
<tr>
<td>Filter frame bypass leakage</td>
<td>BS EN 1886; Section 7</td>
<td></td>
</tr>
<tr>
<td>Supply and extract intake and</td>
<td>C3 (Low loss)</td>
<td>Motorised opening and fitted with an end switch and spring return</td>
</tr>
<tr>
<td>discharge isolation dampers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access doors</td>
<td>Secured from casual access</td>
<td>Key or similar device required to open access doors</td>
</tr>
<tr>
<td></td>
<td>Fan chamber doors fitted with two-stage latch</td>
<td></td>
</tr>
<tr>
<td>Specific Fan Power -</td>
<td>Current Eco design requirement for energy related</td>
<td>EU 1253 – 2014</td>
</tr>
<tr>
<td>Internal (SFP int)</td>
<td>products (Erp)</td>
<td></td>
</tr>
<tr>
<td>Specific Fan Power -</td>
<td>UK Building Regs</td>
<td>Part L</td>
</tr>
<tr>
<td>System (SFP syst)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy recovery</td>
<td>Current Erp</td>
<td>Run Around Coil – 68%</td>
</tr>
<tr>
<td></td>
<td>EU 1253</td>
<td>Heat pipes – 73%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plate heat exchanger – 73%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermal wheel – 73%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat pump – EU2281 / 201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any other device – See standard</td>
</tr>
</tbody>
</table>
The external finish should be corrosion-resistant and may be available in a variety of colours at no additional cost. This can aid identification by colour-coding of units in a plantroom, e.g. green for general ventilation; blue for theatres; red for laboratories and isolation facilities; grey for extract, etc.

Organic materials or substances that can support the growth of microorganisms should not be used in the construction of the plant or its distribution system. The water fittings and materials directory list suitable materials for sealants and gaskets (see also BS 6920).

AHU internal wiring must comply with BS 7671 and be installed in a cable containment system providing suitable mechanical protection. The wiring and its containment system must not allow air bypass at the filters. It should permit the effective cleaning and inspection of the duct including all fixings and internal cable connectors.

Plastic bladed dampers and plastic plate heat exchangers should not be fitted.

Motorised spring return low leakage (Class 3) isolation dampers should be located at the intake, supply, return air and discharge duct connections of an AHU and associated extract unit. They should be of the opposed blade type, opening through a full 90° and be fitted with end switches. They should close automatically in the event of power failure or plant shutdown to prevent any reversal of the system airflow. They will also function to isolate the plant from the distribution system when undertaking cleaning or maintenance.

Note: Internal plant dampers or provision for the fitting of shut off plates also known as dagger plates between elements within an AHU are not required.

Access to elements that require routine service such as filters, fans and all types of heat transfer device should be via hinged doors. In horizontal units the doors should be wide enough e.g. 500 mm minimum to allow easy access. Items requiring infrequent access such as attenuators may be via bolted on, lift off panels or access hatches. All doors and panels should be secured from casual access, close-fitting and without leaks.

Access doors to fan chambers should have a two-stage opening sequence to prevent the door blowing violently open if it is unlatched while there is still residual pressure in the unit.

Note: Providing the AHU is located in a plantroom or area secured from unauthorised entry, its access doors can only be opened with a key or similar device, the fan door is fitted with a two-stage opening latch and there is a fan electrical isolation switch adjacent to the fan chamber access door, then there is no requirement to fit an internal fan chamber mesh guard.

In the healthcare setting 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. In double stacked units the
viewing ports in the upper section should be located in the lower portion of the access doors. Internal illumination should be provided by fittings to at least IP55 rating. Light fittings should be positioned inside the unit (not on the access doors) so that they provide both illumination for inspection and task lighting. All the lights in a unit should be operated by a single switch and be powered independently of the AHU main switch.

9.22 Access to AHUs and items in the distribution system such as auxiliary filters or heater/cooling coils in the plantroom should be via fixed ladders, hook ladders, platforms or pulpit-style movable 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.

Heat rejection devices

9.23 The design conditions given in Chapter # make no allowance for the elevated temperatures that can occur on the roof of buildings. Refrigeration condensers and chiller units should, if practicable, be shaded from direct solar radiation, or the design adjusted to take account of the gain. Care should be taken to ensure that there is sufficient clearance around the plant to allow effective air movement.

9.24 Air-cooled condensers and/or dry coolers should always be the first choice for heat rejection from any refrigeration plant. The use of heat pump systems is also an option. Wet evaporative cooling systems should not be used in healthcare premises unless limitations of space mean that they are the only way that the cooling load can be met. If they are used, national guidance on preventing and controlling legionellae should be closely followed. (See Chapter #)

9.25 Traditional refrigerants are being phased out, and some of their replacements at the time of writing have a degree of flammability. The level of risk this possesses should be formally addressed at the design stage and agreed with the client or their fire safety representative.

Chiller selection – size and resilience

9.26 There is a tendency to meet the calculated maximum chiller load by specifying multiples of a standard size of chiller e.g. the calculated load to be met by 3 chillers each capable of 33% and an extra chiller of the same size to achieve the N+1 resilience requirement. This approach does not lend itself to efficient operation. It is preferable to split the load with for example 2 chillers capable of 40% each and 2 capable of 25% each. This will give an overall capacity resilience and allow for the actual part load demand to be met in the most energy efficient way.

Sequence of components

9.27 The AHU should be arranged so that most of the items are under positive pressure. Any item of plant requiring a drain should be on the positive pressure side of the fan. The following arrangement of components is typical although in many instances not all elements will be required:

- fresh air intake
• motorised isolation damper
• fog coil if energy recovery fitted; frost coil if no energy recovery fitted
• pre-filter
• energy recovery device
• attenuator #
• supply fan
• attenuator #
• cooling coil
• eliminator (for face velocities above 2.5 m/s)
• heater-battery
• humidifier (if required)
• final filter
• motorised isolation damper

# Attenuators may be located in the intake and discharge duct if they are of a suitable type and provided with cleaning access both sides (See clause #)

9.28 AHUs may be configured as horizontal, linear single or double stacked; or as cabinet type units. For double stacked supply / extract units, both fans should be located on the bottom deck where possible as it will make them simpler and safer to change (see diagram of possible arrangement).

Supply AHUs and associated extract units

Intakes

9.29 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.

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

9.31 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 airflow in extracts. Exhaust fumes from the helicopter may also be drawn into intakes.

Note: It is not appropriate to “plan to turn the ventilation off when a helicopter lands” as a means of permitting the location of a helipad adjacent to ventilation intakes and discharges.

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

9.33 On the rare occasions where intakes have necessarily to be sited at or near ground level, the surrounding area should be paved or concreted to prevent soil
or vegetation being drawn in. They should be caged or located within a compound to restrict unauthorised access and 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 and additional filtration may be required. There should be a 4m clear zone around the intake. (See Clause 9.5 and Activated carbon)

9.34 The discharge from an extract system should 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). At all times, there should be a minimum separation of 4 m between them, with the discharge mounted at a higher level than the intake.

Note: Ventilation intakes and discharges should not face each other across a passageway or courtyard even if they are 4 m or more apart.

9.35 Each intake and discharge point should be fitted with corrosion-resistant weatherproof (Class B) louvres or cowls to protect the system from driving rain. Louvres should be sized based on a maximum face velocity of 1·5 m/s in order to prevent excessive noise generation and pressure loss.

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

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

9.38 Cleaning access should be provided either from the outside via hinged louvres or by access doors in the plenum behind the louvre. Where a floor level common plenum is provided, cleaning access should be via a walk-in door. High-level plenums should be able to be safely accessed by temporary or permanent means.

Note: Builders’ work plenums or intake ducts will need to have a smooth finish and be surface-sealed to prevent dust shedding (see paragraph 10.5).

Fans

9.39 Direct drive Electronically Commutated (EC) fans are the preferred choice for ventilation systems. Resilience and an increased capacity can be achieved by installing a “fan wall” comprising two or more EC fans with gravity or motorised dampers downstream to prevent backflow.

9.40 Alternatively, for an application outside of the capacity range of EC fans, direct drive “Plug” fans controlled by an inverter mounted externally could be selected.

9.41 In either case the fan motor should be protected with a high temperature safety cut out.

9.42 Whichever type of fan is selected, if it serves a critical area it should be fitted in a way that allows it to be changed within 20 minutes. To facilitate this, power and
control cable connections should be plug and socket type within the fan chamber. Whenever possible fans should be located on the bottom deck of a double stacked AHU. (See also Clause 9.16)

9.43 Selecting fans from a preferred size range will reduce the number of spares held.

9.44 Belt- and pulley-driven fans should not be installed in healthcare ventilation systems.

9.45 Supply fans should be positioned to “blow through” the central plant so that the cooling coil and humidifier drains will be under positive pressure.

9.46 In extract systems where the air is potentially contaminated, explosive, aggressive or has a high moisture content, the extract fan motor should be located outside the airstream and be capable of being changed without the need to access or change the fan impeller.

Control
9.47 Preferred normal function are both fans running in parallel, in case of failure the remaining fan is to provide least 75% of the desired output

9.48 For most healthcare applications, the fan output should be set to give a constant volume of air. This should be controlled by measuring the pressure drop across the fan using a sensing ring and associated volume controller that will automatically integrate the fan’s K-factor to determine and control the pre-set output air volume. The fan output will then in air volume terms remain constant regardless of changes of system resistance. The actual volume delivered will be related to the air change rate for the application.

Note: Measuring the air pressure in the main supply duct and using that to set the supply fan speed as a percentage of its rated output and using that to set the extract fan speed as a percentage of the supply fan speed is not a satisfactory, accurate or an acceptable way of controlling the desired supply and extract air volumes.

Filters
9.49 The purpose of filtration is to reduce the level of airborne contamination in an airstream. It is generally carried out in stages.

9.50 Filters should be securely mounted in well-fitting frames that minimise air bypass. Frames should be designed so that the airflow pushes the filter into its housing to minimise air bypass. Vertical supports with seals should be provided to master filter joints and reduce bypass. Mounting frames that withdraw so that the filter can be changed without having to reach into the unit are preferred.

9.51 Filters need to be readily accessible 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.

9.52 For AHUs, provided that each filter’s pressure drop is monitored by a sensor linked to the BMS, direct reading gauges or manometers will not be required.
Capped pressure tappings should be provided, however, so that a portable manometer can be connected for diagnostic purposes when necessary.

9.53 General air filters are divided into four categories related to the size of particle in microns (µm) that they can remove as a percentage of the load.

- Coarse filters – Remove less than 50% of 10 µm particles
- PM10 Medium filters – Remove 50 to 95% of 10 µm particles
- PM2.5 Medium filters – Remove 50 to 95% of 2.5 µm particles
- PM1 Fine filters – Remove 50 to 95% of 1 µm particles

**Note:** Ventilation filters can only remove particles from the incoming air. Most particles that could cause an infection originate from the occupants and activities within the building.

9.54 In AHUs the pre-filter and return air filter will keep the energy-recovery device, chiller and heater-batteries clean and working efficiently. The secondary filter will keep the distribution ductwork and supply air terminals clean. In more critical areas an ePM1 filter will provide an enhanced patient environment.

### Table 1 General filters – Typical healthcare selections

<table>
<thead>
<tr>
<th>ISO 16890 Class</th>
<th>Notes and typical healthcare application</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Coarse 60%</td>
<td>Panel pre-filter or return air filter to protect the energy recovery device</td>
</tr>
<tr>
<td>ISO ePM10 &gt;= 50%</td>
<td>General area supply air filter</td>
</tr>
<tr>
<td>ISO ePM1 &gt;= 50%</td>
<td>Critical area supply air filter</td>
</tr>
</tbody>
</table>

**Note:** For additional information on filter selection and indoor air quality see SVHSoc.02 – Change in Air Filter Test and Classification standards.

9.55 In areas of high atmospheric pollution, a higher standard of filtration may be required in order to meet the indoor air quality standard.

9.56 Rigid frame filters incorporating pleated elements are preferred as bag filters are often incorrectly oriented and damaged when changed.

*High Efficiency Particulate Air (HEPA) filters*

9.57 These filters are designed to provide very high-efficiency filtration of particles in the sub-micron size range. HEPA filters self-select the particle that they are least able to trap and are graded against that “Most Penetrating Particle Size” (MPPS).

- High Efficiency Particulate filters (HEPA) 5 grades H10 to H14
- Ultra Low Particulate Air filters (ULPA) 3 grades U15 to U17

**Note:** ULPA filters are designed to remove particles below a size that are either surgically or aero biologically significant. There would have to be exceptional circumstances in order to justify their use in healthcare ventilation systems.
9.58 HEPA filters are expensive so their use should be kept to a minimum. When used they should be of the replaceable panel type with leak proof seals and installed in a manner that permits the validation of the filter and its housing. (See Chapter #)

9.59 In supply systems a HEPA filter should have a non-shedding metal case.

### Table 2 HEPA Filters – Typical Healthcare selections

<table>
<thead>
<tr>
<th>Typical healthcare application</th>
<th>Minimum filter grade to BS EN 1822* (Eurovent grade)</th>
<th>% Efficiency @ MPPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCV theatre terminal</td>
<td>H10 - (EU10)</td>
<td>85</td>
</tr>
<tr>
<td>-</td>
<td>H11 – (EU11)</td>
<td>95</td>
</tr>
<tr>
<td>Immunosuppressed and neutropenic patient rooms or wards</td>
<td>H12 - (EU12)</td>
<td>99.5</td>
</tr>
<tr>
<td>-</td>
<td>H13 - (EU13)</td>
<td>99.95</td>
</tr>
<tr>
<td>Pharmacy: aseptic preparation facility supply Containment level 3 room extract</td>
<td>H14 - (EU14)</td>
<td>99.995</td>
</tr>
</tbody>
</table>

*Incorporates ISO 29463 tests methods

### Return air and extract air filters

9.60 Return air filtration will always be required where heat recovery devices are installed. Return air filters are also used to reduce the load on HEPA filters in recirculating applications such as ultra clean operating suite ventilation canopies and pharmacy aseptic preparation facilities. They should be the same grade as their AHU pre-filter.

9.61 HEPA filters are sometimes fitted in extract systems to capture hazardous substances or organisms. Design provision should 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 personnel having to come into direct contact with it

### Notes:

(1) In view of the costs and problems associated with placing HEPA filters in extracts, it is essential 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; the validation of its performance at installation; the method of safely changing a contaminated filter; and its subsequent disposal.

(2) General extracts from mortuaries and post-mortem rooms may contain odours but these are not in themselves hazardous to health and do not require HEPA filtration prior to discharge. In high-risk post-mortems (e.g. known or suspected TB cases), the infected organs will be removed and dissected in a Class 1 microbiological safety cabinet provided under the COSHH Regulations.
Extracts from infectious disease isolation rooms or wards do not normally require HEPA filtration prior to discharge. However, if the discharge cannot be made in a safe location and it is likely that the vitiated air could be drawn back into the building or there are people in its vicinity e.g. a discharge into a courtyard, HEPA filtration would be required.

9.62 Extract HEPA filters may have a particleboard or plywood case so they can be incinerated.

**Activated Carbon Filters**

9.63 Activated carbon filters can remove gases and vapours from an airstream and are graded according to the range of substances they can remove. They are not normally fitted in air-conditioning supply systems.

9.64 They are occasionally fitted retrospectively because an air intake has been poorly sited and is drawing in noxious fumes. Where used, they should be protected by, or incorporated into, a particulate air filter.

9.65 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.

**Energy recovery devices**

**General requirements**

9.66 Energy recovery will normally be fitted to all supply and extract healthcare ventilation systems. It may be omitted only where permitted by the current energy-related products (ErP) directive in the form of EU Regulation 1253.

9.67 For most systems in healthcare premises a plate heat exchanger, “run-around coil” system or thermal wheel would be appropriate. Selection should be based on the 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.

**Note:** Plate heat exchangers are the preferred option as they require the least maintenance to retain their energy transfer efficiency.

9.68 The following are the minimum energy transfer efficiencies required under EU 1253 (2018) for devices handling equal air volumes:

- Run around coil – 68%
- Plate Heat exchanger – 73%
- Thermal wheel – 73%
- Heat pipe - 73%
- Heat pump or any other device – See specific regulations

9.69 If a plate heat exchanger is chosen, the plates should be constructed of metal; in coastal areas stainless steel is preferred. Plastic should not be used for internal bypass dampers.
9.70 Whichever energy-recovery device is chosen, the extract side will need to be protected by a BS EN 16890:2016 ISO Coarse μ60% filter and provided with a drainage system as described in Chapter 9 paragraphs 9.115–9.122, to remove condensate. Note: most condensate occurs not at extreme conditions.

9.71 The energy-recovery device should be located downstream of the fog coil and pre-filter, before the cooling coil and main heater-battery.

9.72 It is essential to consider the set points and control of the fog/frost coil no frost coil with heat recovery, energy recovery device, cooling coil and heater-battery in order to achieve the most efficient operation. In particular primary energy provided by the fog/frost coil will directly reduce the heat exchange of the recovery device. To this end, the off-coil setting of the fog/frost coil should be the minimum possible to keep the pre filter dry (2 to 3 K). (See Clause # for further guidance).

9.73 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.

9.74 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.

**Heater-batteries**

**General requirements**

9.75 Note the difference in Fog and Frost coils caused by the new energy recovery regs

9.76 Fog/frost heating coils 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.

9.77 Where steam coils are used for a fog/frost battery, they may be constructed using spiral fined copper tube. As they will be prone to fouling, the tube layout and spacing should permit easy access for regular cleaning.

9.78 Main and branch heater-batteries should be constructed of solid drawn copper tube coils with copper fins, generally connected in parallel. In coastal areas an anti-corrosion treatment will be required.

9.79 Where there is a wet heating system in the areas served, the main heater-battery should be sized, in conjunction with the energy recovery device, for the ventilation requirements only and not for the building fabric loss. Ventilation should only be used for heating the building fabric if the area is in use 24 hours per day or the room specification precludes the use of heat emitters and it is not within the
heated volume of the building e.g. a clean room or operating theatre with external walls.

9.80 Access for cleaning should be provided to both sides of all fog coils and heater-batteries.

9.81 Electric, water or steam heater-batteries may be considered; however, electric heater-batteries are expensive to operate so their use should be restricted to low power use, for example trimming control.

9.82 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 condensate main as this will result in a back-up of condensate in the battery.

9.83 Where possible, wet trimmer heater-batteries should be located in plant areas.

9.84 Where it is necessary to locate heater-batteries in false ceilings etc, consideration should be given to the use of electric heaters (note that additional fire detection may be required). If this is not practicable and a LPHW system is used, a drip-tray should be installed under 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-clinical areas and never above patient occupied spaces.

9.85 Auxiliary fan coil units should not be installed in the ceiling above a patient occupied space. They should be accessible for routine maintenance and cleaning without the need to cause significant disruption to the operation of the area that they serve.

**Cooling coils and eliminators**

9.86 Cooling coils supplied with chilled water are the preferred option. For small loads e.g. below #Kw or where chilled water is not available, direct expansion (DX) coils may be used.

**Note:** For DX coils, it may be necessary to divide the chiller circuits unevenly in order to achieve efficient operation under part load conditions. The turn down ration should allow stable control down to 10% of the peak load.

9.87 Cooling coils will need to be periodically decontaminated so the fin spacing needs to be μ 2·5 mm and the fins rigid enough to withstand cleaning. Hinged access doors with viewing ports and illumination inside the duct should be provided both sides of the coil.

9.88 In an AHU when the cooling coil face velocity is greater than 2·5 m/s a drift eliminator will be required downstream of the coil.

**Note:** The eliminator will be an entirely separate device mounted on slide rails so that it can be easily removed without the need for tools. For small DX coils the eliminator may take the form of a joggled extension of the fins.
9.89 All cooling coils should be fitted with their own independent drainage system as specified in Clause 115 onward. A baffle or similar device should be provided in the drip tray to prevent air bypassing the coil. The tray should be large enough to capture the moisture from the coil headers and drift eliminator.

9.90 Where coils are greater than 1 m high either intermediate drip-trays will be required or the fin spacing increased to \( \mu \) 3mm.

9.91 Care should be taken in selection to minimise electrolytic action resulting from condensation on the air side. Cooling coils constructed from copper tubes with copper fins and electro-tinned after manufacture are preferred. Aluminium fins should only be used if vinyl coated.

9.92 All parts of the coil and its associated ductwork in contact with moisture should 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 so stainless steel is preferred.

9.93 Where a cooling coil has to be located above a ceiling, a drip-tray should be installed under the battery and control valve assembly to protect the ceiling from leaks and condensation drips. 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.

9.94 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. The drainage of such items is often problematic. If a suitable fall in the drain line cannot be achieved, then a pump out system should be provided.

**Humidifiers**

9.95 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 (see Chapter 8 and associated HBNs).

**Note:** If in an operating theatre high humidity is required to help prevent tissue drying during surgery, then it should be provided when required using distilled water in a disposable nebuliser driven by medical air and not from a humidifier installed in the ventilation system. In that way the quality of the moisture will be assured.

9.96 If it is unclear at design stage whether humidification may be required, then provision for retro fitting in terms of space provision and a capped drainage system could be provided either in the AHU or a zone branch duct. The need for such provision and the amount of space allowed for it should be agreed in writing with the client.
If a humidifier is required, the manufacturer’s instructions regarding selection, capacity, installation and control should be closely followed. Incorrectly sized, installed or operated humidifiers can become a source of fungal and microbiological contamination within a ventilation system. This may result in a significant airborne infection risk to patients and staff.

Only steam injection manifold-type humidifiers are considered suitable for use in health building air-conditioning systems. The injected steam should be generated locally either by mains steam or electricity, within or adjacent to the humidifier. Water-curtain, water mist or spray humidifiers of any type should not be used.

Note: Jacketed lance mains steam humidifiers will always be a source of heat within the system during the cooling season unless completely isolated when not required.

All parts of the humidifier and its associated ductwork in contact with moisture should be manufactured from corrosion-resistant materials. Stainless steel is preferred.

For self- and locally generated steam humidifiers, the cleanliness of the water supply is essential for their safe operation. The water supply should be derived from a wholesome source or demineralised supply. Chemical treatments should not be added to the water supply of humidifier units. The electrodes of self-generating electrode-boiler humidifiers should be stainless steel.

If the quality of the water supply to a self-generating humidifier unit cannot be assured, an ultraviolet (UV) system to control microbiological growth could be installed. However, given the limitations of UV systems, this will require high quality water filtration 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.

Provision should be made for draining down supply pipework and break tanks for periodic disinfection and cleaning during the seasons when they are not required in service. The humidifier branch water supply isolation valve should be located at the junction with the “running” main to prevent the creation of a dead leg. All parts of the system should be capable of being cleaned or disinfected as necessary. 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.

A zone humidifier, if required, may be installed in a supply branch. The ductwork in which the humidifier is mounted – and for at least 1 m downstream – will need to be stainless steel.

All humidifiers wherever installed should be fitted with their own independent drainage systems as detailed in paragraphs ## and be completely accessible for cleaning.
Drainage

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

9.106 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 up-stand; and that a slope of approximately 1 in 20 in all directions should be incorporated to the drain outlet position.

9.107 In AHUs that have access doors large enough for a person to enter, the drip-tray should be easily accessible for inspection and cleaning.

9.108 In AHUs with access doors too small for a person to enter, the complete drip-tray should be capable of being withdrawn. It should be clamped into the AHU with thumb screws so that it can be removed without the need for tools.

9.109 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 than 1 in 60.

Insert table of water colour from Part B

9.110 Traps fitted to plant located outside or in unheated plantrooms need to be trace heated in winter. The trace heating should not raise the temperature of water in the trap above 5°C.

9.111 Water from each trap should discharge via a clear air gap of at least 15 mm 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.

9.112 Drainage pipework may be thermoplastic, copper or stainless steel. Glass should not be used. The pipework should be a minimum diameter of 22 mm 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.

Note: That in the case of fan coil units, the glass trap and air-break may be omitted and a pump out system fitted. The unit drainage should connect to the main drainage system via a waterless trap that does not allow discharged water to return. The drainage tray itself should be easily removable for routine inspection and cleaning.
**Attenuators**

9.113 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.

9.114 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.

9.115 A thorough assessment of the design should be made to assess the potential noise problems. It should consider the following factors:

- fan and plant noise generation
- airflow 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.

A method of assessment of these factors and the sound attenuation requirements of ductwork systems is given in CIBSE Guide.

**Note:** Attenuators fitted in distribution ducts can themselves become a source of regenerative noise if the air velocity through them exceeds their tested performance value.

9.116 Attenuator units with a sound-absorbing in-fill suitable for the quality of air being handled and protected by a perforated sheet metal casing are the preferred option. Absorption of moisture, dirt and corrosive substances into the “in-fill” and the release of fibrous particles into the airstream should be prevented using a membrane with a declared service life of at least 25 years. If these conditions can be met, then the attenuator can be located in the supply ductwork downstream of the final filter. Cleaning access should be provided at both ends of the unit.

9.117 Sound-absorbing material should not be applied to the inside surface of a duct.

9.118 End of line mixing and VAV boxes may be supplied lined internally with sound absorbing material. The material should be non-particle shedding, protected from casual damage during maintenance and fire resistant.

9.119 See Clause ## to ## for guidance on distribution and point of use noise control.

**Recirculation – Minimum fresh air requirement**

9.120 Recirculation is only used for UCV terminals and clean room applications. Where return air is recirculated, there must be at least 20% of the room air
change rate, or that required by the Building Regulations, or 10 l/s/person, whichever is greater fresh air introduced.

**Distribution**

9.121 The CIBSE guide provides design information for low, medium and high velocity ventilation systems, their ductwork and terminal devices. The guidance in this document highlights the specific factors that are required for or excluded from Healthcare ventilation installations.

9.122 For normal applications in healthcare buildings, low velocity systems are recommended, velocities below 2 m/s are unlikely to be justified.

9.123 The site will often dictate the main routing of ductwork systems as will the location of the AHU relative to the load. Grouping AHUs in centralised plantrooms results in large vertical service shafts and long main duct runs. Decentralising AHUs into service spaces adjacent to the load results in a more compact duct layout.

9.124 Whichever option is chosen, the design should seek to make the layout as symmetrical as possible; that is, the pressure loss in each branch should be near equal. This will aid regulation and may reduce the number and variety of duct fittings that are needed.

9.125 Main distribution ductwork should not be routed above sleeping areas. Where there is no alternative route, additional external acoustic insulation may be required.

9.126 Where auxiliary air-conditioning units, fans, filters or trimming devices are installed in the distribution system, they should 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.

**Ductwork materials and construction**

9.127 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.

9.128 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 may also readily withstand the impacts sustained when rotary equipment is used to clean it internally.

9.129 In instances where moisture levels and/or corrosive elements in the air being conveyed are very high, aluminium, stainless steel, PVC or GRP ducts should be used. Stainless or black steel are the only suitable materials for high temperature ductwork.
9.130 Where other ductwork materials are considered, care should be taken to ensure that the material is satisfactory for the application having regard to the likely service life, possibility of mechanical damage and performance in the event of a fire. Where used, it should be installed strictly in accordance with its manufacturer’s instructions.

9.131 Rectangular ducting with an aspect ratio of 1:1 is preferred but ratios of up to 3:1 are acceptable where there are space constraints. Circular spiral wound or flat oval are also acceptable providing they meet the leakage standard when tested (See Clause 9.147). Flexible duct work is not suitable for air distribution in healthcare applications. It should only be used to make the final connection to a terminal (See clause ##).

9.132 The inside of the ductwork should be free from structural projections and as smooth as possible. Flanged, gasketed joints between sections are preferred.

9.133 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 (Clauses 9.115 onward).

9.134 Where builders’ work plenum chambers or ducts are employed the internal surface should have a smooth surface and should be sealed to prevent dust shedding.

9.135 All types of ductwork should be manufactured and installed to the appropriate current BESA specification.

9.136 Ductwork should be supported with threaded rod and channel. Note that sheet metal ductwork should not use bolt-through supports. Gripple wire may only be used for circular galvanised spiral wound ductwork.

**Note:** All installed ductwork whether new or re-used should be subject to a leakage test on site prior to the application of any insulation. The leakage test will be to BESA TR/19 but with a permissible leakage rate of not greater than 3%.

**Fire aspects, damper types and locations**

9.137 It is essential that all relevant fire aspects of ducting systems are agreed with the fire officer before the design is finalised.

9.138 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.

9.139 Fire and smoke dampers should be provided at the locations required by the HTM 05 series of documents. The damper mounting frame should be securely attached to the building fabric and strictly in accordance with the manufacturer tested details. Where a fire and smoke damper is not mounted directly in a fire compartment wall, it should be correctly supported and the ductwork between it...
and the fire wall should possess the same fire rating as the fire wall that it
penetrates. The fire rated portion of ductwork should not be penetrated by test
holes or inspection hatches. (See also BESA DW/145)

9.140 Any non-standard fire duct or damper arrangement should be tested and signed
off by installer.

9.141 An access hatch should be provided adjacent to each fire and smoke damper so
that its correct operation can be directly observed. The hatch should be as large
as possible to permit inspection, testing and maintenance. The damper test
switch should be mounted adjacent to the inspection hatch. For circular ductwork
rectangular saddle mounted hatches should be fitted. (BESA TR19)

9.142 Smoke-diverting dampers should be provided on recirculation air systems to
automatically divert any smoke-contaminated return air to the outside of the
building in the event of a fire. It should be arranged so that the normal open
diverting damper in the return air branch to the input unit closes and all the return
air is exhausted to outside. (See Clause #)

Duct sections

9.143 When sizing ductwork, the designer should consult the CIBSE guide.

9.144 All fittings should conform to the current BESA specification. Wherever possible,
long radius bends, large radius main branches, not more than 45° angle sub-
branches and long taper transformations should be used.

9.145 Bad design in relation to airflow 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.

Thermal insulation

9.146 In order to reduce energy consumption, achieve efficient energy recovery and
prevent condensation in service voids, all supply and return air ductwork should
be thermally insulated. Insulated ductwork runs outdoors need to be
weatherproofed.

9.147 The thermal insulation of intake and discharge ductwork will be dependent on its
location in heated or unheated plant spaces and risk of surface condensation.

9.148 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

9.149 Noise is generated in ductwork at sharp edges, by tie rods, damper blades, duct
obstructions and sharp bends etc. This airflow-generated noise becomes an
important factor if it is about the same or greater level than the upstream noise level. Airflow-generated noise is often referred to as regenerated noise.

9.150 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 (or about 18 dB). The duct velocities should therefore be kept as low as possible. In general, duct fittings which have lower pressure loss factors in similar flow conditions will generate less noise.

9.151 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.

9.152 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.

9.153 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.

Volume control damper locations

9.154 In order to be able to carry out a full proportional balance, manually operated dampers are typically needed:

- in branches of zone ducts;
- in sub-branch ducts serving four or more terminals;
- in dedicated sub-branch ducts serving a room;
- at terminals not covered by any of the above.

9.155 Dampers integral with terminals are to be avoided for final trimming of air volumes, as they often create noise and air distribution problems.

9.156 Dampers in rectangular ducts should be opposed-blade multi-leaf type. In circular ducts, iris-type dampers are recommended. Dampers should be accessible, incorporate a position indicator and means of locking in the commissioned position. They should be installed with the adjusting handle or knob at the lower vertical edge so that they are accessible for the commissioning team once the ceilings are in place. Dampers should be located as far away as possible from adjacent branches or plant items.

Duct cleaning and access door locations

9.157 Cleaning and access doors are required to facilitate access to plant items and ductwork components for inspection, maintenance, cleaning and replacement, and should be of sufficient size to permit safe access for the required functions.

9.158 Recommended locations for access doors are given in the current BESA TR/19 specification and are generally provided to give access to:
• every regulating damper;
• every fire and smoke, and motorised damper;
• filter (to facilitate filter withdrawal);
• both sides of trimmer cooling/heating coils;
• at zone humidifiers;
• auxiliary fans;
• where required for duct cleaning.

9.159 Care should be taken when siting access doors to ensure that no other services to be installed will prevent reasonable access.

Flexible ducting

9.160 Flexible ductwork can only be used to make the final connection between rigid ductwork and a terminal. It will cause a significant frictional loss and may be difficult to clean, so it should take the most direct route and be as short as possible, never exceeding 0·5 metre in length. It should never be used in lieu of a bend and should possess the same fire rating as the ductwork it is connected to.

Diffuser and grille selection and sizing

9.161 The effectiveness of all ventilation and air-conditioning systems depend 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;
• excessive noise.

9.162 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,
• that producing a perpendicular jet.

Diffusers may be radial or linear, and normally utilise the Coanda effect (that is, adhesion of the airstream 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.

9.163 Supply air terminals can be incorporated into any room surface, for example, floors, walls (high or low level), desktop etc.

9.164 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.
9.165 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;
- 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.

9.166 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.

9.167 A warm jet tends to rise until it attaches itself to a horizontal surface, while a cold jet falls. Care should 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.

9.168 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.

9.169 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 airstreams meet, the individual velocities should not be greater than 0.25 m/s. Further guidance on the selection of grilles and diffusers is given in the CIBSE Guide B.

9.170 In operating theatres, the supply terminals should be able to produce a down flow movement of air in the operating zone 1 m above floor level. (Air speed 0.2 – 0.3 m/s here or latter?)

- ceiling mounted diffusers with fixed directional vanes that provide a downward turbulent airflow are the preferred option; 600 x 600 4-way blow or circular “Air master” style.
- plenum boxes fitted with perforated screens to produce a laminar downflow are also acceptable.
- linear ceiling mounted diffusers that provide a direct downward airflow around the operating zone (additional supply terminals may be located within the area bounded by the linear diffusers to provide ventilation within the air curtained zone).

9.171 The following terminal types are not suitable for use in operating theatres because they do not produce an appropriate pattern of air distribution;

- Swirl diffusers
- Single or multi outlet adjustable directional nozzles or jets of any type
- Sidewall-mounted linear diffusers that utilise the Coanda effect to send air across the ceiling and "drop" it into the operating zone

9.172 Extract terminals mounted at low level should be of the spring clip retained, pull off face type to enable ease of cleaning. The terminal face should be angled to prevent it becoming occluded by movable equipment or stores (See Photos). Perforated plates should not be fitted in extract terminals or extract plenums as they quickly become blocked with lint.

UCV terminal canopy

9.173 UCV canopies should be fitted with one or more non-electronic, mechanical, direct reading pressure gauge(s) to indicate the pressure drop across either a representative terminal HEPA filter or the pressure in each zone of the canopy.

9.174 If a UCV canopy incorporates a method of adjusting the air discharge direction so that the canopy can be "tuned" to the room in which it is installed, then the directional adjustment device(s) should be capable of being locked in position once commissioning is complete to prevent future casual alteration.

9.175 Ceiling mounted canopy diffusion screen(s) can become contaminated with blood splatter when in use. If the UCV canopy is fitted with perforated diffusion screens the blood spatter can penetrate so the screens should be capable of being hinged down for cleaning between theatre cases. The screen retaining mechanism should have a double action to release the screen. Mono-filament diffusion screens should be retained by clip in profiles or an alternative system that allows them to be easily removed when necessary.

9.176 For the validation of UCV terminal canopies see Chapter 12;

Transfer grille - size and location

9.177 Air transfer grilles in walls, partitions or doors form an integral part of the building’s air distribution system. Modern door sets 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”.

9.178 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 which may affect the operation of the spaces and/or the ventilation system and permit airflow in a known direction.

9.179 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.

9.180 Where installed, transfer grilles should be of the non-vision type, sized for a maximum face velocity of 1·5 m/s.
Note: Cross-talk attenuators may be necessary where noise intrusion between adjacent spaces can arise and where individual room confidentiality is required.

Pressure stabilisers - size and location

9.181 Pressure stabilisers are required in areas where it is necessary to maintain a pressure differential between adjacent rooms and to prevent reversal of airflows e.g. in operating suites, isolation facilities and clean rooms. (See also Section # Clauses #)

9.182 Fire precautions for pressure stabilisers are the same as for transfer grilles. If the pressure stabiliser is fitted with a fire and smoke damper, the damper test switch should be easily accessible from, in airflow terms, the least clean side of the damper.

9.183 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.

9.184 Pressure stabilisers should be installed in a visible location so that their operation can be readily observed. For sizing criteria, refer to their manufacturer’s information.

9.185 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 and may be lead lined for radiological protection if required. Baffles may also be needed to preserve privacy or prevent discharge air causing draughts within an anaesthetic room or bedroom. A stand-off baffle will always be needed on the theatre side of the pressure stabiliser between a “Lay-up” preparation room and a UCV theatre to prevent perturbation of the UCV canopy air pattern.

Note: Baffles should be easy to clean and where radiological or laser protection is not required can be made of a rigid transparent material so that the action of the pressure stabiliser can be easily observed.

Distributed air-conditioning elements

9.186 Frank Mills – Non-clinical areas only; Active and passive chilled beams

9.187 ##

9.188 Frank Mills - Variable Air Volume (VAV) boxes

9.189 ##

9.190 Powered terminal filter units

9.191 ##
Air handling units - automatic control

9.192 Chapter 6 of this document gives guidance on energy control strategies and Chapter 7 gives guidance on the point of use factors. Chapter 8 contains guidance to specific healthcare departments and their environmental and functional requirements. This section gives guidance on the control of the AHU and its subsystems. When developing a “controls specification”, the designer should consider the guidance given in all of these Chapters.

9.193 Various options for control of single and multi-zone air-conditioning systems are given in CIBSE Guide B.

General requirements

9.194 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 airflow
- facilities to control the system or room pressure
- temperature control and indication
- humidity control and indication
- devices to monitor and indicate the plant operating state
- alarms to indicate plant failure, low airflow, and filter state

The control functions actually provided will depend on the purpose of the ventilation system.

9.195 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 and as detailed in the fire alarm cause and effect statement.

9.196 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 airflow is established within the extract system, or vice-versa depending on the required pressures within the rooms being served. Chapter 8 gives guidance for specific healthcare applications.

9.197 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.

9.198 Alarms should be provided to show “filter fault” and “low airflow”. The “filter fault” alarm should be initiated by a predetermined increase of pressure differentials across the filter. The “low airflow” alarm should be initiated when the supply air quantity falls to 80% of the design value when the system is operating normally.

Objectives of control system

9.199 The primary objective of a ventilation or air-conditioning 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.
9.200 Control of most systems will be via a Building Management System (BMS). This will enable the operating conditions and control tolerances to be set and monitored. Often, it is not possible to accurately predict building load variation at the design stage. Information provided by monitoring the operation of the plant via a BMS will enable optimum set points to be established and energy consumption reduced. The BMS 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.

9.201 BMS incorporating self-adaptive control algorithms that automatically adjust the set point to 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.

9.202 The failure of specialised ventilation systems can have grave consequences for the delivery of healthcare. Control systems should therefore be simple, robust and reliable. Should the BMS link be lost, the local “outstation” should be capable of controlling the AHU on its own.

Location of controls

9.203 Whether within the plant, duct or room, sensors should be located to provide accurate measurement of the condition of the air being monitored.

9.204 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 overshoot of conditions beyond the design envelope and result in additional energy consumption.

Note: There are practical advantages in locating all control valves for an AHU in a bank (at a convenient height) at one end of the unit. (This should not result in an additional control lag). The unit will hold the control valves and actuators, and fan inverters / controllers as necessary and can be constructed “off site”.

Fire aspects

9.205 A fire control panel should be mounted at the main entrance of the area that the ventilation serves (See also HTM05-02; Clause 5.57). The panel should have restricted access for the fire officer and include independent on/off control and indication of the supply and extract.

Note: In certain critical care departments it is preferable to maintain the supply ventilation in the 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 they 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.

9.206 All supply AHUs should have a smoke sensor linked to the fire control panel and 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**

9.207 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.

9.208 Many ventilation systems may be completely shut down when the area serve 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**

9.209 The plant start control should contain a control logic that will start the plant in the sequence set out in the algorithms in Table 5.1 and 5.2. (Check ref)

**Set-back control**

9.210 In previous times when fan motors only had two speeds, turning the system down meant switching to the lower fan speed. With modern fans the speed is infinitely variable, so “set back” is not a fixed fan speed but rather a control strategy that reduces the system output in order to maintain a desired minimum condition. This may be related to the air velocity at a fixed point, air change rate, pressure differential, temperature, humidity or a combination of any of these parameters.

9.211 Where variable speed controls are installed, the set-back 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 the control algorithms in Tables 5.3 and 5.4.)
Environmental control

Temperature control methods and application

General

9.212 All control valves should fail-safe; that is, they should close if power or airflow failure occurs. The exception is the fog/frost battery control valve, which should open upon power or airflow failure.

9.213 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.

9.214 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

9.215 The limits for room temperature set point are generally between 18°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.

9.216 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 BMS. 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 ±1 K. All other control set points should be selectable either on the control panel or at the BMS interface.

9.217 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 e.g. at the operating table in a theatre. This may be mounted in a supervisory control panel, with the signal repeated on the main system control panel or BMS. It is important that this indicator displays the actual measured temperature and not the selected temperature.

Fog / Frost coil control

9.218 Steam supplied fog/frost coil should be operated as an on/off device to ensure that there is no standing condensate at the base of the coil. They should be fitted with a serpentine sensor mounted upstream of the battery but not in contact with it. This will give “open loop” control; a set point of +1°C is recommended.

9.219 Low pressure hot water (LPHW) supplied fog coils should be controlled using the proportional mode. Their sensor should be located downstream of the coil to give “closed loop” control. The coil should raise the incoming air temperature by 2 K in order to ensure that the pre-filter is above the dew-point, thus keeping it
dry. The greater the energy put into the incoming air by the fog coil, the lower will be the efficiency of the energy recovery device.

9.220 If the temperature downstream of the fog coil, as sensed by a serpentine thermostat, falls below the required set point over any part of the coil, the plant should automatically shut down in order to prevent damage to the other batteries. The serpentine thermostat should not be in direct contact with the coil.

9.221 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.

9.222 Heater-battery control valves should drive closed on system shutdown or fan failure. The control system should then automatically set to provide frost protection.

9.223 There are two basic methods of control for cooling coils:

a) 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.

b) 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.

9.224 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 expensive to operate in terms of energy consumption because of the lack of feedback of room loads. As a result, at low loads and in systems where there are large zonal variations, significant over-cooling and reheating will occur.

9.225 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 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.

9.226 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.
9.227 Where inverters are mounted inside a control box with a safety master switch to cut the power supply when the box is opened, the inverter control and indicator pad should be located on the outside of the box. This will allow on site staff to view the operating parameters and switch the system to manual control if a fault occurs with the automatic control system.

Note: In the healthcare setting it is important to recognise that “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.

Off-plant control
9.228 The control logic should prevent the cooling coil and pre-heater being on at the same time.

Humidity control methods and application
9.229 In order to prevent excessive condensation when starting up from a total plant shutdown, a time delay should be incorporated into the control system such that the humidifier does not start until 30 minutes after the ventilation plant start-up.

9.230 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 supply duct does not exceed 70% saturated, particularly during plant start-up.

9.231 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.

9.232 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 to purge humid air from the system.

General
9.233 All control valves should fail-safe, that is, close in the event of power failure (with the exception of the fog/frost coil), and the humidifier should be interlocked with the low airflow switch.

9.234 The “plant failure” and “low airflow” alarm should be initiated by a sensor 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 airflow. The sensing ring fitted to plug and EC fans will fulfil this function.

9.235 The “filter fault alarm” should be initiated by a predetermined increase of pressure differential across the filters, thereby indicating a dirty filter. (See also clause 9.25?)
9.236 Visual indication should be provided at a manned staff location, for example, the reception or staff base, and on the main control panel and BMS to show “plant failure” and “low airflow”.

**Humidifier Control**

9.237 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-level humidity control.

9.238 Multi-zone systems are more usually controlled by a minimum humidity sensor located in the supply duct(s) following the last heater-battery.

9.239 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.

9.240 The humidifier control valve should close when the ventilation system is in “set back”. In addition, on system shutdown, low airflow or fan failure, the humidifier should be isolated.

9.241 In a self-generating humidifier, if the humidifier is unused for a period exceeding 48 hours, it should automatically drain its water content, including that contained in the supply pipework, right back to the running main and leave itself empty.

**Local Exhaust Ventilation units**

- Purpose
- Capture point
- Fans
- Filters
- Discharge arrangements
- Identification
- Inspection

**General extract units**

- purpose
- types
- discharge arrangements.
10 Installation standards

General

10.1 Air handling units, ductwork sections and associated elements of the ventilation system will be delivered to site suitably packaged to protect them from damage and casual contamination. They should remain protected when stored on site awaiting installation.

10.2 During installation it should be established that the ductwork is being installed to the “Advanced Level” as defined in BESA – Internal Cleanliness of Ductwork TR/19. Should any doubt exist whether the guidance has been observed, the ducts should be cleaned internally to restore them to this standard before being taken into use.

10.3 When the ventilation elements are installed, all open ends should be sealed to prevent the ingress of construction dust as installation progresses. The access doors and panels of AHUs should be kept closed. All AHU dampers and fire dampers should be covered to prevent casual contamination during the construction phase. This is particularly important for fire dampers mounted in the plantroom floor. The damper blades should be wiped clean before final connection to the distribution ductwork.

10.4 The area around the supply air intake should be kept free of vegetation, waste, rubbish, builders’ debris or any other possible source of contamination.

10.5 “Builders work” ducts of brick or concrete should have a smooth internal finish and be surface sealed to prevent the release of dust before being taken into use. They should be fitted with a drainage system if not self-draining.

10.6 Every effort should be made to prevent the internal contamination of the ventilation system during the construction phase as once contaminated it is extremely difficult to completely remove dust and debris. In particular, extract and recirculation fans should not be run up until the area is “Builders Clean”, otherwise the energy recovery device in the AHU could become contaminated and its efficiency significantly reduced.

Air handling units – AHUs

10.7 Units may have a working life of up to 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 isolated and withdrawn without the need to drain down entire systems or dismantle other installed plant.

10.8 Care should be taken during installation to ensure that electrical and mechanical services are not installed in positions that will reduce or impede
access. Mounting all control valves and fan controllers on a frame positioned adjacent to the unit is the preferred option. This approach has the advantage that the frame and its components can be built and tested “off-site”.

10.9 In order to reduce the effects of galvanic corrosion black iron fittings should not be used in the pipework installation. Rolled jointed stainless-steel pipework is preferred.

10.10 Vibration from a remote plantroom can be transmitted by the structure of the building, may be regenerated and sometimes magnified many times. Pipe and ductwork should incorporate anti-vibration couplings, pipe hangers and supports preferably in two planes at right angles, as close to the vibration source as possible.

10.11 It is essential that the AHU / ductwork is mounted far enough from the floor to permit the correct installation of drainage systems for cooling coils, humidifiers and heat recovery systems (typically 600 mm). Easy access for maintenance of drainage systems and their associated pipework should be provided. It should be possible to fully withdraw the drainage tray if it is of the removable type.

10.12 Air handling units should be 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 should be available from the front. Units greater than 1m wide should preferably have access from both sides or access doors large enough to permit the full and safe entry of maintenance personnel.

10.13 Air filters, cooling coil drainage trays and drift eliminators are all items that will need to be changed, inspected or withdrawn on a regular basis. The installation of the AHU should permit this without the need for tools or to dismantle other plant or systems.

10.14 Access to air intakes and discharges, AHUs and items in the distribution system such as filters or auxiliary trimmer batteries located in a plantroom or plant area should be via fixed ladders, hook ladders, platforms or pulpit style movable steps. The installation of distribution ductwork and other electrical or mechanical services should provide sufficient clearance to allow the pulpit steps to be wheeled into position.

Distribution systems

10.15 The installation of all services in service ducts and above ceilings should be coordinated so that cable trays, medical gas and other pipework do not obstruct or prevent access to the ductwork cleaning doors, dampers and any auxiliary plant elements. The use of BIM should highlight clashes at the design stage.

10.16 Plant elements such as VAV boxes, trimmer heaters or cooling coils, humidifier lances or branch filters that are located outside of plant spaces should be accessible for routine inspection and have a cleaning access door on both sides. They should not be installed above any of the following areas:
10.17 Volume control damper (VCD) adjusting handles or knobs should be located at the lower vertical edge of the damper when mounted above ceilings. The means of adjusting the damper should be within sight and reach from a designated ceiling void access hatch once the ceiling is complete. Volume control dampers mounted in any location should have the control adjuster mounted to allow easy access for the commissioning team.

10.18 Access to VCD’s mounted above ceilings should be via low leakage access hatches and not through light fittings.

10.19 Fire and smoke dampers should be installed strictly in accordance with their manufacturer’s instructions. There should be an access hatch and test switch adjacent to the damper so that a single person can trigger the damper and directly observe its operation during the annual test. (Insert picture). When pressure stabilisers incorporate a fire damper, the test switch should be located in an easily accessible position on the less clean side of the pressure stabiliser.

10.20 Where ducts are drilled to provide test holes or to mount sensors, the swarf should be removed before the fan is started.

Note: Care should be taken to prevent the inadvertent drilling of attenuators.

10.21 Flexible ductwork should only be used if there is no other way of connecting an air terminal to a duct. The flexible duct should be not more than 0.5 m in length, should be as fully extended as possible and should never be used in lieu of a bend. The fire rating of the flexible duct should be no less than that of the fixed duct that it is connected to.

Point of use

10.22 Items of equipment that require access for inspection and cleaning should not be installed in locations that prevent easy access.

10.23 Items of equipment that require access for inspection and cleaning such as fan coil units should not be installed directly above medical or diagnostic equipment.

Note: A common problem occurs because installation layout drawings show fan coil or similar units on the room plan. These are often only “indicative” of the fact that there will be a unit in the room but are taken as the desired install position by those carrying out the installation. As an example, the installation drawing for an interventional imaging room shows a fan coil unit in the centre of the ceiling. If it is installed in this position it will be directly above scanner once that is installed. The fan coil unit will then not be accessible for routine inspection and maintenance and should it leak water it will do so over the scanner putting it out of action.
10.24 The installed position of ceiling terminals in storerooms e.g. theatre bulk sterile pack store, should coordinate with the siting of the storage racking. The airflow at the terminals will need to be routinely measured so the racking and its contents should not obstruct access to the terminal when using a calibrated hood. The same problem can occur in recovery rooms and ward areas where bed curtain rails and bed hoist tracks can prevent the measurement of airflow from ceiling terminals.

10.25 Low level extract grilles should be of the pull off face type for ease of cleaning.

10.26 (See pictures ref low level extract installations)

**Service penetrations**

10.27 Where services penetrate the fabric of the building, they should be sealed to prevent any uncontrolled air leakage between rooms and service spaces or voids. Situations where this occurs will be:

- service spaces behind IPS panels at wash basins and scrub troughs;
- cased in wall-mounted medical gas pipeline units and ceiling-mounted pendants;
- electrical trunking and bedhead rail systems;
- boxed-in main and local drainage pipework;
- ceiling-mounted operating lights, examination lights and other pendant-supported items.

The sealing should be at the point that the service penetrates the wall, ceiling or floor and not at the access panels or covering shrouds as these will need to be removed from time to time. Sealing of the penetrations should be done at 1st fix stage as access will become progressively more difficult once final covers and finishes are applied.

**Floor marking**

10.28 In UCV theatres the entire clean zone under the UCV canopy should be designated by a contrasting colour of flooring material. Note that the clean zone is not the same as the overall size of the canopy and it is vital to consult the UCV canopy supplier in order to get the position and size of the zone correct. Mistakes are expensive to correct!

10.29 (See pictures ref low level extract installations)
11 Commissioning systems

Commissioning: general

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 suppliers. Commissioning of the ventilation system will normally be the responsibility of the main or mechanical contractor who should coordinate the process.

11.2 Commissioning is often subdivided into sections e.g. 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.

11.3 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.

11.4 The duct design process 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

11.5 Balancing/commissioning dampers will be required in each branch of the distribution ductwork. In a critical system such as an operating suite, the branch to each room should have a balancing damper.

11.6 Test holes for the measurement of airflow 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 should be identified at the design stage.

11.7 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.

11.8 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 pilot tube and take readings;
where the duct has a constant cross-sectional area.
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.

**Note:** Plug and EC fans are supplied with a measuring ring so their output can be read directly. This needs to be connected to an external pressure tapping or electronic fan control unit.

### Information to be provided

11.9 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 data listed in Table 11.1;
- equipment schedules;
- controller and regulator schedule;
- fan performance curves;
- wiring diagrams for electrical equipment, including interlock details

#### Table 3 Information to be provided on schematic drawings

<table>
<thead>
<tr>
<th>Items in system</th>
<th>Information to be provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fans</td>
<td>Fan total pressure&lt;br&gt;Volume flow rate at normal and set back speed&lt;br&gt;Maximum motor current</td>
</tr>
<tr>
<td>Plant items</td>
<td>Type and identification numbers from equipment schedules&lt;br&gt;Fluid and air volume flow rates&lt;br&gt;Fluid and air side pressure losses&lt;br&gt;Dry bulb temperatures&lt;br&gt;Wet bulb temperatures&lt;br&gt;Humidity</td>
</tr>
<tr>
<td>Dampers, including motorised and fire dampers</td>
<td>Identification numbers from equipment schedules&lt;br&gt;Location</td>
</tr>
<tr>
<td></td>
<td>Identification number&lt;br&gt;Volume flow rate</td>
</tr>
</tbody>
</table>
### 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 and size of duct |
| Identification number |

### Controllers

| Set points |

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**Notes:**

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.

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**Commissioning personnel**

11.10 It is unlikely that all the required commissioning skills will be possessed by one individual; a commissioning team is therefore usually needed. The objective of commissioning is to ensure that the necessary performance and safety requirements are met.

11.11 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.

11.12 In order to be successful the commissioning process should start before 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.

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**Commissioning brief**

11.13 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 airflow 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 airflow 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.

11.14 The CIBSE Commissioning Code, Series ‘A’ – “Air Distribution”, provides full guidance on the information that will be required by the commissioning team.

11.15 The designer should specify the type of measuring instruments and test procedures. He should include in the contract documents instructions on verifying the accuracy of test instruments which should be supported by reference to relevant calibration certificates.

11.16 The system, on completion should be operated by the contractor as a whole and subject to performance tests in accordance with the contract requirements. These will include independent validation of the system performance on behalf of the client.

11.17 The commissioning process should be carried out in the order in which it appears in this guidance document. That is to say the static checks and visual inspections itemised in Clause # should be followed by the dynamic tests described in Clause ##, the performance tests listed in Clause ### and finally the handover procedures set out in Clause ##.

11.18 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**

11.19 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 Clause ### of this guidance.
Standard of Installation

11.20 During the installation of the system the following should 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 the AHU airtightness test as per EN 1886 has 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 BESA TR/19: Ductwork Leakage Testing but the leakage rate to be not greater than 3%.

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 should be recorded in the commissioning manual;

- that gaps around doors and hatches are as specified in the design;
- The permeability tests are carried out as per Chapter 12; Clause ##
- that the correct operation of pressure stabilisers, control dampers, isolating and non-return dampers have been checked;
- 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 all service penetrations of the fabric of the area are sealed at the point of penetration; (See also Chapter 10; Clause #)
- 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.
Certification of equipment

11.21 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:

a. type test performance certificates for fans;
b. pressure test certificates for:
   (i) heater-batteries;
   (ii) cooling coils;
   (iii) humidifier (if appropriate);
c. type test certificates for attenuators;
d. type test certificates for primary and secondary filters;
e. individual test certificates for high efficiency particulate air (HEPA) filters.

Equipment tests

11.22 Prior to setting the system to work the following should be witnessed and proving tests should be carried out as detailed:

Filters

11.23 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 elements. Therefore, the following checks should be made:

a. filter seals should be fitted and in good condition;
b. filters should be installed correctly with respect to airflow;
c. bag filters should be installed so that the bags are vertical and their pockets free;
d. HEPA filters should be installed and tested to prove that they and their housing achieve the specified filter efficiency.
e. all filters should be checked to ensure they are free of visible damage;
f. the differential pressure indicators should be checked for accuracy and that they are marked with the initial and final filter resistance.

Drainage arrangements

11.24 The drain should conform in all respects to the standard set out in Chapter 9; Clauses ## to ## of this HTM. In addition, the following should be proved:
that the drain tray is easily removable or completely accessible;
that the drift eliminator (if fitted) is removable without the use of tools
that a borosilicate glass trap is fitted and is easily removable;
that the trap discharge point to drain has a clear air gap of at least 15 mm;
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;

11.25 The operation of the drainage system is then 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
11.26 The following should be witnessed and proving tests should be carried out as
detailed:

- the operation of all fire dampers; (fire dampers fitted with a thermally actuated
  “memory metal” mechanism should be proved using a hot air heat source);
- the access provided to enable the dampers to be visually inspected and / or
  reset 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
11.27 Before commencing the dynamic commissioning the area should be clean
and free of construction dust. The fan drive, direction of rotation, speed and
current drawn should be set in accordance with their manufacturer’s
instructions.

11.28 In the vast majority of healthcare applications, the fan output should be set to
give a constant volume of air. This to be controlled by measuring the pressure
drop across the fan using a sensing ring and associated volume controller that
will automatically integrate the fan ‘K’ factor to determine and control the pre-
set output air volume. The fan output will then in air volume terms remain
constant regardless of changes of system resistance. The actual volume
delivered will be related to the air change rate for the application.

11.29 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” should be followed. The
Airflow rates should be set within the tolerances laid down in the design brief. This will normally be the design airflow rate +10%; -0%.

**Note:** Plug fans are fitted with a measuring ring so that the design volume flow can be set when first started. It can then be reset as the airflow balance progresses. This method will result in the correct airflow with the least total system resistance once balancing is completed.

**Air commissioning measuring equipment standards**

11.30 All test and measuring equipment used should have a certificate to prove that it has been calibrated within the previous 12 months at a facility using traceable national standards.

11.31 System performance should be measured at the main and branch duct supply and extract test points using a pitot and manometer or a hot-wire anemometer.

11.32 Supply and extract air volumes at the room terminals should be measured using a calibrated hood with back pressure compensation. If a hood correction factor is applied, it should be determined by a direct comparison with a duct measurement immediately adjacent to a terminal and not a general comparison between air at the main supply duct and the total as measured at the terminals. For multidirectional terminals, a correction cross should be fitted in the measuring hood.

**Note:** Measurements taken with a homemade hood or cone should not be accepted.

11.33 Measurements at extract grille faces will, where possible, be taken using a calibrated hood. Alternatively they can be scanned using a rotating vane anemometer and a free area factor applied. The grille face free area and factor used should be stated in the commissioning report.

**Order of commissioning**

11.34 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. The supply balance should then be rechecked.

11.35 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. The extract should then be rechecked.

11.36 On completion of the balance, all volume airflow in supply and extract ducts and from grilles and diffusers should be measured and recorded. The true air-change rate can them be calculated from the data obtained.

**Note:** For accuracy, the room dimensions should be physically measured on site rather than deriving them from design drawings.
11.37 All supply and extract duct volume control dampers should be locked and their position marked and the fan motor speed settings noted and recorded.

11.38 All grille and diffuser volume control registers should be locked to prevent alteration and their final position marked.

Room air distribution

11.39 The pressure-relief dampers and pressure stabilisers should be set to achieve the specified room static pressures, and locked. The grille’s direction-control vanes and diffuser cones should be set to give the specified air movement pattern. Visualisation techniques may need to be used to prove the required airflow pattern is being achieved and to detect any adverse Coanda effects.

Air-conditioning plant

11.40 The specified flow rate and/or pressure drops should 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 should be locked to prevent alteration.

Control system

11.41 The control system should not be commissioned until both the air distribution system and air-conditioning equipment have been commissioned.

11.42 Because of the specialised nature of control systems and the fact that each manufacturer’s system will contain its own algorithms and settings, the commissioning should be completed by the supplier, and witnessed and documented by a representative of the user.

11.43 In the vast majority of healthcare applications, the fan output should be set to give a constant volume of air. This to be controlled by measuring the pressure drop across the fan using a sensing ring and associated volume controller that will automatically integrate the fan factor to determine and control the pre-set output air volume. The fan output will then in air volume terms remain constant regardless of changes of system resistance. The actual volume delivered will be related to the air change rate for the application.

Note: Measuring the air pressure in the main supply duct and using that to set the supply fan speed as a percentage of its rated output, and using that to set the extract fan speed as a percentage of the supply fan speed, is not a satisfactory, accurate or acceptable way of controlling the desired supply and extract air volumes.

11.44 The location of all control and monitoring sensors should be checked and their accuracy proved.

11.45 The control systems ability to carry out its specified functions should be proved.
11.46 If the plant is provided with a “users” control panel in addition to the one located in the plantroom then the operation of both should be proved. This will typically apply to operating departments and laboratory systems.

### Specific performance standards

11.47 The performance of the system should be measured and compared with information provided by the designer.

### Plant capacity and control

11.48 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.

11.49 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 should be proved. Artificial loads will be required in order to simulate the internal gains/losses and the outside design conditions.

11.50 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 fog coil. The plant should be run for 24 hours with all doors closed. During this period the inside conditions should stay within the tolerances specified. Alternatively the BMS may be used to obtain the information required.

### Noise levels - general

11.51 The commissioning noise level is that 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. Appendix # gives a summary for many applications. Full details and design information are contained in HTM 08-01 – “Acoustics”.

11.52 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.

11.53 An industrial-grade Type 2 sound level meter will normally be sufficient to check the noise level. Its accuracy should be checked using a calibrated sound source before use.

11.54 The noise level readings are to be taken at typical normal listening position 1.5 m above floor level and at least 1 m 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 five readings should then be calculated.
11.55 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 HTM 08-01.

Filter challenge

General ventilation filters

11.56 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.

11.57 Air leakage around a filter housing significantly reduces the filter efficiency. The as fitted filter housing and access door arrangement should not permit air to bypass.

HEPA filters (for exhaust protective enclosures and laboratories)

11.58 Pathogenic material may be discharged through damaged or badly installed HEPA terminal filters. The complete installation should be tested using the method set out in BS EN 14644. The challenge tests may be carried out using either of the following techniques:

- a light scanning airborne particle counter (LSAPC) and a natural challenge to detect leaks;
- dispersed oil particle (DOP) to provide the challenge and a photometer to detect leaks.

11.59 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.

11.60 With a LSAPC the filter face is sampled at several points to establish the smallest non-penetrating particle size. This will directly relate to the grade of filter under test. The filter face, its seal and housing are then scanned, and if a significant number of particles at or above this size are detected, there is deemed to be a leak at or near the test position.

11.61 With DOP a challenge aerosol of inert particles of the type produced by a dispersed oil particle generator is 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.

11.62 Should the HEPA filter fail this test it should be replaced. Should the filter mounting seal or housing fail this test it may be repaired and the test repeated.
Ventilation system commissioning records

11.63 Following commissioning the main contractor should collate the individual commissioning reports together with the plant user manuals ready for handover.

11.64 The fire dampers will have been tested by a specialist and a written statement detailing which fire dampers were tested, when and by whom must be provided. If any fire dampers in the system were not tested, then they need to be listed and appended to the statement.

11.65 The airflow balancing report compiled by the commissioning engineers should be available to the validator.
12 Acceptance testing - validation

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.

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.”

Appointment of validator

12.4 In order to ensure that the complete system operates correctly it will be necessary to validate it as a whole from the air intake through to the extract discharge. It is unlikely that the client’s in-house staff will possess the knowledge or equipment necessary to undertake this process. Validation should therefore be carried out by a suitably qualified independent Authorising Engineer appointed by the client.

12.5 To retain independence, the validator should be appointed and paid directly by the client. The validator will act as the client’s representative to inspect the system, check its performance and recommend acceptance, or not to the client.

Note: Client means the healthcare provider not a contractor or service provider.

Design proposal review

12.6 It is essential that whomever has been designated to carry out the final validation acceptance of the system (typically the AE(V)) should be involved in the initial client’s brief and design specification, preferably prior to the project being put out to tender. They will then be fully aware of the client’s requirements and any limiting factors.

Note:- While it is beneficial to involve the clients validator in the design process it should be remembered that the appointed designer carries the “design risk” and advice from the validator will not obviate this.

12.7 It is important that the validator understands the complete project and not just the obvious ventilation aspects. Decisions about the type of ceilings, doors, access hatches, fire compartmentation, floor markings, room functions, their adjacency and the proposed work flow patterns all have a direct effect on the
likelihood of being able to achieve the desired ventilation performance. It is not sufficient to consider the ventilation in isolation.

12.8 During this process any derogations proposed by the contractor / supplier should be clearly defined, agreed and documented with the client. All parties will then be clear as to what will be the acceptable standard of installation and performance when finally validated.

12.9 The contract arrangement should give the validator the right to visit site as they deem necessary during the contract period.

**First fix inspection**

12.10 The validator should carry out a physical walk around inspection of the installation at a point in the project when the AHU is “on site” and the main and branch ductwork is for the main part installed, but prior to the ductwork being concealed behind wall panelling or ceilings.

12.11 If possible the following air tightness tests should be witnessed during the inspection:

- AHU installation leakage (EN 1886)
- Supply and extract duct leakage (EN ###)(DW/143)
- Initial permeability test (See ## below).

12.12 The quality of the installation, compliance of the AHU, suitability of the basic installation, location and future accessibility of commissioning dampers, location and compliance for testing of fire dampers, etc. can all be assessed during the visit.

12.13 When validation large projects having many AHUs it is worthwhile to visit the AHU manufacturer to inspect a specimen unit and agree its compliance before all the remaining units are built and transported to site. At that time the leakage and deflection tests can be demonstrated by the AHU supplier in their factory.

12.14 Once units are delivered to site it is useful to get all of the mechanical and electrical services connected to a specimen AHU. The location of pipework joints, drain points, anti-vibration couplings, isolating and control valves can all be agreed as can the route of cable ways and control wiring. The object will be to create an agreed “exemplar unit”. If all other AHUs are installed in an identical fashion, they will be automatically considered compliant at the time of final validation.

12.15 On completion of the 1st fix visit the validator should provide the client with a short report identify items that are not compliant with the specification.

**Permeability testing**

12.16 The following areas will require permeability testing:

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Draft for technical engagement

HTM 03-01 Part A
December 2019
• Isolation suites of any type
• Operating suites of any type
• Pharmacy aseptic preparation facilities and IAP rooms in sterile services departments
• Category 3 and 4 containment facilities

The methodology for permeability testing is set out in BSRIA document BTS 3/2018 – Air permeability testing of isolation facilities

12.17 An initial permeability test should be witnessed at first-fix stage when the envelope of the suite is physically complete but before wall, ceiling and floor finishes are applied. The objective will be to find and eliminate any construction leaks e.g. between a floor slab and curtain wall, before they become covered up during the fit out stage.

12.18 A full permeability test in accordance with the methodology given BSRIA BTS 3/2018 should be carried out at practical completion to ensure that all service penetrations have been adequately sealed.

Note: Any leaks discovered during the test are to be sealed at the point of penetration of the building fabric envelope and NOT at the gaps around IPS panels, ceiling hatches or bedhead trunking covers, etc. (See also Chapter 10; Clause#)

Second fix inspection

12.19 Dependent on the size and complexity of the installation a second and further inspection visits may be required. The validator should attend site as frequently as necessary in order to try to eliminate any installation issues as the project develops and while trades are still in attendance rather than having to resolve them at the time of final acceptance.

Final Acceptance Inspection - Validation

12.20 The commissioning of a ventilation system will normally be carried out by the suppliers of the various elements. The final acceptance validation will check that all the elements work as a whole to achieve the project aim.

12.21 The following regime of inspection and testing should be applied to the validation of all new and refurbished ventilation systems. It could also be applied to systems that have undergone significant changes such as the replacement of a fan or other major component.

Basic requirements

12.22 The area served by the ventilation system to be validated should be physically complete with final finishes applied. The doors should fully close against the design pressure differential with IPS panels fitted and any access hatches closed. All ventilation plant serving it should be operating correctly and have been commissioned in accordance with the project contract.
Note: In projects on existing sites, the area of the building being built/refurbished is often sealed off from the “in use” part to prevent dust penetration. At final validation the seals need to be at least temporarily breached in order to be able to determine the ventilation performance at “normal” conditions. If this is not possible, then the validation will be conditional on a final “actual” performance check when the seal is removed at the time of handover.

12.23 The area served should be free of any rubbish, debris, obvious dust and have been wet mopped before the validation is undertaken.

Note: It is not necessary to clean the area to the point that the validator needs to gown up in order to enter it. A certain amount of disturbance to hatch seals, ceilings, panels, etc. will be inevitable during the validation process, so the area will require a final “clinical” clean before being taken into use.

12.24 The validation process should be a continuation of the earlier site inspections and will in many cases be carried out in parallel with the commission process.

12.25 Unless stated elsewhere in the design specification, the conditions in the principal space served by the ventilation system being validated should be stable and within the given ranges.

- Temperature: 19–23°C dry bulb.
- Humidity: 30–70% Relative humidity.

12.26 Any test or measuring equipment used should have a certificate to prove that it has been calibrated within the previous 12 months at a facility using traceable national standards.

12.27 In the case of a noise meter, its “matched sound source” should have a certificate to prove that it has been calibrated within the previous 12 months at a facility using traceable national standards. The noise meter should be calibrated to the sound source on each occasion that it is used.

12.28 The validator has the right to either witness readings taken by the commissioning team or to take such readings and measurements as they deem fit in order to satisfy themselves as to the actual performance of the system.

Validation process

12.29 The validation process should follow the sequence given below. Any failures discovered during the process will need to be rectified before continuing. The validator should check the following:

- the location of the air intake and discharge, their position relative to each other, and other intakes and discharges;
- inspection and cleaning access to the vermin mesh and as necessary throughout the installation;
- the security, suitability of and access to the AHU location
- sufficient space and access arrangements for service and maintenance
- that the AHU is uniquely identified and complies with the minimum standards set out in Chapter 9
- the AHU and distribution system have been leak tested and comply with the design
- all fire and smoke dampers have been tested and a certificate signed and dated by the tester is available for inspection
- the area served by the ventilation system is complete and free from significant defects that could invalidate the acceptance process
- the supply and extract airflow rates are in accordance with the design +10%; -0% and the system terminals are in balance. Note that the total supply and extract air volumes measured at the AHU should equate to that measured at the terminals
- the air change rate calculated from the measured airflow and room dimensions accord with the design specification
- the room differential pressure regime is in accordance with the design and that if pressure stabilisers are fitted that they operate correctly and silently
- the air velocity at a specific location(s) if required in the application specification
- the noise level does not exceed the design value
- the system indicators correctly and clearly show whether the ventilation system is in an operational state
- any user controls fitted operate correctly (For example of “Cause and Effect testing” see Appendix #)
- the temperature and humidity in the space being ventilated are accurately indicated on the users panel and that they can be adjusted within the specified limits, if applicable
- the estates control functions operate correctly and the plant condition is clearly shown both on the plant control panel and at the BMS interface
- that any additional tests called for in the project specification have been carried out and witnessed by the validator or the client’s appointed expert

Note: Validation is not a “snagging” inspection. The main contractor has presented the installation as being complete, fully commissioned, achieving the specified level
of performance and ready for handover. The validator’s role is to check on behalf of the client that the contractor is correct in that assertion.

If the validator discovers that there are a significant number of “snags” and non-compliances, the validation should be terminated. It is up to the contractor to “snag” the project, carry out remedial works and re-present the installation for acceptance. The validator will then need to repeat the validation process. The client is entitled to deduct any resulting additional validation fees incurred from the contractor.

12.30 It is vitally important to complete the validation process before the system is accepted by the client. Due to the nature of the ventilation installation and the intensity of use in the healthcare setting, it will not be possible to correct any faults or non-compliances once the system has been accepted and taken into use. There are also medico-legal aspects around taking a non-compliant system into use.

Validation report

12.31 Following validation, a full report detailing the findings should be produced and sent to the client’s lead project manager. The report should conclude with a clear statement whether the system achieved the standard set out in the agreed design specification.

12.32 The client’s lead project manager should lodge a copy of the validation report with:

- Head of the user department
- Infection Prevention and Control
- Estates and Facilities

Cause and effect testing

12.33 See appendix

Additional specialist tests

12.34 Certain critical areas will require additional testing and validation in addition to the process given above.

UCV Theatres

12.35 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 operational requirement for these systems as set out in Section 8 of HTM 03-01.

UCV canopy validation procedure

12.36 The validation procedure set out in clauses ## to ## should have been satisfactorily completed prior to attempting to validate the UCV canopy. 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 their design airflow rates.

12.37 Tests to validate the suitability and performance of an ultra-clean canopy 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**

12.38 Leakage tests to ensure that:

- the UCV canopy is correctly assembled and sealed so that no air will bypass the filters.
- the canopy HEPA filters are correctly sealed in their housings
- the canopy HEPA filters are of a uniform quality and undamaged

12.39 Air velocity measurements to ensure that:

- a sufficient quantity of air is being delivered by the canopy
- the airflow has sufficient velocity to reach the operating site plane

12.40 An entrainment test to ensure that contaminants arising outside of the UCV canopy footprint are not drawn into it.

12.41 Visualisation techniques to gain an understanding of the overall system performance.

12.42 Noise measurement to ensure that working conditions are satisfactory.

12.43 Control system “Cause and Effect” checks to ensure that the system operates and indicates as specified. (For example see Appendix #)

12.44 Microbiological monitoring to determine how effective the system is when in use.

**Test and measuring background conditions**

12.45 The entire theatre suite should be clean and free from debris and visible dust. It should be in a condition that if the validation is successful the suite will only require a final clinical clean before being taken into use. (See Para 12.23)

12.46 All doors should remain closed when readings and scans are being taken.

12.47 The conditions in the Operating room should be stable and within the given ranges.

- Temperature:– 19 - 23°C dry bulb.
- Humidity:– 30 – 70% Relative humidity.
Test and Measuring Equipment

12.48 Any test or measuring equipment used should have a certificate to prove that it has been calibrated within the previous 12 months at a facility using traceable national standards.

12.49 In the case of a noise meter, its “matched sound source” should have a certificate to prove that it has been calibrated within the previous 12 months at a 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 flow canopies

12.50 A test grid should be constructed on the floor within the ultra-clean canopy footprint as projected by the inside dimensions of the side walls or boundary air curtain. A suitably marked test sheet will provide a consistent standard of test grid.

Note: The entire clean-zone footprint of the UCV canopy should be designated by a contrasting coloured inlay in the floor covering. A line marked on or cut into the floor covering is not sufficient.

12.51 The test grid to comprise test squares of 280 mm dimension.

12.52 The test grid to be aligned along the centre lines of the canopy footprint with its centre under the centre point of the canopy.

12.53 Any test square with 80% of its area within the UCV footprint should be used as a test position.

12.54 An inner zone will be designated that is not less than 36% of the total footprint. It will be made up of a number of test squares distributed symmetrically about the canopy footprint centre line. Regardless of the shape of the canopy footprint, the inner zone will comprise a minimum grid of 6 x 6 test squares.

12.55 Unless specified otherwise, a test position should be in the geometric centre of a test square.

12.56 Test position 1 will be the left most test square in the row nearest to the operating room wall that houses the theatre control panel.

(For an example of a grid for a 2.8 x 2.8 metre canopy see Figure #)

UCV canopy leakage tests

12.57 The diffuser screen fitted below the face of the canopy HEPA filters should be lowered or removed while the leakage tests are being carried out. The installed HEPA filters are to be checked to ensure that their grade accords with the design specification and that their performance has been certified by their manufacturer.
Test equipment

12.58 A light scattering airborne particle counter (LSAPC) connected to an isokinetic fishtail scanning probe will be used to detect the size and number of particles present.

12.59 Spot readings are taken at several filter faces to establish the smallest non-penetrating particle size. If 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.

UCV canopy clean zone leak test

12.60 The test will confirm that there is no unfiltered air leakage in the canopy.

12.61 The construction joints and service penetration points under the UCV canopy within its side walls or boundary air curtain should be scanned to prove that there are no leaks.

12.62 A leak is defined as a significant and repeatable rise above the background level.

Terminal HEPA filter seal leak test

12.63 The test will confirm that there is no unfiltered air bypassing the HEPA filter seal.

12.64 Each HEPA filter seal should be scanned to prove that there are no leaks.

12.65 A leak is defined as a significant and repeatable rise above the background level.

HEPA filter media leak test

12.66 The test will confirm that the HEPA filters have not sustained damaged while being installed.

12.67 The face of each HEPA filter should be scanned to prove that there are no leaks.

12.68 A leak is defined as a significant and repeatable rise above the background level.

Vertical flow UCV canopy air velocity tests

Test set up

12.69 The canopy face diffuser screen should be in place for these tests.

12.70 Take spot readings to establish that the room is within the specified temperature and humidity test conditions.

12.71 Set out the test grid as described previously.
Swing the operating lamp arms and any other stem arms so that they align to present the least resistance to airflow, 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 canopy footprint. (See photo)

Test instrument

The measuring instrument to be a hot wire anemometer with a digital read out. The instrument resolution to be at least 0·01 m/s, have a tolerance of ±0·015 m/s or 3% 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

The instrument should be mounted on a test stand and set to take a mean reading over a ten-second sample interval.

The test instrument should record readings automatically for later download or be connected to a printer.

The test stand should be positioned on each test point in turn and the reading taken when the instrument has stabilised.

When taking a reading the test person should not stand within the same quadrant as the test instrument.

Readings are to be taken at the test positions with the instrument probe facing the wall housing the surgeons panel - commencing at the first test position. Readings are taken either working along the rows from left to right or for all test positions in one quadrant at a time.

When all test positions under one half of the canopy have been covered, readings of temperature and humidity are taken at the specified height in the centre of the canopy. The read-outs from the surgeon’s panel should be recorded at this time.

Having completed one half of the test grid, the operating lamp arms and any other stem arms should be swung round through 180° and the test stand reversed so that the wall housing the surgeons panel is behind the test person. Readings are recommenced starting at the right of the test row and working from right to left or a quadrant at a time, as above.

Measurements of air velocity are to be taken at every test position 2 m above floor level and the results averaged. The average of the total readings taken is to be not less than:

- 0·38 m/s for a canopy with no side walls or side walls that terminate at 2 m above floor level.
- 0·30 m/s for a canopy with side walls that terminate 1 m above floor level.
For UCV canopies that are an assembly of two or four units, each containing a recirculation fan, the average air velocity for each unit should not exceed ±6% of the measured average velocity for the canopy.

**UCV canopy low level air velocity test**

Measurements of air velocity are to be taken at each of the inner zone test position 1 m above floor level.

The measured velocity at every test position in the inner clean zone should be not less than 0.20 m/s.

**UCV canopy entrainment test**

**Rationale for the entrainment test**

The performance of UCV canopy 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.

UCV canopies having permanently fitted side walls that terminate 1 m above floor level do not need to be tested as the walls physically prevent entrainment.

**Principle of the test**

A source of particles is produced outside of the UCV canopy footprint and is used to challenge the system. A sample probe and detector are placed within the ultra-clean airflow and used to determine the percentage penetration of the test particles at predefined locations under the UCV canopy footprint. The source and sample probe are moved in tandem around the UCV canopy and pairs of readings taken at the detector, 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.

**Test set up**

The challenge will be provided by using non-HEPA-filtered air emerging from the preparation room via the pressure stabiliser or transfer grille and ducted to the specified release position.

The canopy face diffuser screen should be in place for these tests.

The test is performed without any theatre equipment in place beneath or closely adjacent to the UCV canopy. All doors in the theatre suite should be closed and remain so for the duration of the test.

The operating lights and support booms should be moved to a central position beneath the canopy and raised to 2 m above floor level, so as not to interfere with the peripheral airflows. (See photo)
12.92 Spot readings are taken at the centre of the canopy, 1 m from floor level, to establish that the room is within the specified temperature and humidity limits (see #).

12.93 The test grid is set out as described previously (See clause #).

**Test equipment**

12.94 The source unit will be a fan/blower or other method that ducts non-HEPA-filtered air (see 12.102) and expels it via a delivery head mounted on a test stand or clamped to the UCV canopy sidewall at the specified release position to provide the particle challenge. The challenge air will be delivered vertically downwards from a position 2 m above floor level alongside the outside edge of the side wall or in line with the downward air curtain if the canopy does not have side walls. The challenge airflow velocity should be the same as the measured average velocity at the 2 m level for the canopy under test.

12.95 The detector will be a light scattering airborne particle counter (LSAPC) capable of sampling a minimum of 28.3 litres of air (1 ft³) per minute and providing readings for particle sizes from 0.3 µm to 5 µm. The instrument should be compliant with the requirements of EN ISO 14644. An alternative instrument may be used providing it is of no lesser specification.

12.96 The sampling head will be an isokinetic fishtail scanning probe mounted on a test stand 1 m above floor level and connected to the LSAPC by a hose not greater than 2 m long.

**Test positions and orientation of source and detector sampling probe**

12.97 The test positions will be at the centre of each test square, as defined for the velocity test (see ###).

12.98 For rectangular UCV canopies, 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 not less than 3 and not more than 5 complete test squares between test positions.

12.99 A further series of measurements are to be obtained around the periphery of the inner zone (defined in ###.) 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 not less than 3 and not more than 5 complete test squares between test positions.

12.100 The centre of the challenge particle source delivery head is aligned with the centre of the designated test square, with its longer edge against the outer edge of the side wall or air curtain and delivering the challenge 2m above floor level. The air containing challenge particles is directed vertically downward. 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 test position. The sampling probe will then also be moved to remain opposite the source.

12.101 In the case of non-rectangular canopies, 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**

12.102 A measurement of particle penetration through a representative section of the HEPA filter media is to be taken. The smallest non-penetrating particle size will be used as the reference background level and set in the detector instrument. The detector instrument should be set to take a reading over a 15-second sample interval and record the number of particles at the non-penetrating particle size determined above.

12.103 An initial sample of air at the source delivery head should be taken to check that there are sufficient particles of the considered size present. The challenge will be considered suitable if:

a. The particles are within the size range 0·3 to 5 microns and thus capable of remaining airborne for a substantial time.

b. The particles should not be able to penetrate the canopy HEPA filters in sufficient numbers to cause a background count that is more than 0·1% of the challenge count.

c. The number of particles present will enable a minimum of 3 logarithm (1000-fold) range of counts to be recorded between the source and background readings. A concentration of approximately $10^5$ particles per cubic metre of source air has been shown to be adequate.

**Note:** The same equipment should be used to measure both the challenge source and penetration so as not to bias results through particle losses within the test equipment.

12.104 The sampling probe of the detector instrument is mounted on a test stand with its orifice facing outwards horizontally from the centre of the UCV canopy, 1 m above floor level. The sampling probe will 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 ## illustrates the challenge and sampling probe orientations when evaluating a 2·8 m x 2·8 m UCV terminal and photos # show a typical test set up).

12.105 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 theatre control 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 distribution head
and sampling probe will be moved to the next test positions, working around the test grid in a clockwise direction.

12.106 The test stands will be positioned on each test point in turn and a pair of readings (challenge, then penetration) taken when the instrument has stabilised.

12.107 When taking a reading the test person should stay within the UCV canopy footprint but on the side opposite the sampling probe.

12.108 A single measurement will be taken at the geometrical centre of the UCV canopy footprint. The centre measurement will be taken with the sampling probe mounted vertically 1 m above floor level. For this test the challenge source distribution head will be placed at the test position that yielded the greatest penetration at the periphery of the canopy footprint.

**Analysis and interpretation**

12.109 The following standard is to be achieved:

a. Penetration to be not greater than 10% of the challenge at each test position in the outer zone.

b. Penetration to be no greater than 1% of the challenge at each test position in the inner zone.

c. Penetration to be no greater than 0·1% of the challenge at the centre of the test grid.

12.110 If a result is close to, or above, the given limits, then a further reading should be obtained using a longer time base (1 minute) and the penetration should not exceed the given limit.

**Basis of the test**


**UCV canopy flow visualisation**

12.111 The use of smoke to gain an understanding of the overall performance of the canopy may prove useful at this stage in the validation process but cannot be relied on to produce a contractually definitive measure of performance.

**UCV canopy noise level**

12.112 An industrial-grade sound level meter to BS EN 61672 Type 2 fitted with a muff will be used to check the noise level. The instrument should be calibrated using a matched sound source prior to each set of readings.
The noise level readings are to be taken at typical normal listening position 1·5 m above floor level and at least 1 m from any surface and not on any line of symmetry. Measurements should be taken under the centre of each quadrant and in the centre of the canopy and the five readings averaged.

The readings should be taken with the UCV canopy at operational speed and repeated with it at set back.

For UCV operating suites the noise level should not exceed:

- Operating room and spaces without doors that are open to it e.g. the scrub – 45 NR (50dB(A))
- All other peripheral rooms of the suite 45 NR (50dB(A))

**UCV terminal control system checks**

**Temperature**

The readings of temperature taken under the UCV canopy should be within ±1°C of each other and the readout on the theatre control panel.

**Humidity**

The readings of humidity taken under the UCV canopy should be within ±5% of each other and the readout on the theatre control panel.

**Direct reading differential pressure gauges**

The differential pressure across the terminal filter should be measured to confirm the accuracy of the indicated reading of any gauge.

**Control functions**

The operation of all control functions provided on the theatre control panel should be proved for conformity with the design specification.

If an auxiliary panel has been fitted, then its interlocking with the main theatre control panel control functions should be proved to conform to the design specification.

**Panel indicator lights**

The panel indicators should illuminate as appropriate when the control functions are selected or warning levels are reached. (See Appendix # for an example “Cause and Effect” test regime)

**BMS interface**

The operation, monitoring and alarm functions should be proved to conform with that set out in the design specification.

**UCV theatre microbiological tests**

There is little value in performing microbiological sampling in an empty operating theatre supplied with ultra clean ventilation. The foregoing filter challenge tests, air velocity measurements and entrainment test will 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 canopy. Therefore, there will be an insignificant number of bacterial and/or fungal CFUs present until the theatre is actually used.

12.124 Once the theatre has been taken into use, microbiological sampling during a surgical procedure should help to confirm the satisfactory performance of the system and discipline of the users. (Details of in-use microbiological tests can be found in HIS Document #.)

UCV operating suite validation report

12.125 Following validation, a full report detailing the findings should be produced and sent to the client's lead project manager. The report should conclude with a clear statement on whether the UCV operating suite as a whole achieved the standard set out in the agreed design specification.

12.126 The clients lead project manager should lodge a copy of the report with:

- theatre manager;
- infection prevention and control;
- estates and facilities.

Pharmacy – aseptic preparation facilities

12.127 The following regime of inspection and testing should be applied to the validation of new installations. The test regime has been devised to ensure that the system, as installed, fully achieves the operational requirement for these systems as set out in EUGGMP and the design specification.

Basic requirement

12.128 The validation procedure set out in paragraphs # to # should have been satisfactorily completed prior to attempting to validate the aseptic preparation facility. The facility to be validated should be physically complete with final finishes applied and have been completely cleaned. All ventilation systems serving it should be operating correctly and delivering their design airflow rates.

Aseptic preparation facility – validation procedure

12.129 Tests to validate the suitability and performance of the aseptic preparation facility 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

12.130 Challenge tests to ensure that:
• the supply terminal HEPA filters are sealed in their housings so that no air will bypass them;

• the terminal filters are of a uniform quality and undamaged.

12.131 Differential pressure measurements to ensure the correct pressure cascade

12.132 Particle counting at a specified number of test positions in order to determine the individual clean room classification in accordance with ISO EN 14644.

12.133 Control system checks to ensure that the system operates as specified.

12.134 Microbiological sampling to check the air quality.

**Test and Measuring Conditions**

12.135 While validating the aseptic preparation facility, the conditions in the clean rooms should be stable and within the given ranges:

Temperature: –19°C to 23°C dry bulb.

Humidity: 30% to 70% Relative humidity.

**Test and measuring equipment**

12.136 Any test or measuring equipment used should have a certificate to prove that it has been calibrated within the previous 12 months at a facility using traceable national standards.

**Supply terminal HEPA filter seal leak test**

12.137 The test will confirm that there is no unfiltered air bypassing the HEPA filter seal.

12.138 Each HEPA filter seal should be scanned using an LSAPC to prove that there are no leaks.

12.139 A spot reading will be taken at the face of the filter to determine the background particle level. A leak is defined as a significant and repeatable rise above the background level.

**Terminal HEPA filter media leak test**

12.140 The test will confirm that the HEPA filters have not sustained damaged while being installed.

12.141 The face of each HEPA filter should be scanned using a LSAPC to prove that there are no leaks.

12.142 A leak is defined as a significant and repeatable rise above the background level.
Clean room particle count

12.143 The test will confirm the number and size of particles present and therefore the classification of the clean room in terms of ISO 14644 or EUGMP as specified in the project brief.

12.144 The number of test positions is determined by reference to Table A.1 in ISO 14644-1.

12.145 The complete test methodology will be as set out in ISO 14644 Parts # to #.

Radiopharmacy - aseptic preparation facilities

12.146 Validation will be as for a pharmacy aseptic preparation facility.

12.147 Additional radiological test as specified in the project brief will be required. These will be carried out and / or witnessed by the client’s appointed specialist.

Sterile services departments with inspection, assembly and packing (IAP) rooms

12.148 Validation will be as for the standard practice described in paragraphs # to #.

12.149 The pressure cascade and associated automatic monitoring sensors and alarms will need to be tested for correct operation in accordance with the design specification.

Note: The detail of the sealing between the instrument washers, transfer hatches and sterilisers that penetrate the walls of the IAP room will be critical in the attaining the specified room pressure.

12.150 Following satisfactory validation, the IAP room should be physically cleaned using specialist contractors. Particle counts at locations related to the floor area as set out in table A.1 of ISO14644 Part 1 will then be taken to establish whether the room achieves a Class 8 cleanroom standard.

Containment level 3 laboratories

12.151 Validation will be as for the standard practice described in Pars # to #.

12.152 The room will be subject to a permeability test as set out in Chapter #; Clause #.

12.153 The pressure cascade and associated automatic monitoring sensors and alarms will need to be tested for correct operation in accordance with the design specification.
Question to consultees: Any others to mention - Isolation rooms have their own document – Should we reference it?

How about Pathology, Histology, Mortuary, Endoscope decontamination units? Or should this information be in chapter 8 which will be a list of departmental / application requirements?

##

**Microbiological sampling**

12.154 It is essential that all of the validation test specified above has been successfully completed and the areas thoroughly cleaned prior to any microbiological sampling.

12.155 Microbiological sampling will not normally be required for either general or local exhaust ventilation (LEV) systems unless otherwise specified.

12.156 The procedure for carrying out microbiological sampling in interventional imaging treatment rooms and conventional operating theatres prior to use, and UCV operating theatres when in use, is set out in a document produced by the Healthcare Infection Society (HIS).

12.157 The procedure for carrying out microbiological sampling in clean rooms is set out in ISO 14644.
13 Information

Records required

13.1 There is a requirement under the Building Regulations to provide documentary evidence of the design, commissioning and subsequent performance of ventilation systems.

13.2 Electronic records should be in a format that is compatible with the client’s archive and retrieval system.

Handover

13.3 The following general information is required at plant handover:

a) “as-fitted” drawings of the plant showing the location of all items and listing the size of ducts, grilles and diffusers together with their factors;

b) “schematic” drawing of the air distribution system showing design and actual airflows from all outlets together with the design and actual airflows in each duct. The duct centre correction factors should be given and the grille factors;

c) the location of all volume control dampers should be marked on the “as-fitted” and “schematic” drawings;

d) a floor plan of the area served by the plant showing all doorways, hatches, transfer grilles, pressure relief dampers, pressure stabilisers, supply and extract terminals. The total supply and extract volumes should be shown for each room served by the plant. The volume flow and direction of flow through transfer grilles, pressure relief dampers and pressure stabilisers should also be shown together with the room pressures in pascals measured with regard to atmospheric pressure. For operating suites the “key” door should be identified;

e) a fire plan of the area served showing the fire zone and location of all fire and smoke dampers and detectors. An explanation of the ventilation strategy in the event of an in zone fire, adjacent zone fire or smoke being drawn into the air handing unit from an outside source should be provided.

f) 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;

g) manufacturer’s operating instructions and “setting to work” guidance for all specialist components incorporated in the systems;

h) a schematic of the control system showing the location of all plant sensors.
control algorithm(s) of the actual plant operation and the set points entered
during commissioning together with the control panel access codes and
keys.

**Plant design information**

13.4 The following plant design information is required at plant handover:

a) a simple statement of the design intent;

b) a description of the plant’s intended mode of operation;

c) winter outside design temperature in °Cdb;

d) winter outside design humidity in % saturation;

e) winter room supply air design temperature in °Cdb;

f) winter room supply air design humidity in % saturation;

g) winter inside design temperature for each room in °C;

h) winter inside design humidity for each room in % saturation;

i) summer outside design temperature in °Cdb;

j) summer outside design humidity in % saturation;

k) summer room supply air design temperature in °Cdb;

l) summer room supply air design humidity in % saturation;

m) summer inside design temperature for each room in °C;

n) summer inside design humidity for each room in % saturation.

o) winter psychrometric chart showing the condition of the air between all items
   of plant and the design outside, supply and room air conditions;

p) summer psychrometric chart showing the condition of the air between all
   items of plant and the design outside, supply and room air conditions;

q) the design mass airflow rate used to size the plant in kg/s.

r) the design volumetric flow rate in m³/s.

**Individual equipment information**

13.5 The following information concerning heater-batteries is required at plant
handover:

a) the size of the battery, number of passes and fin spacing;
b) the design flow and return temperatures and flow rate in l/s;

c) the pressure drop across the water side of the battery in Pa;

d) the number of phases, supply voltage, current drawn and number of steps if electric;

e) the maximum rated capacity of the battery and actual design rating in kW;

f) the design and actual face velocity in m/s;

g) the pressure drop across the air side of the battery in Pa;

h) the design on and off coil air temperature and humidity at winter and summer design conditions.

**Cooling coils**

13.6 The following information concerning cooling coils is required at plant handover:

a) the size of coil, number of passes and fin spacing;

b) the design flow and return temperatures and flow rate in l/s if chilled water;

c) the pressure drop across the water side of the coil in Pa;

d) the supply pressure and mass flow rate if direct expansion;

e) the maximum rated capacity of the coil and actual design rating in kW;

f) the contact factor;

g) the design sensible and latent cooling loads in kW;

h) the design and actual face velocity in m/s;

i) the pressure drop across the air side of the coil in Pa;

j) the design on and off coil air temperature and humidity at summer design conditions.

**Humidifiers**

13.7 The following information concerning humidifiers is required at plant handover:

a) the size of the humidifier and number of lances;

b) the supply pressure and mass flow rate of the steam;

c) the number of phases, supply voltage, current drawn and number of steps if electric;

d) the maximum rated capacity of the humidifier and actual design rating in l/hour;
e) the design and actual face velocity in m/s;

f) the design upstream and downstream air temperature and humidity at winter design conditions.

**Filters**

13.8 The following information concerning filters is required at plant handover:

a) the size of the filter and number in bank;
b) its grade;
c) the design and actual face velocity in m/s;
d) the initial pressure drop across the filter when clean in Pa;
e) the final pressure drop across the filter when dirty in Pa;
f) the manufacturer’s name and filter identification code.

**Fans**

13.9 The following Information concerning fans is required at plant handover:

a) the size of the fan and its type;
b) the fan curve;
c) speed and direction of rotation;
d) the drive motor frame size;
e) the number of phases, voltage and maximum design and actual current drawn;
f) the design and actual delivered air volume m$^3$/s;
g) the fan suction pressure at high and low speed in Pa;
h) the fan delivery pressure at high and low speed in Pa;

**Attenuators**

13.10 The following information concerning attenuators is required at plant handover:

a) the size of the attenuator and number in bank;
b) the design and actual face velocity in m/s;
c) the initial pressure drop across the attenuator in Pa;
d) the upstream sound level in dB(A); the downstream sound level in dB(A);
System information

13.11 The preservation of information and records of ventilation systems and their performance is a legal requirement. It is therefore essential that when new systems are completed full information as to their purpose, design, layout and actual commissioned performance are handed on to the client. The information if electronic should be in a form that is compatible with the client’s IT standard and can be accessed and searched by it.

13.12 In new “green field” developments an inventory of the installed ventilation systems should be compiled. In existing developments, the client will normally have an inventory of their installed systems and all new systems should be added to it.

13.13 The inventory will be subdivided into the following categories:

- local exhaust ventilation systems - (LEV) – Note these are statutory items.
- critical healthcare ventilation systems - (CHV)
  (These are systems the loss of which would seriously limit the delivery of healthcare e.g. operating suite, SCBU, critical care areas, interventional imaging suite, aseptic preparation facilities, etc.)
- general ventilation system [supply and extract] - (GVS)
- general extract systems - (GES)
- systems installed for smoke clearance in the event of a fire, classed as smoke and heat exhaust ventilation systems - (SHEVS)
  (e.g. smoke extract fans in stairwells, automatic smoke clearance dampers in atriums)

Note: During the design and contract process ventilation system are often given “construction” codes for drawing reference and site identification. It is imperative that prior to handover the actual identification codes conform to the system in use at the site or desired by the client. Each system code should be unique and conform to the categorisation format for the clients inventory given above.

13.14 For each ventilation system the inventory should contain the following details:

- A unique system identification code e.g. LEV 001; CHV 001 etc. as appropriate
- The location of the ventilation fan unit or supply and extract AHU(s)
- The location of the fresh air inlet
- The location of the extracted air discharge
- The specific area(s) served by the system
- The date the system was installed
- The date the system was validated and accepted by the client

13.15 Each ventilation system should have a logbook (physical or electronic) that contains the following information:

- The unique system identification reference
- Purpose of the system
- Date of installation
- Details of the installed equipment and ductwork layout
- Detail of the fire plan and location of fire and smoke dampers
- Design performance parameters e.g. airflow rates, air change rates, pressures, etc.
- Commissioned date and performance
- Record of the system validation and acceptance
- Records of the annual inspection and verification
- Maintenance records and plant information e.g. fan specifications and filter sizes

13.16 The records should be linked to the inventory and stored in such a way as to be readily available in the event of plant breakdown or other incident.

13.17 Every ventilation system should be clearly identified with a permanent label. The label should show in lettering 100 mm high the inventory reference code of the AHU and clearly identify the area that it serves. The label should be mounted with screws or rivets in an easily visible place near the fan of the unit adjacent to the local electrical isolator. The system control panel should have a duplicate label. Any subsystems and the principal branch ducts should be similarly labelled.

13.18 The direction of airflow should be clearly marked on all ducts (see BS 1710).

13.19 All airflow test-points should be clearly identified with a permanent label and the design information given (e.g. TPS 1 – Anaesthetic supply; 400 x 300; Design 185 L/s).

13.20 If two ventilation system supply a common room or an outlier from another zone, then the room identification label should state the relevant ventilation identification codes e.g. theatres 5&6 utility; [CHV 012 & CHV 015] as should the labels on their individual AHUs.

Fire and Smoke dampers
13.21 A complete schedule of dampers fitted, their location and unique identification code
13.22 A statement of when they were tested and by whom.

Spares
13.23 The scale of spare fans to be provided should relate to the number of AHUs using fans of the same size.
13.24 A complete set of new filters should be handed over.
13.25 A complete set of any other consumable item installed in the installation should be handed over.
BIM status
13.26 If the installation was modelled using BIM during construction, the BIM model should be brought up to date prior to handover.

13.27 Training for estates staff who will be tasked with keeping the BIM model in date will need to be given ideally while the original BIM team is available

Maintenance routines
13.28 Any product or installation specific maintenance routines should form part of the handover documentation and, if necessary training.

13.29 Information on maintenance regimes is given in HTM 03-01; Part B.

Predicted service life
13.30 Air Handling Units (AHUs) have a predicted service life of 20 years. Part B of this HTM states that ventilation systems should be taken out of use, deep cleaned, their controls renewed and re-commissioned after 10 years. The handover information will both assist this process and help inform the selection of replacement plant.
References