Scottish Health Technical Memorandum 2025

(Part 3 of 4)

Validation and verification

Ventilation in healthcare premises

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Contents

1. Introduction

General

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

1.2 This edition of Scottish Health Technical Memorandum 2025; *Ventilation in healthcare premises* is published in four separate parts. It is equally applicable to both new and existing sites. It gives comprehensive advice and guidance to healthcare management, design engineers, estates' managers and operations' managers on the legal requirements, design implications, maintenance and operation of specialist ventilation in all types of healthcare premises.

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

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

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

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

2. General

Commissioning personnel

2.1 It is unlikely that all of 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.

2.2 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.

2.3 In order to be successful the commissioning process must 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.

Commissioning brief

2.4 The commissioning team will require a detailed brief from the system designer. This should include:

a. a "user" brief comprising a description of the installation and its intended mode of operation;

b. the precise design requirements with regard to the scheme of air movement, room static pressures, supply and extract air flow rates and acceptable tolerances;

c. full details of the design conditions both inside and out, for winter and summer together with the control strategy;

d. equipment manufacturers’ type, test data, commissioning, operation and maintenance recommendations;

e. drawings showing the layout of the system, positions of air flow measurement test points, dampers, regulating devices and filters within the duct runs, together with sizes of ducts and terminal fittings. It will save time if these drawings are annotated with the design volumes and static pressures required at each branch and outlet point;

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.

2.5 The CIBSE Commissioning Code, Series 'A' – *Air Distribution*, provides full guidance on the information that will be required by the commissioning team.

2.6 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.

2.7 The system, on completion should be operated by the contractor as a whole and subject to performance tests in accordance with the contract requirements.

2.8 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 Chapter 3 should be followed by the dynamic tests described in Chapter 4, the performance tests listed in Chapter 5 and finally the handover procedures set out in Chapter 6.

2.9 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.

3. Pre-commissioning checks

3.1 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 Chapter 4 of this guidance.

Standard of installation

3.2 During the installation of the system the following must be witnessed:

a. that the plant and installations have been provided and installed in accordance with the design specification and drawings;

b. that only approved sealants have been used in the installation;

c. that all components function correctly;

d. that the satisfactory sealing of access doors and viewing ports have been carried out;

e. that air pressure tests and air leakage tests on ventilation ducting have been carried out in accordance with the methods set out in the HVCA's DW/143: *Ductwork Leakage Testing*. It is usual to carry out these tests a section at a time as the ductwork is installed and before its insulation is applied. The results must be recorded in the commissioning manual;

f. that gaps around doors and hatches are as specified in the design;

g. that the correct operation of pressure relief dampers, pressure stabilisers, control dampers, isolating and non-return dampers have been applied;

h. that test holes have been provided in their specified locations and are sealed with "top hat" grommets;

i. that control dampers are secured and their quadrants fitted correctly;

j. that the interlocks are operative and in accordance with specification;

k. that the electric circuits are completed, tested and energised;

l. that electric motors have been checked for correct direction of rotation;

m. that cooling and heating media are available at correct temperatures and pressures and in specified quantities;

n. that the air-conditioning plant components and controls function correctly;

o. that the air-conditioning plant interlocks and safety controls function correctly;

p. that the plant is physically complete, insulation is applied and all ducts and pipework are identified as specified;

q. that the building housing the ventilation plant is generally in a fit condition for commissioning and performance tests to commence, i.e. windows, doors, partitions, etc. are completed, surfaces sealed and their final finish applied;

r. that the areas containing the ventilation plant and those being served by it are clean;

s. that access to all parts of the system is safe and satisfactory.

Cleanliness of installation

3.3 During installation it must be established that the ductwork is being Installed to the "Advanced Level" as defined in DW/TM2*: Guide to Good Practice - Internal Cleanliness of New Ductwork Installations* published by the HVCA.

3.4 Should any doubt exist whether the guidance has been observed, the ducts must be cleaned internally to restore them to this standard before being taken into use.

3.5 "Builders work" ducts of brick or concrete must be surface sealed to prevent the release of dust **before** being taken into use.

3.6 The area around the supply air intake must be free of vegetation, waste, rubbish, builders debris or any other possible source of contamination.

Certification of equipment

3.7 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:

g. (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

3.8 Prior to setting the system to work the following must be witnessed and proving tests should be carried out as detailed.

Filters

3.9 The quality of filter housing and in particular the seals is a critical factor in maintaining the efficacy of the filtration system by ensuring that air does not bypass the filter panels. Therefore, the following checks should be made:

a. filter seals should be fitted and in good condition;

b. filters should be installed correctly with respect to air flow;

c. bag filters should be installed so that the bags will be effective, their pockets free and in accordance with the requirements of the manufacturer;

d. HEPA filters should be installed in a sealed housing and their seals tested to DIN 1946 if specified;

e. all filters should be checked to ensure they are free of visible damage;

f. manometers should be fitted to indicate the differential pressure across filters and marked with initial and final filter resistance.

Drainage arrangements

3.10 The drain should conform in all respects to the ‘Design considerations’ part of this SHTM. In addition the following must be proved:

a. that the drain tray is easily removable;

b. that a clear trap is fitted and is easily removable;

c. that the drain has a type “A” air break;

d. that the pipework is supported so that the air break cannot be reduced;

e. that the drain system from each drain tray is independent up to the air break;

f. that the operation of the drainage system is proved by introducing water into the duct at the drain tray and observing that it completely drains out. This check is to be repeated both at normal speed and set back once the fans have been commissioned. At this time the clear trap can be marked to indicate the normal water level with the fan running.

Fire dampers

3.11 The following must be witnessed and proving tests should be carried out as detailed:

a. the operation of all fire dampers should be proved, if of the thermally actuated resettable link type, a suitable heat source should be used;

b. the access provided to enable the dampers to be re-set should be sufficient for the purpose;

c. indication should be provided of the dampers' position (open/tripped);

d. 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.

4. Commissioning

Air-handling and distribution system

4.1 The fan drive, direction of rotation, speed and current drawn should be set in accordance with its manufacturer's instructions.

4.2 After the installation has been checked to ensure that it is in a satisfactory and safe condition for start up, it should be set to work and regulated to enable the plant to meet its design specification. The proportional balancing method described in the CIBSE Commissioning Code 'A' must be followed. The air flow rates must be set within the tolerances laid down in the design brief.

4.3 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.

4.4 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.

4.5 On completion of the balance all volume air flows in supply and ducts and from grilles and diffusers must be measured and recorded.

4.6 The main supply and extract duct volume control dampers must be locked and their position marked. Where these dampers are also used as isolation dampers, they should be fitted with a stop to prevent opening beyond their marked "open" position.

4.7 All grille and diffuser volume control registers must be locked to prevent alteration.

Room air distribution

4.8 The pressure relief dampers and pressure stabilisers must be set to achieve the specified room static pressures and locked. The grille direction control vanes and diffuser cones must be set to give the specified air movement pattern. Visualisation techniques may need to be employed in order to prove that the required air flow pattern is being achieved.

Air-conditioning plant

4.9 The specified flow rate and/or pressure drops must be set for all heater batteries, cooling coils and humidifiers. The methods described in the CIBSE Commissioning Codes “W” and “R” should be followed. On completion, their regulating devices must be locked to prevent alteration.

Control system

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

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

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

4.13 The control system's ability to carry out its specified functions must be proved.

4.14 If the plant is provided with a “users” control panel in addition to the one located in the plant room then the operation of both must be proved. This will typically apply to operating departments and laboratory systems.

5. Performance tests

Air movement

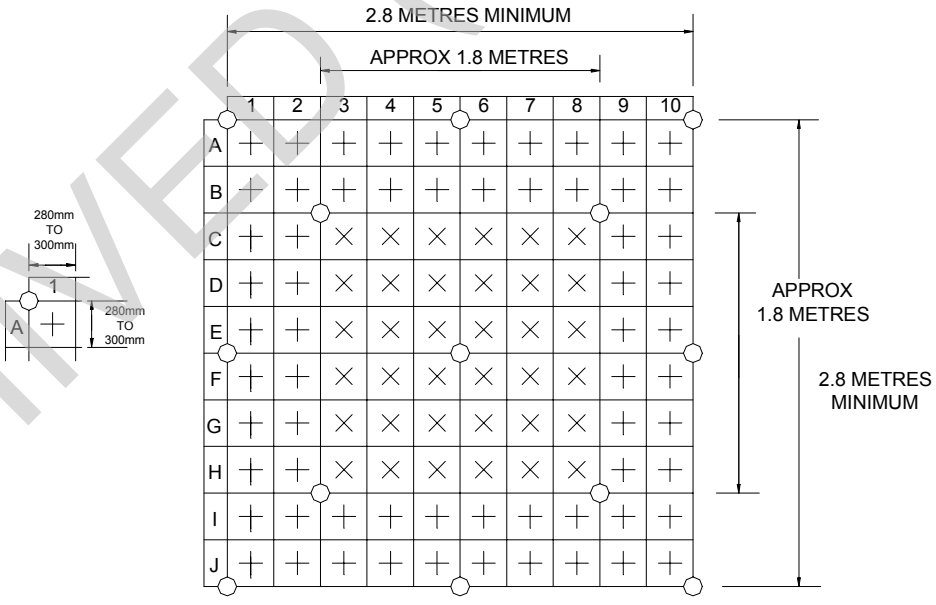
General ventilation systems

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

Operating department - UCV systems

5.2 The air velocity from ultra-clean terminals should be measured by dividing the face into approximate 300 mm x 300 mm elemental squares. A test grid is shown in Figure 1. The velocity should be measured at the centre of each elemental square 2 m above floor level and be within the limits set out in Table 1. Additionally in the central 1.8 m x 1.8 m area the velocity 1 m above floor level at the centre of each elemental square should be at least 0.2 m/sec.

Figure 1: Ultra clean system - test grid



Key:

+ Measure air velocity 2 m above floor level (see Table 1)

x Measure air velocity 2 m above floor level (see Table 1) and also measure air velocity 1 m above floor level (min 0.2 m/s)

o Bacteriological sampling position

5.3 Using the test grid, velocity checks should be carried out using a uni-directional hot-wire anemometer. Readings should be taken at 10 second intervals to establish the average velocity for each individual grid position.

Table 1: Minimum discharge velocities

Vertical Flow systems (velocity measured 2 m above floor level)		Horizontal flow system
Full Wall terminating not greater than 1 m above floor level (these walls may be demountable extensions of the fixed partial wall)	Fixed partial walls terminating 2 m above floor level	Measured 1 m from filter/diffuser face
0.3 m/s	0.38 m/s average	0.40 m/s

5.4 Some UCV systems are designed to have a variable velocity over the working zone, the velocity decreasing from the centre towards the edge of the terminal. In such systems the total air volume should be the same as uniform velocity systems of the same size. The individual elements should be tested as above to establish this air volume.

Laboratory systems

5.5 The performance of the system will need to be measured with the designated safety cabinets and/or fume cupboards operating (see also paragraph 5.17).

Local exhaust ventilation (LEV) systems

5.6 Local exhaust ventilation (LEV) systems are used to protect personnel from chemical, gaseous, biological and general dust hazards. They are designed to capture the pollutant at source and safely discharge it. The following are typical examples of LEV applications:

a. laboratory fume cupboards;
b. pharmacy safety cabinets including cytotoxic and radio-pharmacy cabinets;
c. pathology microbiological safety cabinets, formaldehyde mixing and specimen preparation bays;
d. glutaraldehyde mobile cabinets and workstations;
e. dental grinders, buffers, casting machines, sand blasters and plating baths;
f. X-ray and photographic film processing units;
g. mortuary bone saws, dissection tables and specimen bench extracts;
h. EBME equipment decontamination units;
i. fixed and mobile welding bay fume extract equipment;

j. battery charging bay extracts;

k. chemical decanting bays;

l. paint spray booths;

m. wood working machinery dust control systems;

n. general dust extract systems.

5.7 All LEV systems must be subjected to an initial thorough examination and test. HS(G)54: *The Maintenance, Examination and Testing of Local Exhaust Ventilation* published by the Health and Safety Executive gives guidance on the standards required. The examination and test must be carried out by a competent person and results preserved for future reference.

5.8 The face and capture velocities of cabinets and hoods together with the static pressure behind the hood must be measured and recorded. The actual performance of the system must, as a minimum, achieve the standard set out in the design specification.

5.9 Some LEV systems, such as safety cabinets and fume cupboards, are subject to their own specific guidance documents.

Microbiological safety cabinets

5.10 Safety cabinets must be subjected to a thorough examination and test using the procedures set out in BS EN 12469. This is a specialist task and should be carried out by the manufacturer.

Laboratory fume cupboards

5.11 The complete installation must be tested using the methods set out in BS 7258*: Laboratory Fume Cupboards*: Part 1: Appendix C: *Commissioning Tests* and Part 2: Section 3: Paragraph 11 *Commissioning Tests*.

Glutaraldehyde mobile cabinets and workstations

5.12 Developments are continuing to take place in the design of systems using glutaraldehyde generally used for the disinfection of ‘scopes’. These include totally enclosed processing machines to fume cupboard type installations. Technical requirements and guidance is being developed and will be published when complete.

Plant capacity and control

5.13 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.

5.14 The installation's ability to achieve the specified inside design conditions with the plant operating at winter and summer outside design conditions must be

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

5.15 On completion of the plant performance test, recording thermohygrographs should be placed in each room/area served by the plant and also the supply air duct upstream of the fog/frost coil. The plant should be run for 24 hours with all doors closed. During this period the inside conditions must stay within the tolerances specified.

5.16 Operating department ultra-clean systems designed to have partial walls with full wall extensions may incorporate a volume control facility to allow the system to be run with reduced velocity when the demountable full walls are in place. Its operation must be proved and a notice explaining its function affixed to the control panel.

5.17 The commissioning and testing of safety cabinets and fume cupboards is a specialised task and should be carried out by the equipment manufacturer or an approved specialist. Any special performance requirements and the precise mode of operation of the areas' ventilation system should be defined, and the operation of associated run on timers, differential pressure monitors and plant interlocks proved.

Noise levels

General

5.18 The commissioning noise level is the level measured with a sound level meter in the unoccupied room and taking account of the external noise together with the noise generated by the ventilation system. When occupied and in use this commissioning level will constitute a continuous background noise which will allow the overall L_{10} 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.

5.19 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 air flow, temperature and humidity.

5.20 An industrial-grade sound level meter to BS EN 60651: 1994 will normally be sufficient to check the noise level.

5.21 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 and should not exceed 55dB(A) unless otherwise specified.

5.22 In the event of a contractual deficiency a precision-grade sound level meter complying with BS EN 60651: 1994 should be used. Noise level readings should be taken at five positions in the room at 1.5 m from each corner and

in a central position not on any line of symmetry. The logarithmic mean of the five level results should be calculated and used to check the noise level.

5.23 The discrete frequency components and source of noise should be determined by the procedure given in SHTM 2045; *Acoustics*. When the plant and equipment have been installed and the mean near-field sound pressure levels measured, discrete frequency components will be judged to be present and predominant in a ⅓ octave band if a ⅓ octave sound-pressure level in any of the near-field sound-pressure level measurements in the range 50–12,500 Hz exceeds the arithmetic average in the two adjacent ⅓ octave bands by more than the amount shown in Table 2.

Table 2: Frequency limits

⅓ octave band mid – frequency Hz	63–100	125	160	200–250	315–10000
Difference not to exceed (dB)	6	5	4	3	2

For this test a precision-grade sound level meter to BS EN 60651: 1994 should be used with a filter set complying with IEC R225.

Operating departments

Table 3: Interior noise level – operating suite

Room	Overall noise level L_{10} dB(A)	Ventilation plant commissioning – dB(A)	Ventilation plant design – dB(A)
Operating room (ultra clean)	Remote plant:50 Modular type:55	–	–
Operating room (conventional)	50	45	40
Anaesthetic	50	45	40
Preparation	50	45	40
Scrub-up	50	45	40
Corridor	55	50	45

Safety cabinets

5.24 Noise level readings are to be taken at 0.3 m from the aperture and 1 m from any other part of the structure including its ductwork. The level should not exceed 55 dB(A).

NOTE: This is a higher standard than is required by BS EN 12469.

Filter challenge

General ventilation filters

5.25 *In situ* performance tests will not normally be required for primary and secondary filters and their housings.

HEPA filters (for exhaust protective enclosures and laboratories)

5.26 Pathogenic material may be discharged through damaged or badly installed HEPA terminal filters. The complete installation must be tested using the method set out in BS 5295: Part 1: Appendix C: *Method of Testing for the Determination of Filter Installation Leaks*. A challenge aerosol of inert particles of the type produced by a dispersed oil particle (DOP) generator should be introduced into the return air, upstream of the terminal filter. The downstream face of the filter and its housing may then be scanned for leakage using a photometer.

5.27 A leak shall be deemed to have occurred if a steady and repeatable reading on the photometer at any point exceeds 0.01% of the upstream reading. Should the filter fail this test it must be replaced. Should the filter housing fail this test it may be repaired and the test repeated.

Ultra-clean ventilation (UCV) systems

5.28 Upon satisfactory completion of the terminal filter installation test, a test to determine whether particles originating outside of the clean zone are being drawn into it should be carried out.

5.29 The performance of partial walled systems may be affected by room air being entrained into the clean zone of the UCV system. Systems can be checked by “seeding” the air outside the partial walls with particles and checking for their penetration into the sterile zone. This should be under non-surgical conditions but with equipment in place.

5.30 A DOP generator should be set up so that particles are seeded outside the UCV system. The final choice of test challenge and detection system must take account of the final filter so that the seeded particles are not recirculated by the system so that the detection instrument is swamped. The four sides of the UCV system at the higher level of the partial wall are recommended positions for seeding and at the lower level for measuring the challenge. The particle penetration should be measured 1 m above floor level at the grid locations shown in Figure 1.

5.31 Particle count readings should be taken at the filter face in order to give a background count. Using this background count, the penetration of the particles should be practically zero at the centre, less than 1% in the periphery of the 1.8 m zone and less than 10% in the rest of the outer area of the clean zone.

NOTE: During the above tests, prolonged exposure of the filters to the challenge aerosol should be avoided.

Bacteriological sampling

General ventilation systems

5.32 Bacteriological sampling will not normally be required for either general or local exhaust ventilation (LEV) systems unless otherwise specified.

Operating rooms

5.33 The level of airborne bacteria introduced by the supply air can be checked by closing all doors and leaving the operating room empty with the ventilation system running for one hour, after which a bacterial sampler mounted on the operating table should be activated remotely. Aerobic cultures on non-selective medium should not exceed 35 bacterial and/or fungal particles per cubic metre of ventilating air.

5.34 The results should be examined to establish the broad category of organisms present. A high preponderance of fungal organisms may be an indication of inadequate filtration for the particular installation.

NOTE: Precise guidance is inappropriate and will depend on local circumstances.

5.35 A check of airborne bacteria during a surgical operation should be carried out as soon as possible after handover. Unless there are unusually high numbers of personnel or extensive activity in the room, the number of airborne bacterial and/or fungal CFUs averaged over any five minute period, should not exceed 180 per cubic metre. This work should be carried out by the nominated infection control officer or consultant microbiologist if not the same person.

Ultra-clean systems

5.36 The installation should be tested during surgical procedure at intervals between the time of first incision and final closure of the wound. A test grid is shown in Figure 1. This test should be performed by a microbiologist using the technique described by Whyte, Lidwell, Lowbury and Blowers (1983). The following minimum performance requirement should be obtained:

a. air leaving the diffuser or final filters should contain not more than 0.5 CFUs/m^3 of air. If the air filters have been tested after installation by a particle penetration test, this test is not necessary;

b. air sampled close to the wound site during operations, that is within 300 mm of the wound should on average, contain less than 10 CFUs/m^3 of

air using conventional cotton clothes. Levels less than 1 CFU/m^3 can be expected when using occlusive clothing or body exhaust systems;

c. air sampled at the perimeter of the clean zone during surgery should contain not more than 20 CFUs/m^3 using conventional clothing and levels less than 10 CFUs/m^3 when using occlusive clothing or body exhaust systems.

Microbiological safety cabinets

5.37 The complete installation must be tested using the methods set out in BS EN 12469: 2000: 'Biotechnology. Performance criteria for microbiological safety cabinets'.

6. Handover procedure

Design information

6.1 The information provided by the designer should include:

a. schematic diagrams of air distribution systems;

b. schedules of test points, dampers, plant items, control sensors, grilles, diffusers and air transfer devices;

c. schematic diagrams of the control systems marked with the set points;

d. a statement of the design intent and psychrometric charts marked with the design conditions.

Commissioning data

6.2 Details of the design and actual performance, the layout of the installed system and its correct and safe operation must be collected together and handed over to the client. A minimum list of the records required after commissioning is given below:

a. a record of the ductwork leakage tests taken during installation;

b. external wet and dry bulb temperatures;

c. internal wet and dry bulb temperatures for each room;

d. details of any simulated heat gains and losses;

e. wet and dry bulb temperatures recorded on both sides of each heater, cooler, humidifier and at the main supply duct from the plant;

f. air flow rate at plant inlet, main supply duct, main extract duct and extract discharge;

g. air flow rate at each supply and extract grille with all doors closed and the air flow through door grilles;

h. air flow direction across each open doorway and a record of any contraflows;

i. pressure recordings in rooms, on both sides of all plant components and a record kept of the external wind speed and direction;

j. the measured response to an increase in set conditions initiated from the room control panel (if fitted);

k. main fan and motor speeds, and power consumption when plant is “on” and “set back”;

l. flow and return temperatures and flow rates of the medium to heater and cooler batteries;

m. results of a simulation of “replace filter” and “low air flow” alarms;

n. temperature differences across doorways where trimmer heater batteries are installed to limit the difference in temperature (for example, between a preparation room and operating room in a theatre suite);

o. noise readings as defined in paragraphs 5.18 to 5.24;

p. details of tests on ancillary plant and installations.

Acceptance checks

6.3 Before accepting the installation the following should be witnessed by the client's officer who will become directly responsible for the operational management and routine maintenance of the plant:

a. that air leakage test certificates are satisfactory;

b. that insulation is applied and complete;

c. that all ductwork is identified to Model Engineering Specification C82 (BS 1710);

d. that fire damper locations are marked;

e. that fire dampers are operated and reset;

f. that grilles, diffusers, pressure relief dampers and pressure stabilisers are uniquely identified;

g. that registers and volume control dampers are locked and tamper-proof;

h. that battery pipework is lagged and identified to Model Engineering Specification C82 (BS 1710);

i. that water regulating valves are locked at design flow position;

j. that filters are clean and fitted with the manometers marked with clean and dirty filter differential pressure;

k. that duct lights operate;

l. that water seals to the drains are satisfactory and the normal level is clearly marked;

m. that the humidifier and cooler battery/cooling coil have been disinfected in accordance with the procedure set out in Appendix 1;

n. that the plant starts, runs, sets back, restarts and stops in accordance with the control schedule;

o. that the supply and extract automatic dampers operate;

p. that the manual plant isolating damper operates.

Schematic drawings showing the layout of the air-conditioning plant, air distribution system and the control scheme have been provided, suitably framed in the plantroom adjacent to the plant. An additional copy should be included in the commissioning manual.

A simple description of the design intent, inside and outside (winter and summer) design conditions together with instructions on the plant's mode of operation has been provided, suitably framed in the plantroom adjacent to the plant. An additional copy should be included in the commissioning manual.

The commissioning manual is available and contains the information specified in Appendix 2.

Operational procedures

6.4 The following operational procedures will need to be defined at the time that the plant is handed over and taken into use. The procedures may need to be modified in the light of experience gained in the actual operation of the plant:

a. the safe plant start, run, set back, restart and stop procedures including minimum run up times to achieve desired operating conditions;

b. the frost protection sequence;

c. the condensation protection sequence, if required;

d. the arrangements to protect the plant and prevent it becoming a source of infection if it is not to be taken into immediate beneficial use.

Maintenance routines

6.5 In order that the installation can be properly maintained and operated, it is essential that users are provided with the following basic information:

a. "as fitted" drawings;

b. plant information manuals containing manufacturers' manuals and operating instructions;

c. commissioning manuals listing the results of commissioning tests as detailed in Chapter 5 and containing the information specified in Appendix 2;

d. any special tools and spare parts.

In addition, schedules of routine maintenance activities, suggested spares lists and operational information should be prepared.

6.6 The frequency of any particular maintenance activity and the need for planned preventative maintenance can only be finally determined after monitoring the plant in operation.

Training

Service and maintenance staff

6.7 The personnel actually charged with operating the plant should be trained in its operation and any special maintenance activities demonstrated. The training should draw attention to any hazards arising due to the maintenance activities.

User staff

6.8 It is recommended that at the conclusion of commissioning, the plant and its operation should be explained to the users.

6.9 In the case of operating departments the surgeon(s) in particular will need to have an understanding of how the plant provides the conditions that they require. In turn the theatre operating department's users' committee should be encouraged to follow the recommendation of making one person, possibly the operating department's manager, responsible for adjustment to achieve working environmental conditions. When an UCV 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. The correct operation of this system should be demonstrated to the user and a warning notice included on the control panel (see paragraphs 5.13–5.17).

6.10 Laboratories may have specific requirements with regard to the number of plants that should be on at any one time. There may also be restrictions on the permissible combination of safety cabinets and fume cupboards that can be used simultaneously. Where this is the case the staff must be informed and the correct operation of the system(s) demonstrated to them. Warning and explanatory notices should be fixed adjacent to the equipment to which they refer. Any hazards arising from the incorrect operation of the system should be stated on the safety notices and explained to the users.

Guarantee period

6.11 Any defects or deficiencies appearing within the guarantee period should be brought to the attention of the main contractor.

Design in use study

6.12 A design in use study should be undertaken after the plant has been in operation for a year. The designer, installer, commissioning team, plant maintenance manager and a representative of the user department's staff should meet to discuss the way that the plant has met the original expectations.

Appendix 1

Disinfection

Prior to practical completion and again immediately prior to handover, (if these events are not concurrent), all humidifiers and cooler batteries/cooling coils should be disinfected. Those carrying out the work shall produce dated certification that it has been completed. The disinfection procedure is given below;

a. all procedures should comply with the Health and Safety at Work etc Act and COSHH regulations;

b. notify all persons working in those areas served by the plant to be disinfected;

c. switch off all ventilation systems containing the devices to be disinfected;

d. close the plant isolating dampers;

e. open and remove the inspection covers/access doors on both sides of the devices;

f. spray all internal surfaces of the humidifier section or cooler battery/cooling coil with a 5 ppm chlorine solution until all surfaces are thoroughly wetted; also flood drip-trays and the drainage system with the same solution and allow to stand for a minimum of two hours;

g. spray all internal surfaces of the humidifier and cooler battery/cooling coil with sufficient clean water to remove all traces of the chlorine solution from the device, its drip-tray and drainage system;

h. restore the plant to normal operation;

i. immediately before practical completion the microbiologist should be requested to take swab tests from all drain trays and cooler battery/cooling coil tubes and fins;

j. **as an alternative to steps (f) and (g) detailed above, the surfaces may be steam cleaned;**

k. a record must be kept of who carried out the disinfection procedure, when it was completed and the method used.

Appendix 2

Plant handover information

General

1. 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 air flows from all outlets together with the design and actual air flows 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 must 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 must 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. 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;

   f. manufacturers' operating instructions and “setting to work” guidance for all specialist components incorporated in the systems;

   g. a schematic diagram of the control system showing the location of all of the plant monitoring and control sensors;

   h. control algorithm(s) of the actual plant operation.

Plant design information

2. 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;

      (i) winter outside design temperature in °Cdb;

      (ii) winter outside design humidity in % saturation;

      (iii) winter room supply air design temperature in °Cdb;

      (iv) winter room supply air design humidity in % saturation;

      (v) winter inside design temperature for each room in °C;

      (vi) winter inside design humidity for each room in % saturation;

      (vii) summer outside design temperature in °Cdb;

      (viii) summer outside design humidity in % saturation;

      (ix) summer room supply air design temperature in °Cdb;

      (x) summer room supply air design humidity in % saturation;

      (xi) summer inside design temperature for each room in °C;

      (xii) summer inside design humidity for each room in % saturation.

   c. winter psychrometric chart showing the condition of the air between all items of plant and the design outside, supply and room air conditions;

   d. summer psychrometric chart showing the condition of the air between all items of plant and the design outside, supply and room air conditions;

   e. the design mass air flow rate used to size the plant in kg/s;

   f. the design volumetric flow rate in m^3/s.

Individual equipment information

Heater batteries including heat recovery

3. The following information concerning heater batteries is required at plant handover:

   a. the size of the battery and number of passes;
   b. the design flow and return temperatures and flow rate in l/s if LP or MPHW;
   c. the pressure drop across the water side of the battery in Pa;
   d. the supply pressure and mass flow rate if steam;
   e. the number of phases, supply voltage, current drawn and number of steps if electric;
   f. the maximum rated capacity of the battery and actual design rating in kW;
   g. the design and actual face velocity in m/s;
   h. the pressure drop across the air side of the battery in Pa;
   i. the design on and off coil air temperature and humidity at winter and summer design conditions.

Cooler batteries/cooling coils

4. The following information concerning cooler batteries/cooling coils is required at plant handover:

   a. the size of the battery and number of passes;
   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 battery in Pa;
   d. the supply pressure and mass flow rate if direct expansion;
   e. the maximum rated capacity of the battery 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 battery in Pa;
   j. the design on and off coil air temperature and humidity at summer design conditions.

Humidifiers

5. 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 pressure drop across the air side of the humidifier in Pa;
   g. the design upstream and downstream air temperature and humidity at winter design conditions.

Filters

6. The following information concerning filters is required at plant handover:

   a. the size of the filter and number in bank;
   b. its Eurovent grade;
   c. the dust holding capacity in kg;
   d. the design and actual face velocity in m/s;
   e. the initial pressure drop across the filter when clean in Pa;
   f. the final pressure drop across the filter when dirty in Pa;
   g. the design upstream air temperature and humidity at winter and summer design conditions;
   h. the manufacturer's name and filter identification code.

Fans

7. The following Information concerning fans is required at plant handover:

   a. the size of the fan and its type;
   b. speed and direction of rotation;
   c. the drive details, belt and pulley sizes;
   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;
   i. the design on and off fan air temperature and humidity at winter and summer design conditions.

Attenuators

8. 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);
   e. the downstream sound level in dB(A);
   f. the design upstream air temperature and humidity at winter and summer design conditions.

Appendix 3: Abbreviations

BS	British Standards
°C	Degree Celsius
CIBSE	Chartered Institute of Building Services Engineers
CFU/m^3	Colony forming units per cubic metre
db	Dry bulb
dB(A)	Decibel
DIN	German Standard
DOP	Dispersed oil particles
EBME	Electro Biomedical Equipment
HEPA	High Efficiency Particulate Air
HMSO	Her Majesty's Stationary Office
HSE	Health and Safety Executive
HVCA	Heating and Ventilating Contractors Association
Hz	Hertz
kg	kilogram
kg/s	kilogram/second
kW	kilowatt
LEV	Local exhaust ventilation
LP	low pressure
l/s	litres per second
L_{10}	logarithm to the base ten
m	metre(s)
MPHW	medium pressure hot water
mm	millimetre(s)
m/s	metre(s) per second
m^3/s	cubic metre(s) per second
Pa	Pascal
P&EF	Property and Environment Forum
SHTM	Scottish Health Technical Memorandum
SHTN	Scottish Health Technical Note
SHPN	Scottish Health Planning Note
SI	Statutory Instrument
UCV	Ultra clean ventilation
WRc	Water Research Centre

References

NOTE:
Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
Acts and Regulations				
	Building (Scotland) Act	HMSO	1959	
	Clean Air Act	HMSO	1993	
	Electricity Act	HMSO	1989	
	Health and Safety at Work etc Act	HMSO	1974	
	Registered Establishments (Scotland) Act	HMSO	1998	
	Water (Scotland) Act	HMSO	1980	
SI 2179 & 187	The Building Standards (Scotland) Regulations (as amended)	HMSO	1990	
	Building Standards (Scotland) Regulations: Technical Standards Guidance	HMSO	1998	
SI 1460	Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP2)	HMSO	1997	
SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
SI 437	Control of Substances Hazardous to Health Regulations (COSHH)	HMSO	1999	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd 1994)	
SI 635	Electricity at Work Regulations	HMSO	1989	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	
SI 2792	Health and Safety (Display Screen Equipment) Regulations	HMSO	1992	
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	
SI 682	Health & Safety (Information for Employees) Regulations	HMSO	1989	

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
SI 1380	Health and Safety (Training for Employment) Regulations	HMSO	1990	
SI 341	Health and Safety (Safety Signs and Signals) Regulations	HMSO	1996	
SI 2307	Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)	HMSO	1998	
SI 2793	Manual Handling Operations Regulations	HMSO	1992	
SI 3242	Management of Health and Safety at Work Regulations	HMSO	1999	
SI 1790	Noise at Work Regulations	HMSO	1989	
SI 3139	Personal Protective Equipment (EC Directive) Regulations (as amended)	HMSO	1992	
SI 2966	Personal Protective Equipment at Work (PPE) Regulations	HMSO	1992	
SI 128	Pressure Systems Safety Regulations (PSSR)	HMSO	2000	
SI 2306	Provision and Use of Work Equipment Regulations (PUWER)	HMSO	1998	
SI 3163	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	HMSO	1995	
SI 3004	Workplace (Health, Safety and Welfare) Regulation	HMSO	1992	
British Standards				
BS 848	**Part 1:** Fans for general purpose performance testing using standardized airways	BSI Standards	1997	
BS 1710	**Specification for identification of pipelines and services**	BSI Standards	1984	
BS 3928	**Method for sodium flame test for air filters (other than for air supply to I.C. engines and compressors)**	BSI Standards	1969	
BS 4533	**Luminaires. Particular requirements. (Relevant parts)**	BSI Standards		
BS 4718	**Methods of tests for silencers in air distribution systems**	BSI Standards	1971	
BS 4979	**Methods for aerodynamic testing of constant and variable dual or single duct boxes**	BSI Standards	1986	
BS 5295	**Environmental cleanliness in enclosed spaces** **Parts 1 & 2**	BSI Standards	1989	

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
BS 5410	**Code of practice for oil firing. Installations of 44kW and above capacity for space heating, hot water and steam supply purposes** **Part 2**	BSI Standards	1978	
BS 5440	**Installation of flues and ventilation for gas appliances**	BSI Standards	1990	
BS 5588	**Fire precautions in the design, construction and use of buildings** **Part 9:** Code of practice for ventilation and air-conditioning ductwork	BSI Standards	1999	
BS 5720	**Code of practice for mechanical ventilation and air-conditioning in buildings**	BSI Standards	1979	
BS 5726	**Microbiological Safety Cabinets** **Part 1:** Specification for design construction and performance	BSI Standards	1992	
BS 5726	**Microbiological safety cabinets.** **Part 4:** Recommendation for selection, use and maintenance	BSI Standards	1992	
BS 6281	**Devices without moving parts for the prevention of contamination of water by backflow** **Part 1:** Specification for type A gaps for inlet or feed pipes.	BSI Standards	1992	
BS 6798	**Specification for installation of gas-fired boilers of rated input not exceeding 70 kW net**	BSI Standards	2000	
BS 7258	**Laboratory Fume Cupboards** **Parts 1 & 2**	BSI Standards	1994	
BS 7258	**Laboratory fume cupboards.** **Part 3:** Recommendations for selection, use and maintenance	BSI Standards	1994	
BS 8313	**Code of practice for accommodation of building services in ducts**	BSI Standards	1997	
BS EN 255	**Air conditioners liquid chilling packages and heat pumps with electrically driven compressors**	BSI Standards	1997	
BS EN 12469	**Biotechnology. Performance Criteria for microbiological safety cabinets**	BSI Standards	2000	
BS EN 60651	**Specification for sound level meters**	BSI Standards	1994	

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
PO 6609	**Insitu aerosol testing of HEPA filtration- an explanatory supplement to BS 5295 Part 1**	BSI Standards	1996	
Scottish Health Technical Guidance				
SHTM 2005	Building management systems	P&EFEx	2001	CD-ROM
SHTM 2007	Electrical services supply and distribution	P&EFEx	2001	CD-ROM
SHTM 2011	Emergency electrical services	P&EFEx	2001	CD-ROM
SHTM 2020	Electrical safety code for low voltage systems (Escode – LV)	P&EFEx	2001	CD-ROM
SHTM 2023	Access and accommodation for engineering services	P&EFEx	2001	CD-ROM
SHTM 2040	Control of legionellae in healthcare premises – a code of practice	P&EFEx	2001	CD-ROM
SHTM 2045	Acoustics	P&EFEx	2001	CD-ROM
SHPN 1	Health service building in Scotland	HMSO	1991	
SHPN 2	Hospital briefing and operational policy	HMSO	1993	
SHTN 1	Post commissioning documentation for health buildings in Scotland	HMSO	1993	
SHTN 4	General Purposes Estates and Facilities Model Safety Permit-to-Work System	EEF	1997	
	NHS in Scotland – PROCODE	P&EFEx	2001	Version 1.1
NHS in Scotland Firecode				
SHTM 81	Fire precautions in new hospitals	P&EFEx	1999	CD-ROM
SHTM 82	Alarm and detection systems	P&EFEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises: general fire precautions	P&EFEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EFEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EFEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EFEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EFEx	1999	CD-ROM
SFPN 3	Escape bed lifts	P&EFEx	1999	CD-ROM
SFPN 4	Hospital main kitchens	P&EFEx	1999	CD-ROM
SFPN 5	Commercial enterprises on hospital premises	P&EFEx	1999	CD-ROM
SFPN 6	Arson prevention and control in NHS healthcare premises	P&EFEx	1999	CD-ROM
SFPN 7	Fire precautions in patient hotels	P&EFEx	1999	CD-ROM

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
SFPN 10	Laboratories on hospital premises	P&EFEx	1999	CD-ROM
Health and Safety Publications				
EH 40	HSE Occupational Exposure limits	HSE	Annual	
MES	Model Engineering Specifications	NHS Estates	1997	As required
Miscellaneous References				
	Buffalo Forge Co. Fan Engineering	Buffalo Forge Co. Woods		
	CIBSE Guides and Commissioning Codes, A, W and R	CIBSE	1986	
	HVCA: Specification for sheet metal ductwork	HVCA		
DW/143	Ductwork leakage testing			
DW/TM2	Cleanliness of new ductwork			
CM0101	HVCA: Standard maintenance specification for mechanical services in buildings: CM0101 Volume 1 Heating and Pipework Services Volume 2 Ventilating and Air Conditioning Volume 3 Control, energy and building management systems Volume 4 Ancillaries, plumbing and sewerage Volume 5 Electrics in buildings	HVCA		
	Model Water Byelaws: Dept. of the Environment	HMSO	1986	
	Water Supplies Byelaws Guide	WRC		