Department for Education

Technical Annex 2F: Mechanical Services and Public Health Engineering

Output Specification

May 2020

Contents

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Summary

This document is one of a number of Technical Annexes which form part of the Generic Design Brief (GDB)

Review Date

The next planned review date for this document is November 2020.

Who is this publication for?

This document is for technical professionals involved in the design and construction of school premises, to use as part of the Employer's Requirements of the DfE Construction Framework. It may also be used as the basis of similar documentation for other procurement routes using the Output Specification.

Document Updates

- **Version 9**: May 2020 - Amendments to natural ventilation and ventilation systems; pipework; water storage and temperature monitoring; underground drainage; and fume cupboards.
- **Version 8.0**: May 2019 - Revised to incorporate end user feedback, evidence collected and updates to applicable standards.
- **Version: 7.0**: November 2017 - Issued as OS 2017.
- **Versions 1-6**: July 2016 - November 2017 - Includes initial working towards OS 2017.

1. Introduction

1.1. This document is one of a number of Technical Annexes which form part of the Generic Design Brief (GDB). It sets out the required technical standards and performance criteria for mechanical services and public health engineering in schools and shall be read in conjunction with the GDB, in particular Sections 2.9 and 2.11, and the other Technical Annexes to the Generic Design Brief, as well as the School-Specific Brief (SSB), including the School-Specific Schedule of Accommodation (SoA), School-Specific Area Data Sheets (ADSs) and, where relevant, the Refurbishment Scope of Works (RSoW). The definitions in paragraph 1.3 of the GDB apply to this Technical Annex and all other parts of the OS.

1.2. The information exchange required at each stage of the procurement process is detailed in the Employer's Requirements Deliverables.

1.3. The requirements in this Technical Annex are in respect of Buildings, FF&E and ICT Infrastructure and shall apply to all parts of the Works in any New Buildings, as well as to Building Elements or Building Services provided in Refurbished Building(s) which are designated Renewed or Replaced in the RSoW.

1.4. Where the requirements refer to an area, space or Suite of Spaces, this shall apply to all spaces in any New Building(s) or Remodelled Area. Any area or space within New Buildings or Remodelled Area shall conform to all relevant requirements in this Technical Annex.

2. Common Requirements

2.1. Overview

2.1.1. This section outlines the requirements which are common between mechanical, and public health engineering services, in particular requirements for pipework, pumps, valves and other pipework fittings.

2.2. Refurbishment

2.2.1. As described in the GDB, any work required to Refurbished Buildings shall be as defined in the RSoW under the headings of architectural elements (including FF&E) and M&E elements, including ICT Infrastructure. The work will be categorised as Renewed, Replaced, Repaired, Retained or have 'No work':

a) Any **Renewed** mechanical services or PHE shall be designed to satisfy the relevant outputs of the GDB and this Technical Annex (and by the code in the ADS where relevant)

b) Any **Replaced** mechanical services or PHE shall satisfy the relevant outputs of the GDB and this Technical Annex (and by the code in the ADS where relevant), as far as possible within the constraints of the location, the adjacent elements and the sub-structure

c) Any **Repaired** mechanical services or PHE shall comply with the specifications in any project-specific drawing issued as part of the SchoolSpecific Brief, and the overall performance after repair shall be at least as good as that of the existing provision

d) Any **Retained** mechanical services or PHE shall be left as existing, with minimal work required unless needed in order to complete other Works that form part of the project, and the overall performance shall be no worse than the existing performance

e) Any element requiring '**No work'** shall be left as existing.

2.2.2. Subject to paragraphs 1.3 and 1.4 in this Technical Annex and Section 1.5 in the GDB, in respect of work to Refurbished Buildings, the required level of compliance with this Technical Annex is set out in the RSoW.

2.2.3. Generally, the requirements in this Technical Annex refer to all parts of the Works except any building elements or services that are designated Repaired, Retained or ‘no work’ in the RSoW, or spaces designated ‘Untouched’ in the School-Specific SoA.

2.2.4. Any Repaired or Retained elements shall conform to any regulations, British and European standards and policies relevant to existing provision at the time of original installation, in accordance with the system type.

2.2.5. Existing heating systems shall be flushed and cleaned in accordance with BSRIA pre-commissioning cleaning guidance before connection of new heating plant and pipework.

2.2.6. Where new boiler plant is installed, the boiler primary heating circuit shall be hydraulically isolated from existing steel pipework via a plate heat exchanger.

2.2.7. Services and items such as radiators shall be co-ordinated with FF&E and ceiling layouts. Co-ordination drawings shall be provided as detailed in the Employer’s Requirements Deliverables.

2.2.8. Services shall be integrated with existing site-wide systems as far as possible, for example, security, fire alarm, external lighting and building energy management systems.

3. Pipework

3.1. General Requirements

3.1.1. This section covers the common criteria for any pipework across low temperature hot water (LTHW), domestic hot and cold-water systems and sprinkler installations.

3.1.2. The Contractor shall ensure that the following requirements are met.

a) All pipework, insulated or otherwise, is identified in accordance with BS 1710 using adhesive colour bands. All visible pipework is finished in gloss paint to match the interior decoration

b) All pipework is suitably insulated. The insulating materials have a Global Warming Potential (GWP) of zero. Mineral wool pipe section insulation is installed in line with BS 3958-4 and BS 5422. Loadbearing pipeline supports are insulated. Insulation within plant room is protected with aluminium sheet

c) LTHW and domestic services distribution pipework and drainage are not routed in COMMs rooms, server rooms and electrical plant rooms

d) Disinfection and water quality tests for hot and cold water systems comply with BS EN 806-4. Inspection and test records for water systems are in accordance with BSRIA BG 2/2010

e) Pipework is free from leaks and the audible effects of expansion, vibration and water hammer

f) The pipework is installed to prevent electrolytic corrosion from the use of dissimilar metals. Pipeline fittings are regularly spaced along pipeline runs and at items of equipment and anchors are be installed to resist axial stress transmitted by flexure of horizontal and vertical pipe runs and loading on vertical pipes. Fixings are provided with associated backing plates, nuts, washers and bolts for attachment to, or building into building structure

g) Inspection and testing of pipelines are in accordance with HSE GS 4 and at 1.5 times normal working pressure

h) All copper water pipelines are installed in line with BS EN 1057. Copper fittings, joining materials and supports are provided in line with British Standards. Copper pipework is not used where it can be damaged

i) Pre-soldered capillary fittings are lead free copper or copper alloy (such as tin/copper) complying with BS EN 1254

j) Any screwed joints to valves, gauges, and the like are to BS EN 10226-1, BS EN 10226-2 and BS EN 10226-3 using PTFE tape to BS 7786

k) Maintenance joints in pipework up to and including 54mm nominal size are copper alloy union couplings, bronze to bronze navy pattern. Flanged maintenance joints are used in pipework of nominal sizes greater than 54mm. Flanges are solid full-face copper alloy, slip-on type suitable for brazing, complying with BS 4504: PN10 or BS EN 1092 as appropriate

l) Flanges used for connections to flanged equipment valves, and the like are match flanges provided on the equipment. All flanged joints are made with full face rubber insertion jointing rings to BS 7874 or BS EN 681 and BS EN 682 as appropriate, brass nuts, bolts and washers, complying with the requirements of the same British Standard and pressure rating or table as the flanges being connected.

m) Flexible connections shall be avoided. They shall not be used on classroom ventilation units, wash-hand basins and sink taps. Basin taps shall be fitted with solid copper connections and double brass or copper backnuts to lock the taps in place. Plastic backnuts shall not be used on basins or sinks.

3.2. LTHW Pipework

3.2.1. The Contractor shall ensure that, in all low temperature hot water (LTHW) systems provided meet the following requirements:

a) The main heating distribution pipework is routed such that it is concealed throughout, except for final drops to heat emitters. Pipework, valves and ancillaries are accessible for maintenance

b) Pipework drops and horizontal runs on Low Surface Temperature (LST) pipework are concealed or inaacessible

c) The main heating pipework is run in corridors at high level and branches off to serve individual rooms

d) Wherever possible pipework runs at high level and drops to low level to connect to heat emitters as required. This does not preclude emitters being served from below in the event that this is the optimum route. Where it is proposed to serve emitters from below this shall be approved by the Employer

e) All distribution pipework is installed with drain down and isolating valves, to allow the system to be drained in its entirety

f) Automatic air vents are provided at the top of all risers and on high points within the system. Pipework is laid to fall wherever possible to minimise the number of high points

g) Pipework is installed to allow easy self-venting and commissioning. The flushing of hot and cold water systems complies with BS EN 806-4

h) Any concealed underfloor heating system pipework is pressure tested and witnessed before any final floor covering is applied

i) All indoor AC units and DX coils are fitted with a condensate drain. Condensate wastes shall be connected to the main drainage system via a running trap in a waste guaranteed to carry waste regularly.

3.3. Domestic Hot and Cold-Water Systems

3.3.1. Domestic hot and cold water shall be provided to toilets, changing rooms and showers, kitchens and food rooms and cleaners’ stores which have sinks.

3.4. Domestic Hot and Cold-Water Pipework

3.4.1. The Contractor shall ensure that, for any domestic hot and cold-water pipework provided, the following requirements are met:

a) All distribution pipework is installed with drain down valves to allow the system to be drained in its entirety. Automatic air vents are provided at the top of all risers and on high points within the system. Pipework is laid to falls wherever possible to minimise the number of high points and installed to allow easy selfventing and commissioning

b) The design and detailing of hot and cold-water systems complies with BS 8558 and BS EN 806-2 and in accordance with HSE publication ‘The control of legionella bacteria in water systems approved code of practice and guidance’, L8

c) The domestic hot water supply system incorporates the facility to pasteurise the system during periods when there is little or no use to prevent the growth of legionella within the system

d) Calorifiers have de-stratification pumps

e) The cold water supply is in line with BS 8558, BS EN 806-2

f) The pipeline sizes for hot and cold water systems are calculated to meet simultaneous demand for the building in accordance with BS EN 806-3

g) Pipe sleeves comply with BS EN 1057

h) Pressure-relief discharge pipework from electric water heaters is taken to drain.

3.4.2. Installation, hydraulic pressure testing, flushing and commissioning shall be in accordance with BS 8558, BS EN 806-4, BSRIA BG 2/2010 and CIBSE Commissioning Code W. Sample points shall be at the main supply to CAT5 tanks; hot water storage cylinders; and cold-water storage tanks.

3.4.3. As detailed in the Employer's Requirements Deliverables, the Contractor shall produce the following:

a) In conjunction with the School, a legionella risk assessment and management scheme for controlling the risk of exposure to legionella bacteria in accordance with HSE approved code of practice L8: 'Legionnaires' disease. The control of legionella bacteria in water systems'

b) A Water Quality Policy document setting out the guidance and strategy that will be followed to protect staff, pupils and visitors against the risk of legionella infection. It shall include the framework of the procedures designed to achieve this aim. It shall specify the management, operational and specialist responsibilities and lay down a clear management and communication structure to ensure that it is fail-safe.

3.5. Fuel Pipework

3.5.1. The Contractor shall ensure that gas pipework is installed in accordance with the Gas Safety (Installation and Use) Regulations 1998 and the requirements of BS 6891 and IGEM standards including IGEM/UP/11, IGEM/UP/2.

3.6. Refrigerant Pipework

3.6.1. The Contractor shall ensure that all refrigerant pipework is installed in accordance with F-Gas Regulations 842/2008 which provides detailed requirements for refrigerant containment. Installation shall be undertaken in accordance with IoR 'Commercial System Installation Guide – 2009' – Part 4 System Installation.

3.6.2. Copper tube shall comply with BS EN 12735-1.

3.6.3. Steel and stainless-steel pipework shall conform to the requirements of BS EN 14276 – 2.

3.6.4. Insulation on external refrigeration pipework shall be UV resistant and shall be clad in metal or rigid UV resistant plastic to prevent damage, e.g. by birds.

3.7. Reference Standards for Pipework

3.7.1. The Contractor shall ensure that the design and installation of any pipework provided in LTHW, and domestic hot and cold-water systems and sprinkler installations complies with the relevant parts of the following standards (or updated documents if relevant).

3.7.2. All pipework:

1. BS 1710 – 'Specification for identification of pipelines and services'

2. BS 3958-4 – 'Thermal insulating materials. Bonded preformed man-made mineral fibre pipe sections'

3. BS 5422 – 'Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C'

4. BS 8558 – 'Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages'. Complementary guidance to BS EN 806

5. BS EN 806 – 'Specifications for installations inside buildings conveying water for human consumption. Installation'

6. BSRIA BG 2/2010 – 'Commissioning water systems'

7. CIBSE Commissioning Code W – 'Water distribution systems'

8. HSE GS 4 – 'Safety in pressure testing'

9. BS EN 1057 – 'Copper and copper alloys - seamless, round copper tubes for water and gas in sanitary and heating applications' (+A1:2010)

3.7.3. LTHW pipework:

1. BSRIA BG 50/2013 – 'Water treatment for closed heating and cooling systems'

2. BS 6880-3 – 'Code of practice for low temperature hot water heating systems of output greater than 45 kW: Part 3 Installation'

3. BS EN 14336 – 'Heating systems in buildings. Installation and commissioning of water-based heating systems'

3.7.4. Domestic Hot and cold-water pipework:

1. HSE publication, L8 – 'Legionnaires' disease, the control of legionella bacteria in water systems approved code of practice and guidance'

2. BS EN 806-3 – 'Specifications for installations inside buildings conveying water for human consumption. Pipe sizing. Simplified method'

3. WRAS approved fittings from the WRAS Products and Materials Directory available online at WRAS https://www.wras.co.uk/search/products/

4. Water Supply (Water Quality) Regulations 2016

3.7.5. Fuel Pipework:

1. BS 6891 'Specification for the installation and maintenance of low-pressure gas installation pipework of up to 35mm (R11/4) on premises'

2. IGEM/UP/2 'Installation pipework on industrial and commercial premises'

3.7.6. Refrigeration Pipework:

1. BS EN 12735-1 – 'Copper and copper alloys - Seamless, round copper tubes for air conditioning and refrigeration Part 1: Tubes for piping systems'

2. BS EN 14276-2 – 'Pressure equipment for refrigerating systems and heat pumps - Part 2: Piping - General requirements'

3.8. Pumps

3.8.1. LTHW Pumps

3.8.1.1. The Contractor shall ensure that all LTHW pump sets provided shall be twin-head or in parallel configuration arranged for auto changeover and duty rotation. Each pump set shall have hand/auto/off local control.

3.8.2. Domestic Hot and Cold-Water Pumps

3.8.2.1. Where there is sufficient mains water pressure a direct mains water supply can be used in accordance with appropriate and current Water Regulations Advisory Scheme (WRAS) regulations and guidance. Where there is insufficient water pressure and/or supply rate a boosted cold-water supply shall be provided.

3.8.2.2. Where required, the potable water supply shall be boosted from a tank to domestic water outlets via a WRAS approved domestic water booster set. The boosted potable cold-water service will be distributed through the School Building via ceiling level/voids and dedicated service risers to serve sanitary appliances and equipment.

3.8.3. Reference Standards for Pumps

3.8.3.1. The Contractor shall ensure that the design and installation of any pumps provided complies with the relevant parts of the following standards (or updated documents if relevant):

1. BS ISO 2953 – 'Mechanical vibration. Balancing machines. Description and evaluation'

2. BS EN ISO 9906 – 'Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3'

3. BS EN ISO 5198 – 'Centrifugal, mixed flow and axial pumps. Code for hydraulic performance tests. Precision class'

4. BS EN 16297-1:2012 – 'Pumps. Rotodynamic pumps. Glandless circulators. General requirements and procedures for testing and calculation of energy efficiency index (EEI)'

5. BS EN 16297-2:2012 – 'Pumps. Rotodynamic pumps. Glandless circulators. Calculation of energy efficiency index (EEI) for standalone circulators'

6. BS EN 16644:2014 – ‘Pumps. Rotodynamic pumps. Glandless circulators having a rated power input not exceeding 200 W for heating installations and domestic hot water installations. Noise test code (vibro-acoustics) for measuring structure- and fluid-borne noise’

3.9. Valves, Fittings and Components

3.9.1. LTHW Valves, Fittings and Components

3.9.1.1. The Contractor shall ensure that, in any LTHW valves, fittings and components provided, the following requirements are met:

a) A micro-bubble deaerator, dirt separator and strainer are installed on the common heating return pipe of all heating systems

b) Micro-bubble deaerators, dirt separators and strainers are installed on the primary and secondary heating return pipes where plate heat exchangers are installed

c) Provision for expansion/contraction of water within the system and cold-water feed is provided either by a packaged pressurisation unit with heating system quick fill facility or a feed and expansion tank

d) Quick fill units and expansion tanks are located and insulated so that they cannot easily freeze

e) Expansion vessels are adequately sized for the full water content of the circuit

f) Where a feed and expansion tank is installed, it is of sufficient capacity and in suitable condition for the proposed development

g) Heating circuit design enables flow balancing under all load conditions

h) Differential pressure control valves are provided on the heating supplies to groups of radiators in order to provide system stability and flow control

i) Isolating valves, check valves, expansion valves and double regulating valves are installed appropriately to aid commissioning, giving consideration for access and maintenance

j) Test points, temperature and pressure relief valves, temperature and pressure gauges and draining devices are provided to aid commissioning and balancing

k) Automatic air vents are provided to aid balancing in the system

l) Pipework and supports take account of axial expansion

m) Dosing pots are provided in the plant room for addition of corrosion inhibitors and other water treatment chemicals

n) Adjustable valves are provided in break tanks to allow the storage quantity to be adjusted.

3.9.2. Domestic Hot and Cold-Water System Valves, Fittings and Components

3.9.2.1. The Contractor shall ensure that, for any domestic hot and cold-water system valves, fittings and components, the following requirements are met:

a) Pressure gauges are installed in line with BS EN 837-1 and temperature gauges installed in line with BS EN 13190

b) WRAS approved pipeline strainers are installed

c) Floats for ball valves comply with BS 1968 for copper and BS 2456 for plastic. Ball valves shall be brass copper alloy

d) Lift type check valves are provided in copper alloy and in line with BS 5154

e) Thermostatic mixing valves are installed in line with BS EN 1111 TMV3. The Contractor shall ensure that thermostatic balancing valves (Type A) are installed in line with BS 7350

f) Draining taps (Type A) are installed in line with BS 2879

g) Direct hot water storage cylinders are installed in line with BS 1566-1 and shall be Kitemark certified

h) Immersion heaters are installed in line with BS EN 60335-2-73 and be BEAB Approved

i) Valve tests are conducted in line with BS EN 12266-1

j) The domestic hot and cold-water systems are provided with draw off taps and stop valves

k) Ball isolating valves and lift type check valves are provided

l) Water meters in line with BS EN 14154-1 are provided as outlined in Annex 2H: Energy and meter accessories are in line with BS EN 14154-2

m) Backflow prevention devices are provided and comply with BS EN 13959. Antipollution check valves shall comply with BS EN 14454 and hose unions shall comply with BS EN 14451 for in-line anti-vacuum valves

n) Copper alloy body, diaphragm type float operated valves are installed that comply with BS 1212-2

o) Drainage taps (type A) are installed to comply with BS 2879

p) Glass fibre reinforced tanks and cisterns are designed and installed in line with BS EN 13280 and are designed to have a minimum of one cycle per day

q) Magnetic water conditioners are provided where the calcium carbonate content of the incoming mains water supply is greater than 200mg/l or 14 on the Clark scale

r) Valves of nominal sizes, 54mm and less have ends screwed and threaded to BS EN 10266 or have capillary ends to BS 1254

s) Larger valves have flanged ends, complying with BS 4504 or BS EN 1092 as appropriate and are similar to those selected for the pipework.

3.9.3. Reference Standards for Valves, Fittings and Components

3.9.3.1. The Contractor shall ensure that the design and installation of any valves, fittings and components provided complies with the relevant parts of the following standards (or updated documents if relevant):

1. BS EN 837-1 – ‘Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing’

2. BS EN 13190 – ‘Dial thermometers’

3. BS 2456 – ‘Specification for floats (plastics) for float operated valves for cold water services’

4. BS 5154 – ‘Specification for copper alloy globe, globe stop and check, check and gate valves’

5. BS EN 1111 – ‘Sanitary tapware. Thermostatic mixing valves (PN 10). General technical specification’

6. BS 2879 – ‘Specification for draining taps (screw-down pattern)’

7. BS 1566-1 – ‘Copper indirect cylinders for domestic purposes. Open vented copper cylinders. Requirements and test methods’

8. BS EN 14154-1 – ‘Water meters. General requirements’

9. BS EN 14154-2. – ‘Water meters. Installation and conditions of use’

10. BS EN 13959. – ‘Anti-pollution check valves. DN 6 to DN 250 inclusive Family E, type A, B, C, and D’

11. BS EN 14454 – ‘Devices to prevent pollution by backflow of potable water. Hose union backflow preventer DN 15 to DN 32 inclusive. Family H, type A’

12. BS EN 10253-1 – ‘Butt-welding pipe fittings. Wrought carbon steel for general use and without specific inspection requirements’

13. BS EN 10253-2 – ‘Butt-welding pipe fittings. Non alloy and ferritic alloy steels with specific inspection requirements’

14. BS EN 10266-1 – ‘Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads’

15. BS EN 10226-2 – ‘Pipe threads where pressure tight joints are made on the threads. Taper external threads and taper internal threads’

16. BS EN 10226-3 – ‘Pipes threads where pressure-tight joints are made on the threads. Verification by means of limit gauges’

17. BS 4504 – ‘Circular flanges for pipes, valves and fittings’

18. BS EN 1092 – ‘Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories’

4. Mechanical Services

4.1. Mechanical Services Overview

4.1.1. The following sections outline the performance requirements for the mechanical building services systems and how the building and occupancy needs will be met. They include requirements for the heating, cooling and ventilation systems.

4.1.2. The Contractor's design shall meet the criteria for the temperatures, thermal comfort and ventilation rates given in this Technical Annex.

4.1.3. The Contractor shall ensure the plant room(s) and entrances/exits to the plant room(s) are designed to be large enough for the equipment to be installed, maintained and removed safely and in line with regulations.

4.2. Heating Systems

4.2.1. Overview

4.2.1.1. The following section details the requirements for the design and installation of any heating systems, including associated plant, pumps, distribution systems and emitters within Schools.

4.2.2. Heat Generating Systems and Main Plant

4.2.2.1. The DfE's preferred methods of heat generating systems for Schools are:

a) Connection to an available existing or planned heat distribution network

b) Gas fired condensing boilers

c) Low or Zero Carbon (LZC) technologies.

4.2.2.2. The Contractor may propose an alternative form of heat generating plant, but shall provide appropriate energy analysis, capital and running cost analysis and justification for the proposed system(s) e.g. oil, LPG.

4.2.2.3. The Contractor shall ensure that any heat generating system provided is designed and installed appropriately. This shall include, but not be limited to, the following.

a) Heat loss calculations

b) Main plant selection

c) Emitter selection and sizing

d) Pipework distribution design based on max velocity 1.15 m/s for pipework up to 50 mm diameter and 2 m/s for > 50 mm diameter

e) Heating system ancillaries and valve selections

f) A setback temperature of 5°C shall be used for the heating systems.

4.2.3. Operative Temperatures

4.2.3.1. The Contractor shall ensure that any heating system provided is capable of meeting the normal and maximum operative temperatures during the heating season that are listed in Table 10.2.

4.2.3.2. The Contractor shall ensure that:

a) For all pumped systems the initial stage of frost protection is to enable the pumps in the event that the internal temperature of the building drops to 5°C (this temperature shall be adjustable)

b) In the event that the temperature drops to below 2°C, (this temperature shall also be adjustable) then the second stage of frost protection commences and the heat generating plant circulates the heating medium around the system

c) In addition, trace heating is provided on systems at a higher risk to frost protection (for example systems that run externally to the building fabric or in unconditioned areas).

4.2.4. Boilers

4.2.4.1. The Contractor shall ensure that, for any boiler provided, the following requirements are met:

a) There is an adequate gas supply available for the proposed installation. The Contractor shall be responsible for all aspects of liaising with the utility supply company to provide the necessary gas connection. The gas supply shall be without the use of gas boosters wherever possible

b) Boilers are provided to give a margin to allow for maintenance; to be sized as 2 boilers at 66%; or 3 at 40%; or modular boilers sized so that N boilers provide 100% capacity and N+1 are installed

c) The burner control is modulating type in accordance with AD L and that the boilers are controlled to optimise the efficiency of the system

d) 'Weather compensation' is used to vary the boiler flow rate according to the outdoor air temperature to maximise energy saving

e) Condensing boilers make full use of the condensing mode of the boilers during part load conditions, i.e., the boilers operate with a return temperature of 50ºC, except when external temperatures require full load operation

f) The boilers have maximum NOx emissions of 40 mg/kWh unless otherwise stated in the planning application or other relevant standards documents.

4.2.4.2. The Contractor shall ensure that there is an appropriate flue provision for any boiler installation that is manufactured by a Member of the British Flue and Chimney Manufacturers Association (BFCMA). The flue shall be twin walled and insulated. The flue system shall be designed to manufacturer's recommendations and comply with the requirements of The Clean Air Act and the local planning authority.

4.2.4.3. The Contractor shall ensure that any boilers provided are located in a dedicated main plant room or purpose formed boiler room. The plant room shall be naturally ventilated, including the air required for combustion purposes, via louvres and/or louvered doors. The ventilation shall comply with the requirements of current Building Regulations, IGEM standards British Standards and UKLPG recommendations. Permanent ventilation openings at high and low level will be provided to the external wall of the boiler plant room as necessary to comply with IGEM/UP/10 and BS 6644. See also Section 9 for requirements for gas services installations.

4.2.5. Energy Networks

4.2.5.1. Where a connection to a new or existing energy network or the use of an energy centre is to be used, the Contractor shall supply, and design the associated systems to all relevant current standards and regulations.

4.2.5.2. Where the Contractor is proposing to construct an energy centre, as part of the development, then the Contractor shall ensure that it is appropriately designed and installed to allow for future developments in technology to be utilised where appropriate.

4.2.5.3. The Contractor shall use the Heat Map site to check for availability of a heat network. The Heat Map can be found at: http://tools.decc.gov.uk/nationalheatmap/

4.2.6. Low and Zero Carbon Heat Sources

4.2.6.1. Low and zero carbon (LZC) technologies may be required to comply with AD L and/or local planning requirements.

4.2.6.2. The following details the requirements for the preferred LZC technologies, as a primary or secondary heat source, within schools in the event that LZC technologies are required as part of the proposed Energy Strategy.

a) The Contractor shall establish an Energy Strategy for the site. Further details can be found in Annex 2H: 'Energy'

b) LZC sources shall be provided with sub meters for fuel input, power output and heat output

c) CHP Units shall be installed to TR/37 'Guide to good practice: installation of combined heat and power' (BESA, 2015)

d) The Contractor shall ensure that the controls to the CHP units are sequenced such that they operate as the primary heat source to ensure optimum usage and run time

e) If a ground source heat pump is selected, then the Contractor shall ensure that the geology and environmental factors are appropriate for a ground source heat pump system to be installed

f) Where an LZC technology is being proposed to provide cooling to a School, reference shall be made to Annex 2H: 'Energy.

g) The Contractor shall complete the design and installation of Biomass boiler systems to all relevant current standards and regulations including CIBSE AM15 - Biomass Heating Application Manual, 2014

h) The Contractor shall provide biomass boiler units installed in line with the manufacturer's requirements

i) The Contractor shall ensure safe, suitable and efficient fuel storage and delivery and ash handling is in place to accommodate the biomass installation

j) Where biomass is proposed, the day-to-day management of this installation must be fully discussed and agreed with the Employer and School prior to proceeding with this solution.

4.2.7. Heating Distribution Systems

4.2.7.1. In any heating distribution system provided, the Contractor shall:

a) Provide a heating distribution system based on a low temperature hot water (LTHW) system

b) Design and install a flow and return header system to separate the primary heat and secondary circuits; and include in the header system design all necessary pumps, valves and ancillaries to allow for efficient and appropriate delivery of heat throughout the School

c) Ensure a Constant Temperature (CT) secondary circuit is provided to supply any installed Air Handling Units (AHUs), Fan Coil Units (FCUs) and radiant panels; and flow and return Variable Temperature (VT) secondary circuits are provided to serve any space heater emitters, convectors, underfloor heating and radiators

d) Ensure the heating system is zoned and adequately controllable to give good thermal comfort in accordance with Section 10 and Section 2.4 of Annex 2I: ‘Controls’. The heating system shall be zoned based on zones of the building and occupational periods

e) Ensure the header arrangement is designed to achieve a constant return temperature, with the flow of the secondary circuit intentionally greater than the flow of the primary circuit to guarantee a low return temperature for condensing boilers

f) Ensure that sequencing by flow temperature is achieved and boilers are brought on-line in sequence to maintain the flow temperature

g) Ensure that temperature dilution when there are one or more off-line boilers/heat generators is avoided

h) Ensure that where biomass, CHP or heat pumps are used in conjunction with gas boilers the renewable generator is the lead heat generator

i) Ensure that, where a plate heat exchanger is installed in series with the return to a boiler house to allow a renewable source to be connected, the flow of the secondary circuit has a lower flow rate than the primary circuit to avoid temperature dilution

j) Ensure that, where a plate heat exchanger is installed in series with the return to a boiler house to allow a renewable source to be connected, the temperature drop across the plate heat exchanger is taken account of and there is a margin of several degrees above the required temperature on the secondary circuit to account for the loss

k) Ensure that heat meters are correctly installed to be accurate to 0.1°C and 0.1kg/s, and installed in accordance with manufacturers' instructions.

4.2.7.2. The Contractor shall ensure that, where retrofitting additional heating:

a) Where a load circuit is added, it has the same ΔT as the existing load circuit

b) Where boilers are Replaced, they are replaced with those designed for the existing operating load circuit ΔT

c) Whe circulating header is sized for the existing load circuit ΔT

d) The pumps are selected to be large enough for the correct ΔT

e) Insulation is considered and its effects on the load circuit flow rates and circuit ΔTs

f) The existing load circuit flow rates are measured, and the existing and proposed circuit loads are calculated to determine the spare capacity of the existing boiler plant

g) The flow rates and temperatures on existing load circuits are reviewed to identify whether they are too high and could be reduced.

4.2.8. Heating Emitters

4.2.8.1. The Contractor shall ensure that any space or area can be heated by one or more of the following emitter types:

a) Natural convectors and radiators

b) Warm air

c) Radiant heating

d) Underfloor heating

e) Forced convection fans.

4.2.8.2. Where proposing an alternative form of heat emitter where appropriate for the installation, the Contractor shall provide the Employer with detailed reasons and justification.

4.2.8.3. The Contractor shall select any heat emitter based on the following requirements.

a) Heating capacity required

b) The responsiveness required due to change of use in the space

c) Thermal comfort requirements. See Section 10

d) Space available (whether space is available on the floor, around the perimeter or at high level)

e) Safety requirements (including low surface temperature)

f) Robustness

g) Running cost.

4.2.8.4. The Contractor shall ensure that:

a) The materials used in any heat emitters are appropriate for the pipework and boiler systems connected e.g. steel radiators, steel pipe, stainless steel heat exchangers

b) Appropriate water treatment corrosion inhibitors are used

c) The heat emitters and system are selected with the ventilation and cooling strategy in mind in order to reduce energy loss e.g. heating energy lost through open windows in mid-season and wintertime

d) An even temperature gradient is achieved in the room for thermal comfort and that draughts are reduced or eliminated in the teaching spaces in line with the requirements set out in Section 10.3

e) All emitters are accessible for cleaning, especially those mounted at high level, and measures shall be taken to prevent dust build-up in/on the heat emitters. All trench heaters shall be provided with a removable grille for ease of maintenance

f) Heat emitters do not create noise in the occupied space above the indoor ambient noise level given in BB93 for the type of space.

4.2.8.5. The Contractor shall ensure that the following requirements are met:

a) Where radiators are provided in nursery provision, reception classrooms and in SEND dedicated spaces, Special Schools or Designated Units, they are low surface temperature (LST)

b) All radiators are provided with lockable thermostatic valves (TRVs) or other control device which shall not allow the room to be heated more than 2^0C above the normal room temperature, but also afford frost protection if the valve is closed

c) Adequate wall space is available for radiators to be coordinated with fixed furniture allowing unobstructed heat output

d) Where trench heating is installed, it is of a robust nature to withstand furniture and changes of use in the space.

4.2.8.6. The Contractor shall ensure that where a sports hall is served by LTHW radiant heaters, they are provided with adequate protection from damage by sports equipment.

4.2.8.7. The Contractor shall size radiant panels in accordance with Section 4.2.9 to show that radiant heating complies with the thermal comfort criteria for radiant temperatures.

4.2.8.8. Any underfloor heating shall be based on a LTHW rather than an electric system in order to conserve energy.

4.2.8.9. The Contractor shall ensure that, where underfloor heating is provided, the following requirements are met:

a) Maximum surface temperatures comply with Section 4.2.10

b) The floor covering is appropriate for underfloor heating to allow effective heat transfer to the room

c) The design and installation is fully coordinated with other under-floor services such as drainage and electrical cables, and any fixed FF&E

d) Actuators and manifolds are located in a dedicated cupboard or robust boxing adjacent to the space being heated but inaccessible to students and the public

e) The pipework, valves and connections are designed in order to avoid in-screed or underfloor leaks

f) If the screed depth is reduced to increase the response time, consideration is given to the static and dynamic loads placed on the floor. The construction method and materials proposed to provide a reduced screed depth shall be submitted to the Employer for approval.

4.2.8.10. The Contractor shall not install underfloor heating where:

a) The room use and heating profile will change quickly since underfloor heating is a slow response system

b) Floors may be covered with mats (e.g. in soft playrooms in a Special School);

c) Regular spillages can cause hygiene and odour problems (e.g. in toilets, changing rooms or hygiene rooms)

d) The positions of partition walls are likely to change

e) Fixings are required into the screed for furniture (e.g. lab benches) or equipment (e.g. in design and technology)

f) There is bleacher seating.

4.2.8.11. Fan convectors shall be designed to be robust and easily maintained to prevent dust build up.

4.2.8.12. Where heating is provided via AHUs, LTHW shall be used in preference to electrical heater batteries.

4.2.9. Radiant Temperature Difference

4.2.9.1. In any space where the heating system incorporates overhead radiant panels, the Contractor shall undertake calculations as described below to determine the Radiant Temperature Asymmetry (RTA) within each space. In calculating the RTA, ΔT_{pr}, upwards can be assessed directly below a radiant panel or an array of panels using the formulae in BS 7726.

4.2.9.2. For a seated person, the difference in plane radiant temperature between the upper and lower parts of the space shall be taken with respect to a small horizontal plane 0.6m above floor level in accordance with CIBSE Guide A Section 1.6.6.4 (2015 Edition). For a standing person a small horizontal plane 1.1m above floor level shall be taken.

4.2.9.3. The predicted RTA due to the presence of radiant panels overhead shall not exceed 7K. This is particularly important when there is a sedentary activity such as people sitting at a desk. Where there are vulnerable pupils, e.g., those with low mobility or difficulty in thermoregulation, the RTA shall be reduced to 5K.

4.2.9.4. Indicative minimum panel installation heights for a seated person are given in Table 4-1 and Table 4-2 below for a RTA of 7K and 5K. These tables are based on the seated person being positioned directly below the centre of a single overhead radiant panel in a typical classroom configuration.

Flow/Return Temperature (°C)	Assumed Emitter Temperature (°C)	Panel width (mm) 300	Panel width (mm) 600	Panel width (mm) 750	Panel width (mm) 900	Panel width (mm) 1200
50/30	40	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4
60/40	50	< 2.4	< 2.4	< 2.4	2.55	3.05
70/40	55	< 2.4	< 2.4	2.55	2.85	3.4
70/50	60	< 2.4	2.45	2.85	3.2	3.75
80/60	70	< 2.4	2.95	3.35	3.75	4.45
82/71	76.5	< 2.4	3.25	3.7	4.1	4.85

Table 4-1: Minimum panel height above finished floor level (m) / Radiant Temperature Asymmetry, RTA = 7K

Flow/Return Temperature (°C)	Assumed Emitter Temperature (°C)	Panel width (mm) 300	Panel width (mm) 600	Panel width (mm) 750	Panel width (mm) 900	Panel width (mm) 1200
50/30	40	< 2.4	< 2.4	< 2.4	< 2.4	2.85
60/40	50	< 2.4	2.5	2.85	3.2	3.8
70/40	55	< 2.4	2.8	3.2	3.55	4.2
70/50	60	< 2.4	3.1	3.55	3.95	4.65
80/60	70	< 2.4	3.65	4.15	4.6	5.4
82/71	76.5	2.6	4	4.55	5	5.85

Table 4-2: Minimum panel height above finished floor level (m) / Radiant Temperature Asymmetry, RTA = 5K

4.2.9.5. For other panel dimensions, mounting heights and flow and return temperatures the RTA calculator on the DfE website may be used to calculate the RTA.

4.2.9.6. The design shall take account of the mean water temperature, size of radiant panels and the available mounting height. Mounting too low can result in occupants complaining of excessive temperatures above their head and if mounted too high, occupants may not feel the full heating benefit.

4.2.9.7. Once the mounting height is established within a space, the arrangement of radiant panels shall allow sufficient separation between the units to provide an even spread of heat throughout the space whilst preventing a crossover of the radiant flow of heat between panels resulting in zones of intense heat.

4.2.9.8. Radiant panels shall not be located directly above teaching walls or other areas where a teacher or other occupant is likely to be standing for prolonged periods of time, unless RTA calculations can demonstrate that the installation is suitable and would not result in excess temperature differences.

4.2.9.9. If the radiant panels are offset from the preferred layout as part of the services coordination, the impact on RTA shall be assessed. The options of integrating luminaires and acoustic absorbers within radiant panels shall be considered.

4.2.9.10. The surface temperature of ceiling mounted radiant panels in classrooms or offices and in normal height teaching spaces shall be limited to meet BS EN

15251, which requires that for a category III building the vertical air temperature difference in the space during the heating season shall be less than <2 K/m in the occupied zone in order to avoid discomfort and to conserve energy. Where radiant panels are used in spaces over 4m in height, measures shall be taken where necessary to reduce stratification.

4.2.10. Underfloor Heating

4.2.10.1. Any underfloor heating provided shall be designed in accordance with the maximum floor surface temperatures given in Table 4.3.

Type of space or activity	New Build Comfort category and maximum floor surface temperature	Refurbishment Comfort category and maximum floor surface temperature
Teaching and learning, drama, dance, exams, Sports halls used for exams, multi-purpose halls	II (<26 ^{0}C)	III (<29 ^{0}C)
Practical activities such as cooking	II (<26 ^{0}C)	III (<29 ^{0}C)
Sports halls not used for exams	III (<29 ^{0}C)	IV (<31 ^{0}C)
Working areas, e.g., kitchens	IV (<31 ^{0}C)	IV (<31 ^{0}C)
Offices	II (<26 ^{0}C)	III (<29 ^{0}C)
Atria, circulation, reception and corridors - not continuously occupied	III (<29 ^{0}C)	IV (<31 ^{0}C)
Areas for pupils with complex health needs[a]	I (<23 ^{0}C)	I (<23 ^{0}C)

Table 4-3 maximum floor surface temperatures

Note a: *In the case of pupils with complex health needs, the temperature shall be adjustable to cater for the needs of the pupils. In these cases, an assessment of the individual needs must be made by the Contractor in consultation with the School and the Employer. This category applies only to Designated Units or Special Schools for non-ambulant pupils or those with medical conditions.*

4.2.11. Commissioning and Handover of Heating Systems

4.2.11.1. For any heating system provided, the Contractor shall:

a) Ensure that all heating systems installed are fully tested and commissioned in line with all appropriate and relevant current regulations and standards, including those detailed in the Employer's Requirements Deliverables

b) Conduct pre-commissioning, commissioning and seasonal commissioning on all aspects of the heating system and main plant in line with BSRIA BG 2/2010, BSRIA BG 44/2013 and the CIBSE commissioning code, providing a minimum notice period of 1 week to the Employer's engineering representative for witnessing

c) Conduct seasonal commissioning of the heating system during the defects period and fine tune control settings.

4.2.11.2. The Contractor shall run, monitor and maintain the systems provided for a minimum period of one week before handover during the "soak test" that immediately follows the commissioning and testing of the heating system... During this period, the Contractor shall undertake the required demonstration of the system and controls in line with the requirements set out in the Employer's Requirements Deliverables.

4.2.11.3. The Contractor shall record the results of the commissioning and performance testing in line with BSRIA Building Applications Guide BG2/2010 and provide these as part of the operation and maintenance manual documentation.

4.2.11.4. Full requirements for commissioning and handover are detailed in the Employer's Requirements Deliverables.

4.2.12. Hand Dryers

4.2.12.1. Electric hand dryers shall be installed by the Contractor in all toilets and hygiene rooms, unless the School express a preference for paper hand towels in the School-Specific Brief. The hand dryers shall have a drying time of less than 30 seconds; infrared control for no contact start; auto-off; and a noise level less than 65 dBA at 1m.

4.2.12.2. If towels are preferred, the Contractor shall install a paper hand towel dispenser and switched fuse spur and conduit for future connection of electric hand driers by the School, as described in Annex 2G: 'Electrical Services, Communications, Fire and Security Systems'.

4.2.13. Reference Standards

4.2.13.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of any heating systems provided complies with the relevant parts of the following standards (or updated documents if relevant):

1. HM Government – 'Non-Domestic Building Services Compliance Guide'
2. BS 5546:2010 – 'Specification for installation and maintenance of gas-fired water-heating appliances of rated input not exceeding 70 kW net'
3. BS6644:2011 – 'Specification for the installation and maintenance of gas-fired hot water boilers of rated inputs between 70 kW (net) and 1.8 MW (net) (2nd and 3rd family gases)'
4. BS 845-1:1987 – 'Methods for assessing thermal performance of boilers for steam, hot water and high temperature heat transfer fluids'
5. BS 5986:1980 – 'Specification for electrical safety and performance of gas fired space heating appliances with inputs 60kW to 2MW'
6. BS EN 1856-1:2009 – 'Chimneys - Requirements for metal chimneys. System chimney products'
7. BS EN 1993-3-2:2006 – 'Eurocode 3 - Design of steel structures. Towers, masts and chimneys – chimneys'
8. BS EN 442-1:2014 – 'Radiators and convectors. Technical specifications and requirements'
9. BS EN 442-2:2014 – 'Radiators and convectors. Test methods and rating'
10. BS EN 14037-1:2003 – 'Ceiling mounted radiant panels supplied with water at temperature below 120°C. Technical specifications and requirements'
11. BS EN 14037-2:2003 – 'Ceiling mounted radiant panels supplied with water at temperature below 120°C. Test methods for thermal output'
12. BS EN 14037-3:2003 – 'Ceiling mounted radiant panels supplied with water at temperature below 120°C. Rating method and evaluation of radiant thermal output'

13. BS EN 16430-1:2014 – 'Fan assisted radiators, convectors and trench convectors. Technical specifications and requirements'

14. BS EN 16430-2:2014 – 'Fan assisted radiators, convectors and trench convectors. Test method and rating for thermal output'

15. BS 5141-2:1977 – 'Specification for air heating and cooling coils. Method of testing for rating of heating coils'

16. BS EN 1216:1999 – 'Heat exchangers. Forced circulation air-cooling and airheating coils. Test procedures for establishing the performance (+ AMD 14280)'

17. BAG BG 4/2011, BSRIA – 'Underfloor heating and cooling'

18. BS EN 1264-4:2009 – 'Water based surface embedded heating and cooling systems. Installation'

19. BS EN 14336:2004 – 'Heating systems in buildings - Installation and commissioning of water-based heating systems' (incorporating corrigenda January 2009 and September 2013)

20. BS EN 1264-1:2011 – 'Water based surface embedded heating and cooling systems. Definitions and symbols'

21. CIBSE AM15 – 'Biomass Heating Application Manual', 2014

4.3. Ventilation Systems

4.3.1. Overview

4.3.1.1. In any space, the Contractor shall provide ventilation by natural ventilation, by a mixed-mode or hybrid system or by mechanical ventilation.

4.3.1.2. Any ventilation system provided shall be developed to provide fresh air for occupants and maintain/control the indoor air quality (pollutants, CO_2, odours, VOCs) throughout the year. Ventilation should also be considered to meet the requirements for purge and night time cooling as part of the summertime cooling strategy. VOC sensors are not required as part of the system.

4.3.1.3. The Contractor shall ensure that external noise levels from any ventilation and extract systems provided do not exceed local planning requirements in accordance with the IoA/ANC School Design Guide. Mechanical ventilation shall not create excessive noise. Indoor ambient noise levels shall comply with Building Bulletin 93: ‘Acoustic design of schools: performance standards (BB93).

4.3.2. Indoor Source Control

4.3.2.1. The Contractor shall ensure that there is no recirculation of air contaminated by things other than from normal human activity (CO_2, moisture from exhalation, etc.) such as from kitchens and fume cupboards. Extract outlets shall be designed to avoid risk of unintentional recirculation into a supply inlet or natural ventilation opening. Extract systems or transfer arrangements shall be designed to ensure there is a minimum possibility of back draughts from one area to another.

4.3.3. Radon Remediation

4.3.3.1. The Contractor shall carry out risk assessments including Radon measurements in appropriate ground floor rooms where a Building in the Works is located in a Radon Affected Area[1], irrespective of the presence of protection measures included at the time of construction. In such areas, the Contractor shall ensure that the requirements of the Ionising Radiations Regulations and AD C for Radon protection in new Buildings, extensions, and refurbishments, are met.

4.3.3.2. Established remediation techniques, entailing building works, shall be used where necessary to reduce high Radon levels[2].

4.3.3.3. Once a building has been remediated, the indoor Radon levels shall be measured before occupation to confirm the operation of the remediation system and the records retained.

4.3.3.4. O&M requirements for Radon remediation systems and requirements for annual Radon measurements shall be included in O&M manuals, as required in the Employer’s Requirements Deliverables.

4.3.3.5. For buildings in high Radon areas without remediation systems, repeat Radon measurements are required before occupation after any substantial building work.

[1] http://www.hse.gov.uk/radiation/ionising/Radon.htm#legalrequirements

[2] See BRE report BR211, “Radon: Guidance on protective measures for new buildings” and BRE report FB 41 “Radon in the workplace: A guide for building owners and managers: Second edition”.

4.3.4. Natural Ventilation Systems

4.3.4.1. Any natural ventilation provided shall be either:

a) Local: individual room-based openable windows / louvres / vents; or

b) Central: whole building systems utilising the stack / buoyancy and/or wind effect.

4.3.5. Mixed-mode Systems

4.3.5.1. In this Annex, mixed-mode ventilation or hybrid ventilation typically means one space having both natural ventilation and mechanical ventilation installed. The two systems may work together or at different times of year or under different conditions to provide improved thermal comfort and reduce energy use.

4.3.6. Mechanical Ventilation Systems

4.3.6.1. Any mechanical ventilation systems provided shall be either centralised systems serving multiple rooms or local room-level systems.

4.3.6.2. Any Air Handling Units (AHU) used in centralised systems shall be located in plant rooms rather than externally mounted on roof areas.

4.3.6.3. Mechanical ventilation shall be used to negatively pressurise any areas where there are unwanted odours, including dining areas, kitchens, food rooms, and toilets. Where appropriate, ventilation systems shall be interlocked with the gas supply in accordance with IGEM/UP/19. See Section 9: Gas Services.

4.3.6.4. All ductwork and plenums shall be fully accessible for cleaning.

4.3.7. Local Extract Ventilation

4.3.7.1. For any smaller toilet area (2 WCs or less), or where all toilet cubicles open directly off the corridor, an extract system shall be provided, with the make-up air taken from the surrounding corridors and internal spaces. Where a larger toilet area is greater than two WCs, there shall be a dedicated mechanical ventilation system with supply and extract; supply ventilation shall be at 85% of extract to ensure that air is entrained into the space to avoid odours emanating from the WCs. A similar arrangement shall be adopted for any pupil changing and shower areas in sports spaces. Toilet and changing room ventilation fans shall be locally controlled.

4.3.7.2. Where full height cubicle partitions are specified in toilets, make up air shall be provided either by a ventilation air path that preserves acoustic and visual privacy including from mobile phone cameras, or supply air must be provided to the cubicle. See Annex 2A: ‘Sanitaryware’.

4.3.7.3. In any school kitchen, extract fans shall be fitted with a variable speed inverter control, attenuation and grease and particle filtration. The kitchen extract system shall be interlinked with the gas supply. For further details see Annex 2I: ‘Controls’ and Section 7.2.

4.3.7.4. The Contractor shall ensure that adequate make-up air is provided where extract ventilation is used.

4.3.7.5. Further details of extract ventilation systems are given in Sections 6 and 7.

4.3.8. Ventilation Controls

4.3.8.1. Ventilation controls shall be in accordance with Annex 2I: ‘Controls’.

4.3.9. Distribution

4.3.9.1. The following section defines the requirements for ventilation distribution systems. It covers the requirements for air distribution systems connected to main and local plant.

4.3.10. Ductwork

4.3.10.1. The Contractor shall ensure that, in any ductwork provided, the following requirements shall be met:

a) Ductwork velocities are in line with CIBSE Guide B

b) Ductwork is installed in line with BESA DW144

c) Where ductwork is installed in ceiling voids it is fully accessible for maintenance

d) Access points for cleaning ductwork are provided.

e) Where ductwork is exposed, any insulation is protected in a robust cleanable material, e.g. aluminium or plastic. Self-finish aluminium foil that can be easily damaged during cleaning is not robust enough but rigid plastic or aluminium film or rigid sheeting is acceptable

f) The ductwork installation is robust and fit for purpose

g) All fire stopping, fire dampers, and fire protection is installed, as required, in line with the fire strategy; and is documented using photographic records and included in the H&S Files

h) All external ductwork shall be clad in metal or rigid UV resistant plastic to prevent damage, e.g. by birds.

i) Ductwork and external louvres are thermally insulated where necessary for energy efficiency and to avoid cold bridging

j) Flexible ductwork is minimised to avoid high-pressure losses and noise and to facilitate cleaning of ductwork

k) Ductwork is identified and labelled in line with the relevant British Standards.

4.3.11. Dampers

4.3.11.1. The Contractor shall ensure that, in any ductwork provided, the following requirements shall be met:

a) Variable Control Dampers (VCDs) are installed to allow the ductwork to be balanced and commissioned. VCDs are installed such that they do not cause unnecessary noise break out within the system

b) Fire dampers are provided where the ductwork passes through a fire rated wall/floor. The design and type of fire damper is in line with that specified in the Fire Strategy and at a minimum, each fire damper is rated to match the fire rating of the wall or floor it penetrates

c) Smoke dampers are provided in line with the School fire strategy

d) Where VCDs and fire dampers are provided, they are mounted in a position that is identified and accessible for maintenance and inspection

e) Maintenance, inspection and testing requirements for fire and smoke dampers are included in the Fire Safety Management Plan and O&M manuals, as required in the Employer's Requirements Deliverables.

4.3.12. Ventilation of Plant Rooms

4.3.12.1. The Contractor shall ensure that the following requirements shall be met:

a) Any plant rooms have adequate ventilation for all services and any occupants. This shall typically be provided through the use of natural ventilation louvres

b) Any electrical switchrooms are naturally ventilated and provided with background heating to maintain a minimum temperature in line with the switch panel manufacturer's requirements, in order to prevent condensation and to provide building fabric frost protection

c) Ventilation openings are not be oversized and are provided with means of preventing entry of debris and vermin.

4.3.13. Natural Ventilation Units

4.3.13.1. Natural ventilation may be provided through one of the following or through an alternative as long as full justification is provided and agreed to by the Employer:

a) Openable windows (actuated or manual)

b) Louvers with dampers (actuated or manual)

c) Roof mounted units that utilise the stack and wind effect (may be fan assisted).

4.3.13.2. The Contractor shall ensure that any openable windows and vents provided are designed to avoid inhibiting the effective use of the blinds.

4.3.13.3. Where possible, the building geometry should be designed to allow crossventilation.

4.3.13.4. Attenuation of natural ventilation shall be provided where necessary to meet BB93 indoor ambient noise levels where external noise levels are high.

4.3.13.5. The Contractor shall ensure that:

a) Restrictors are installed on all windows to prevent falls in line with the Annex 2C: ‘External Fabric’

b) Secure louvres or openings are provided for night cooling where an exposed soffit has been used as part of the thermal strategy.

4.3.13.6. Any openable roof lights or roof vents shall be designed to provide ease of use by the School staff. If they are automatically operated, they shall be provided with rain sensor override, and/or provided with wall mounted manual override controls for use by School staff. The controls shall not be accessible by students.

4.3.14. Fans

4.3.14.1. Where a mechanical or mixed-mode system is installed, the options to provide ventilation through fans to a School include:

a) Fan assisted natural ventilation (either through a facade, atrium system or roof)

b) Local ventilation supply and/or extract fans

c) Specialist local exhaust ventilation

d) Anti-stratification fans.

4.3.14.2. The Contractor shall ensure that any fans provided:

a) are energy efficient and comply with AD L

b) where mounted at high level are accessible for installation, maintenance and removal.

4.3.15. Air Handling Units

4.3.15.1. Centralised mechanical ventilation shall be provided through one or more Air Handling Units (AHUs). AHUs shall include filters, variable speed fans, acoustic insulation and attenuators as necessary to meet BB93 noise levels. The Contractor shall ensure that the correct level of filtration is provided in line with Regulations including AD F and local planning requirements.

4.3.15.2. The AHU shall include remote filter status indication. See Annex 2I: ‘Controls’.

4.3.15.3. Where an AHU provides mechanical supply and extract it shall contain heat recovery, except when used for kitchens, toilets and food tech areas. Heat recovery can either be achieved through:

a) Cross flow or plate heat exchanger; or

b) Thermal wheel.

4.3.15.4. The Contractor shall ensure that an appropriate AHU is selected based on energy efficiency and space requirements.

4.3.16. Location of Ventilation Air Intakes and Exhausts

4.3.16.1. Any exhausts or intakes provided shall be adequately separated when exhaust air is contaminated or polluted, e.g. exhausts from kitchens, toilets and fume cupboards.

4.3.16.2. In accordance with DW/172, kitchen extract discharge points shall be positioned such that the extracted air cannot be entrained into a supply system. The ductwork shall discharge at least 1.0 m above any openable window or any ventilation inlet or opening.

4.3.16.3. Flues shall be high enough above any roof so as to ensure that the fumes are discharged clear of the roof recirculation zones and cannot re-enter the building or any adjoining building. See Building Bulletin 101: ‘Guidelines on ventilation, thermal comfort and indoor air quality in schools’ (BB101).

4.3.16.4. For any hazardous fume exhaust systems provided, the methods described in Section 7.7.9: Fume Cupboard Exhausts shall be used to determine height and location of fume cupboard exhausts.

4.3.16.5. Where stack heights are limited, e.g., by planning constraints, it will be necessary to increase the plume height by increasing the efflux velocity.

4.3.16.6. Fire dampers shall not be installed in exhaust discharge ductwork from fume cupboards or other fume exhaust systems or kitchen exhaust systems.

4.3.17. Air Terminal Devices

4.3.17.1. The Contractor shall ensure that:

a) Grilles and louvres comply with Annex 2C: External Fabric and Annex 2D: Internal Finishes

b) Supply air grilles and louvres are selected to provide an even air distribution in the room and to avoid excessive temperature differences and air velocities in accordance with Section 10.4: Local Thermal Discomfort Caused by Draughts.

4.3.18. Testing of Dampers and Weather Louvres

4.3.18.1. Air leakage and thermal performance of any dampers provided shall be tested in accordance with BS EN 1751: 2014 or BS EN 1026: 2000.[3] Note: For practical reasons where large dampers are concerned, the requirement in BS EN 1751 for the face area of the test chamber to be 7 times that of the damper may be ignored.

4.3.18.2. External grilles and weather louvres shall be provided to the appropriate weather and airflow ratings to prevent rain penetration as defined by BS 13030:2001[4].

4.3.19. Reference Standards

4.3.19.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of any ventilation systems provided shall comply with the relevant parts of the following standards (or updated documents if relevant):

1. CIBSE Guide B – 'Heating, Ventilation, Air Conditioning and Refrigeration'

2. ASHRAE 62.1:2013 – 'The Standards for Ventilation and Indoor Air Quality'

3. 'Non-Domestic Building Services Compliance Guide' from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/453973/non_domestic_building_services_compliance_guide.pdf

4. Building Bulletin: BB101: 'Guidelines on ventilation, thermal comfort and indoor air quality in schools'. Note: Annex 2F 'Mechanical Services and Public Health Engineering' includes all the requirements from Building Bulletin 101 – 'Guidelines on ventilation, thermal comfort and indoor air quality in schools'. Where there is a discrepancy between Annex 2F and BB101 Annex 2F shall take precedence.

5. BESA DW144 – 'Specification for Sheet Metal Ductwork DW/144' 2013

6. BESA TR/19 – 'Guide to good practice. Internal cleanliness of ventilation systems'. 2nd edition

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[3] BS EN 1751:2014 Ventilation for buildings. Air terminal devices. Aerodynamic testing of damper and valves. BS EN 1026: 2000 Windows and Doors - Air permeability - Test method.

[4] BS EN 13030, 2001, Ventilation for buildings. Terminals. Performance testing of louvres subjected to simulated rain.

7. BS 6583:1985 ‘Methods for volumetric testing for rating of fan sections in central station air handling units (including guidance on rating)’

5. Ventilation of Teaching and Learning Spaces

5.1. In addition to the general ventilation requirements of Section 4 of AD F 2010, the following performance standards for teaching and learning spaces shall apply to the ventilation of any spaces.

5.2. In general teaching spaces and learning resource areas where mechanical ventilation is used or when hybrid systems are operating in mechanical mode, sufficient outdoor air shall be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1000 ppm and so that the maximum concentration does not exceed 1500 ppm for more than 20 consecutive minutes each day, when the number of room occupants is equal to, or less than the design occupancy.

5.3. In general teaching spaces and learning resource areas where natural ventilation is used or when hybrid systems are operating in natural mode, sufficient outdoor air shall be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1500 ppm and so that the maximum concentration does not exceed 2000 ppm for more than 20 consecutive minutes each day, when the number of room occupants is equal to, or less than the design occupancy. In addition:

a) in New Buildings, the system shall be designed to achieve a carbon dioxide

b) level of less than 1200 ppm (800ppm above the outside carbon dioxide level, taken as 400ppm) for the majority of the occupied time during the year this level can be increased to 1750ppm in the case of Refurbished Buildings

5.4. Except as described in Section 9: Gas Services, ventilation shall be provided to limit the concentration of carbon dioxide in all basic teaching spaces and learning resource areas to the levels in paragraphs 5.2 and 5.3, measured at seated head height.

5.5. The design of ventilation openings to deliver these carbon dioxide (CO_2) levels shall be based on the maximum number of occupants the space is designed to accommodate.

5.6. These performance standards are based on the need to control carbon dioxide resulting from the respiration of occupants. In general teaching and learning spaces, in the absence of any other major pollutants, carbon dioxide is taken to be the key indicator of ventilation performance for the control of indoor air quality.

5.7. Ventilation rates for general teaching spaces and learning resource areas are not sufficient for spaces used for practical activities, such as science, design and technology and food where higher rates will be required during these activities. In these practical spaces, higher levels of CO_2 are acceptable for the periods of time when Bunsen burners, cookers and other gas-fired appliances are in use. When practical spaces are used as conventional classrooms they need to provide ventilation for teaching and learning activities as described in paragraphs 5.2 and 5.3. However, they may also need additional ventilation during practical activities to prevent the build-up of unwanted pollutants. See Section 6: Ventilation for Particular Areas and Activities.

5.8. Local exhaust ventilation (LEV) is often required to deal with specific processes or pollutant sources, such as dust or fumes, which pose a risk to the health and safety of users or affect their comfort. LEV should be provided, subject to risk assessments carried out under the ‘Control of Substances Hazardous to Health (COSHH) Regulations’ 2002[5,6]. LEV is required in science, design and technology practical spaces and preparation rooms and in some art practical spaces.

5.9. In extreme hot weather conditions, it should be possible to boost the fan speed of a classroom ventilation unit for short periods (under local teacher control), unless there is a means of cross ventilation of the space, not including the opening of doors. In addition to these measures, ceiling or wall-mounted fans which are under local teacher control may be supplied. The noise level from the boosted ventilation or ceiling or wall mounted fans should not exceed an IANL of 45 dBA, LAeq.

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[5] See CLEAPSS Model Risk Assessments and CLEAPSS Guide G225 Local Exhaust Ventilation in D&T.

[6] Health and Safety Executive, Control of Substances Hazardous to Health (COSHH) Regulations 2002 - www.hse.gov.uk/coshh

6. Ventilation for Particular Areas and Activities

6.1. General

6.1.1. This section gives the design requirements for particular areas and activities additional to those for teaching and learning described in Section 5: Ventilation of Teaching and Learning Spaces.

6.2. Office Accommodation

6.2.1. The ventilation of any offices shall be in accordance with AD F1 Table 6.1b, which, in the absence of excessive pollutants, requires the total outdoor supply rate to be 10 l/s/person.

6.2.2. This outdoor air-supply rate is based on controlling body odours and typical levels of other indoor-generated pollutants. Further guidance on the ventilation of office accommodation using natural or mechanical means is given in AD F. Local extract may be required as described in Section 6.3: Local Extract Ventilation.

6.3. Local Extract Ventilation

6.3.1. This section gives the requirements for any extract ventilation, e.g. from toilets, washrooms, photocopiers and printers.

Room	Local extract
Rooms containing printers and photocopiers in substantial use (greater than 30 minutes per hour).	Air-extract rate of 20 l/s per machine during use is required to eliminate pollutants. Air must be exhausted outside the building. If located in a separate room the room must be ventilated at the rate of 10l/s/person when occupied as for an office. These rates are those given in AD F. Cooling is required to larger reprographics machinery often found in schools, (e.g. with heat loads of around 2kW in use) where its use is intensive, and it is located in a small room. This is due to the high heat loads produced which cannot be dealt with by extract ventilation. An alternative is to locate the machines in a circulation space if there are no noise sensitive activities taking place in the circulation area where the heat can dissipate. Photocopiers are often fitted with active carbon filters which limit ozone emissions. Some of these are sealed for life and others require maintenance. Information about the maintenance of photocopiers can be found in Local Authority Circular: LAC 90/2[7].
Sanitary accommodation and washrooms.	6 l/s per shower head/bath; 6 l/s per WC/urinal. These rates are those given in AD F. Individual facilities can use intermittent air-extract but combined facilities opening off circulation areas shall have continuous extract with a peak rate of at least 6l/s/appliance; a reduced continuous background rate of 4l/s/appliance can be used where there is occupancy sensor control of the higher peak rate.
Cleaners' stores.	Extract ventilation shall be provided to cleaner's rooms where there are sinks or where cleaning chemicals are stored. This can be added onto toilet extract systems where they are nearby.
Food and beverage preparation areas, e.g. in kitchenettes (not commercial kitchens or food rooms)	Intermittent air-extract rate of: 15 l/s with microwave and beverages to operate while food and beverages preparation is in progress. This rate is given in AD F. This is only required where these are located in individual rooms not where they are located in larger open plan office or circulation spaces; IGEM/UP/11 guidance on gas safety should be consulted in preference to AD F for extract rates for gas cookers. IGEM/UP/11 requires a minimum extract rate of 42l/s (150cfm) per Type A Cooker.

[7] HSE (2000) Local Authority Circular 90/2.

Room	Local extract
	See Section 9 on gas services and gas safety regulations.
Specialist rooms (e.g. commercial kitchens, fitness rooms, science laboratories, rooms).	See Section 7.6 on practical spaces for requirements for Local Exhaust Ventilation (LEV). LEV includes fume cupboards and local exhaust hood type vent systems that remove pollutants at source.

Table 6-1: Recommended minimum local extract ventilation rates

6.3.2. Extract ventilation shall be taken to the outside and provided with appropriate time and occupancy controls.

6.4. Ventilation of Large and Circulation Spaces

6.4.1. Large Spaces

6.4.1.1. The following section is intended to supplement BB 101 and provides a minimum specification for the design and installation of the ventilation and associated systems in any large spaces.

6.4.1.2. The general requirements for the ventilation of large spaces within schools shall be to:

a) Remove contamination from the air

b) Provide outdoor air for respiration

c) Provide a method of limiting temperature increase

6.4.1.3. This section applies to:

a) Sports halls and main halls

b) Atria, circulation spaces and corridors

c) Dining areas

6.4.2. Sports Halls and Main Halls

6.4.2.1. Secondary Schools use their sports halls for a range of sporting activities and typically, also for exams, because they can accommodate a whole year group at one time; in this case the environmental conditions need to allow for exam use. Table 6-2 provides a summary of the environmental criteria for the design of sports halls.

Type of Hall	Normal maintained operative temperatures in the heating season (°C)	Summertime temperatures
Sports (General)	17	Overheating Risk Assessment (ORA) (See Section 10.4) to Category III for sports use, (See Table 10-5)
Examination	20	ORA to category II for the examination occupancy profile, (See Table 10-5)

Table 6-2: Design parameters for sports halls / Summary of environmental standards for sports halls

6.4.2.2. For the majority of the time there may only be one or two class groups in many halls e.g. 30 to 60 students using the space and much less outdoor air will then be needed to maintain the required CO_2 levels. The CO_2 levels for general teaching and learning spaces given in Section 5: Ventilation of Teaching and Learning Spaces also apply to sports halls.

6.4.2.3. The examination period, for the purpose of the Overheating Risk Assessment, for Secondary School halls used for exams shall be taken as weekdays 09:00 to 16:00 from 1st May to 8th July, with a lunch break as described in Section 10.5. The Contractor shall ensure that the overheating assessment and dynamic thermal modelling uses a reasonable occupancy profile. This will ensure that ventilation systems are sized correctly.

6.4.2.4. Noise levels are important during examinations and some heating and ventilation systems will be too noisy, e.g., gas fired radiant heating with the burner in the space. Radiant heating can be used effectively in sports halls, but the radiant temperature asymmetry (RTA) shall be considered as part of the overall design strategy, in accordance with Section 4.2: Heating Systems.

6.4.3. Atria, Circulation Spaces and Corridors

6.4.3.1. If these spaces are insufficiently ventilated or overheat it will affect the whole ambience of the School and uncomfortable conditions can also spill over into the teaching areas.

6.4.3.2. See further guidance on design of these spaces given in BB101.

6.4.3.3. This section applies to circulation areas that are typically classified as unoccupied spaces. Where they include break out and group spaces these should be ventilated for teaching and learning activities as described in paragraphs 4.1.2 and 4.1.3.

6.4.3.4. Corridors shall be ventilated. This can be provided by opening windows or vents. The cold draught criteria in Section 10.4 ‘Local Thermal Discomfort Caused by Draughts’ do not apply to corridor areas where the windows or vents are under local or manual control.

6.4.3.5. Corridors should not overheat in schools. Overheating usually occurs because they are landlocked and have very low ventilation rates so either this should be avoided, or adequate ventilation should be provided. Overhead heating and hot water pipework shall be well insulated to avoid overheating of corridor spaces.

6.4.3.6. Adequate ventilation and/or solar shading shall be provided to prevent overheating due to solar gain from glazing.

6.4.3.7. Heat gain into staircases shall be considered. They may need to be ventilated to deal with high heat gains.

6.4.4. Dining Areas

6.4.4.1. The smell of food from dining areas can be a nuisance. The transfer of air from dining areas to the other parts of the School shall be avoided. This can be a particular challenge when atria containing food areas are linked to large areas of the School. The main dining areas and the kitchen shall be under negative pressure. It is often possible to extract from dining areas through the kitchen. The requirements for acoustic separation between the kitchen and dining area when used for other activities, during the day, for example, in a multi-purpose hall shall be met

7. Specialist Ventilation Systems

7.1. General

7.1.1. The following sections detail the technical requirements for a number of specialist ventilation systems within schools, for both New Buildings and Refurbished Buildings.

7.2. School Kitchen Ventilation

7.2.1. General Requirements

7.2.1.1. The Contractor shall design the kitchen ventilation system in accordance with DW/172.

7.2.1.2. Flue heights and efflux velocities and odour control shall be either in accordance with DW/172 or the local planning requirements for commercial kitchens.

7.2.1.3. Maximum internal ambient noise levels shall be in accordance with BB93, 50 LAeq, 30mins dB for new build and 55 LAeq, 30mins dB for refurbishment or remodelling.

7.2.1.4. The Contractor shall use the method set out in DW/172 for calculating the required extract airflow rate for the kitchen canopy or for a ventilated ceiling.

7.2.1.5. Dedicated supply make up air systems shall be designed at 85% of the extract flow rate and leakage paths need to be properly managed.

7.2.1.6. The Contractor shall use the method set out in BS 6173 in order to calculate the required ventilation to support combustion for gas appliances.

7.2.1.7. The Contractor shall ensure that the following requirements are met:

a) Sufficient ventilation is provided to safeguard against the possibility of incomplete combustion

b) An interlock is provided between gas supply and mechanical ventilation to ensure that gas will not be supplied when an inadequate airflow rate is provided. This is for safe operation of appliances and the safety of personnel

c) The system is fully compliant with the requirements set out in in IGEM/UP/11 ‘Gas Installations for Educational Establishments’, IGEM/UP/19 and the requirements for gas services set out in Section 9

d) The system does not cause discomfort to the occupants via draughts. The incoming supply air shall be pre-heated and distributed within the Kitchen area in accordance with DW/172

e) The discharge from the exhaust of the system is appropriately positioned

f) The discharge from the exhaust of the system does not cause discoloration or damage to any part of the building structure or any noise or odour problem to neighbouring rooms or properties

g) Maintenance and cleaning schedules shall be included in O&M manuals and a kitchen user guide shall be produced as part of the Building Users' Guide. The requirements for O&M manuals and a Building User's Guide are set out in the Employer's Requirements Deliverables.

7.2.1.8. HSE Catering Information Sheet 23 details the risk assessment process that shall be applied by the contactor for refurbishment and upgrading of installations that do not meet the requirements for new installations.

7.2.2. Grease Filters and Odour Control

7.2.2.1. Removable baffle type grease filters shall be installed so that they are accessible for cleaning and maintenance. Grease extracted by the ventilation system shall be collected and removed so that it does not accumulate in either the canopy or the ductwork system.

7.2.2.2. DW/172 and Defra guidance[8] summarise the available odour control, filtration, and noise control technologies. The priority should be to provide simple technologies that are easily maintained by the School and to provide adequate efflux velocity and flue height to provide good dispersal rather than to employ expensive odour control and filtration systems with a lower flue height and efflux velocity. In general, the flue shall terminate at least 1m above the roof or any air inlet at an efflux velocity of at least 10m/s as recommended in DW/172.

7.2.2.3. For requirements for gas services including interlocks and carbon dioxide detectors see Section 9.

[8] Guidance on the Control of Odour and Noise from Commercial Kitchen Exhaust Systems, DEFRA, 2005.

7.2.3. Reference Standards

7.2.3.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of the catering kitchen ventilation systems and associated systems comply with the relevant parts of the following standards (or updated documents if relevant):

1. Building Bulletin 101 – 'Guidelines on ventilation, thermal comfort and indoor air quality in schools' (BB101). Note Annex 2F: 'Mechanical Services and Public Health Engineering' includes all the requirements from Building Bulletin 101 'Guidelines on ventilation, thermal comfort and indoor air quality in schools'. Where there is discrepancy between Annex 2F and BB101 Annex 2F shall take precedence.

2. DW/172 – 'Specification for Kitchen Ventilation Systems'

3. DW/144 – 'Specification for Sheet Metal Ductwork'

4. HSE Catering Information Sheet No 10 – 'Ventilation in catering kitchens'

5. HSE Catering Information Sheet No 23 – 'Gas safety in catering and hospitality'

6. IGEM/UP/11 – 'Gas installations for educational establishments'

7. CIBSE TM 42 – 'Fan Application Guide'

8. BS EN 16282-2 – 'Equipment for commercial kitchens - Components for ventilation of commercial kitchens - Part 2: Kitchen ventilation hoods; design and safety requirements'

9. BS EN 16282-3 – 'Equipment for commercial kitchens - Components for ventilation in commercial kitchens - Part 3: Kitchen ventilation ceilings; Design and safety requirements'

7.3. Food Room Ventilation

7.3.1. Overview

7.3.1.1. The following section provides a minimum specification for the design and installation of the ventilation and associated systems in any food rooms for Secondary pupils.

7.3.2. Design Criteria

7.3.2.1. The Contractor shall use the following criteria:

a) There is a door between the food room and any linked space such as a food preparation room to prevent contamination from dust

b) Exhaust ventilation rates shall be calculated taking account of room size and usage

c) During normal cooking activities, noise generated by extraction systems shall not be loud enough to prevent the students from hearing the teacher, or the teacher from hearing the students' voices, as this poses a significant hazard. If possible, it shall be kept below 50 dB or (10dB above the maximum Indoor Ambient Noise Level of 40 dBA required by BB93) in accordance with Section 2.12.2 of the IoA/ANC Acoustics of Schools: a design guide, 2015. Where this is not possible, higher noise levels of up to 55 dBA will only be acceptable where the teaching staff have control over the ventilation system and can switch it off locally as required for teaching. Noise levels during normal teaching and practical activities shall comply with Section 1.1.3 of BB93. IoA/ANC 'Acoustics of Schools: a design guide', 2015 gives guidance on the higher noise levels allowed during process related local exhaust ventilation, such as from cooker fume extract systems

d) The room shall be kept under a negative pressure during cooking activities

e) Displacement ventilation systems which extract the hot air from high level and supply cooler tempered air at low level help to remove heat gains from the occupied zone and limit the ventilation rates required during cooking activities. For ventilation of domestic cookers in food rooms where there are up to 13 cookers in the space, there shall be minimum supply and extract of 42 l/s (150m^3/hr) of air per appliance, in accordance with IGEM/UP/11. This may be reduced where displacement ventilation of high effectiveness is used, and a lower rate is shown to be adequate

f) Exhaust ventilation may be in the form of individual extraction hoods, but if used, these must not obstruct student sightlines to the whiteboard. Where separate canopies are used above individual appliances, they shall be designed to have a flow rate exceeding 42 l/s (150m^3/hr). This figure is inclusive of the 8 l/s required for CO_2 control

g) In these spaces the assumption is that gas hobs will never all be used at the same time at their full rate and will only be used with pupils for periods of less than one and a half hours at a time

h) Mechanical ventilation systems shall be interlocked with the gas supply in accordance with IGEM/UP/11 and IGEM/UP/19. See Section 9: Gas Services

i) Opening windows will require fly guards to prevent insect contamination unless there is mechanical ventilation providing filtered supply air. Fly guards are required where a ventilation system relies on natural ventilation openings at all times. In this case, the resistance to airflow of the fly guards must be taken into account in calculations of effective areas of openings. See Section 11.3 on calculation of effective areas of ventilation openings

j) If refrigerators or freezers are kept in storerooms, ventilation must be sufficient to maintain temperatures in accordance with manufacturers recommended ambient temperatures for the siting of the equipment

k) Heat recovery on supply and extract systems may be provided to minimise heat losses associated with high ventilation rates when cooker hoods are running

l) General room extract systems needs to be positioned to avoid excessive buildup of grease with provision made for easy replacement/cleaning of filters

m) Whilst cookers/hobs are not in operation, the ventilation standards shall be the same as a general teaching space. See Section 5. However, during cooking, the levels of CO_2 given in paragraph 9.3.3 shall be achieved

n) The Contractor shall ensure that the system does not cause discomfort to the occupants via draughts. The incoming supply air shall be pre-heated and distributed within the space as per the guidance set out in DW/172

o) The Contractor shall also ensure that the discharge from the exhaust does not cause discoloration or damage to any part of the building structure.

7.3.3. Gas Interlocks

7.3.3.1. An interlock is required between gas supply and mechanical ventilation to ensure that gas will not be supplied when there is an inadequate airflow. This is to ensure the safe operation of appliances and the safety of personnel.

7.3.3.2. Where there are only Type A appliances i.e., there are no flued gas appliances such as deep fat fryers, interlocking may be achieved by environmental monitoring of carbon dioxide as described in IGEM/UP/19, BS 6173 and Section 9.3.

7.3.3.3. For requirements for gas services including interlocks and carbon dioxide detectors see Section 9.

7.3.3.4. HSE Catering Information Sheet 23 details the risk assessment process that shall be applied by the contactor for refurbishment and upgrading of installations that do not meet the requirements for new installations.

7.3.4. Reference Standards

7.3.4.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of the food technology room ventilation system and associated systems shall comply with the relevant parts of the following standards (or updated documents if relevant):

1. DW/172 – 'Specification for Kitchen Ventilation Systems'

2. DW/144 – 'Specification for Sheet Metal Ductwork'

3. BB101 – 'Ventilation, thermal comfort and indoor air quality in schools'. Note Annex 2F: 'Mechanical Services and Public Health Engineering' includes all the requirements from Building Bulletin 101 'Guidelines on ventilation, theremal comfort and indoor air quality in schools'. Where there is a discrepancy between Annex 2F and BB101 Annex 2F shall take precedence.

4. HSE Catering Information Sheet 23 – 'Gas safety in catering and hospitality'

7.4. ICT Server Room Ventilation

7.4.1. Overview

7.4.1.1. The following section is a minimum specification for the design and installation of the ventilation and associated systems in any server room for Information and Communications Technology (ICT). See Section 4 of the GDB for ICT system requirements.

7.4.2. General Requirements

7.4.2.1. Typical server rooms can produce high-density heat loads which can affect ICT equipment. The Contractor shall ensure that environmental conditions are maintained in line with the manufacturer's recommendations for the equipment to be housed within, or any respective warranty requirements. Security of ventilation openings in the façade shall comply with the GDB.

7.4.3. Ventilation Systems, Air Flow Rates and Heat Loads

7.4.3.1. The type of ventilation system required and the strategy to cool the server room will be dependent on the heat loads generated by the equipment.

7.4.3.2. If a mechanical ventilation system is used this shall be provided with filtration to prevent dust ingress.

7.4.3.3. Server room cooling units shall be sized on the sensible heat loads provided by the manufacturers of the equipment to be installed allowing for diversity or the actual measured power consumption of the equipment. An additional load of 10% should be included for future expansion. For modern server rooms it should not be necessary to provide more than 250 W/m² of cooling. Typically, the cooling duty will be in the range of 1.2kW - 6kW for Secondary Schools and 400W – 1kW for Primary Schools.

7.4.3.4. DX or VRF cooling shall be provided to meet the temperatures specified in equipment warranties in peak summertime periods.

7.4.3.5. The normal operating range (set point) shall be designed to meet manufacturer's recommended requirements. Temperatures may not exceed this range for more than 200 hours a year. The maximum temperature of the room measured at high level above the server racks shall not exceed 28 °C. The minimum temperature of supply air shall be 15 °C.

7.4.3.6. The Contractor shall minimise the ventilation and cooling required, for example by locating server rooms on the north façade or in areas of the building where there are lower thermal gains and on an outside wall. A ventilation opening to outside or locally controlled extract fan shall be provided to allow for ventilation for occupancy and battery failure. This shall allow for ICT staff who are servicing equipment in the server room; and ventilation required by UPS systems for the safe operation of the batteries to allow for the release of inflammable or corrosive gases. Nongassing valve regulated batteries are required for the UPS and do not off-gas except under fault conditions.

7.4.3.7. The Contractor shall ensure air conditioning units are positioned for easy maintenance and units and their pipework shall not be located above equipment cabinets in case of leakage. The condensate shall be taken by gravity to the nearest drain outside the room.

7.4.3.8. Most UPS systems and server room ICT equipment is capable of operating continuously in an A3 classification environment as stated within ASHRAE TC 9.9 2011 Thermal Guidelines for Data Processing Environments. This is defined as:

a) room temperatures of up to 27 °C

b) up to 200 hours per year at up to 30 °C

c) maximum temperature of 35 °C

7.4.3.9. The contractor should demonstrate how the position of the environmental control systems (e.g. air conditioning unit) supports the cooling strategy of the server cabinets.

7.4.3.10. The server room power supply shall be provided with a sub-meter. See Annex 2H: ‘Energy’.

7.5. Design Technology (D&T) and Local Exhaust Ventilation

7.5.1. Overview

7.5.1.1. The following section is a requirement for the design and installation of the ventilation and associated systems in workshops including fumes from heat bays and wood dust extract where provided.

7.5.1.2. Ventilation for D&T rooms will require controllable systems designed for dust and fumes that may be produced from equipment and processes. This section includes requirements for varying needs depending on the equipment present:

a) wood dust extract systems

b) hot metal and foundry ventilation systems

c) laser cutting and 3-D printing fume extraction systems

7.5.2. Design Criteria

7.5.2.1. The three major concerns for D&T spaces are dust, fume and heat extraction. These pollutants can be present simultaneously. Design, installation and maintenance requirements for D&T rooms shall comply with BS 4163: Health and safety for design and technology in educational and similar establishments.

7.5.2.2. A requirement for D&T spaces is to have a centralised airflow rate or the sum of the local extract flow rates of 2.5 $l/s/m^2$ when practical activities are occurring. This rate may be made up from the room’s ventilation unit, the LEV or both. This shall be locally controllable by staff. This area-based ventilation rate in $l/s/m^2$

applies to spaces of 2.7m height or higher. The equivalent air change rate per hour (ach) can be calculated from ach = ($l/s/m^2$ rate) x 3.6/ (Room height (m)). For spaces below 2.7m in height, the equivalent air change rate to a 2.7m high space shall be used.

7.5.2.3. Noise generated by extraction systems should not be loud enough to prevent the normal teacher's voice from being heard by students, or the students' voice being heard by the teacher. It should be kept below 50 dB or (10 dB above the maximum Indoor Ambient Noise Level of 40 dBA) in accordance with Section 2.21.2 of the IoA/ANC Acoustics of Schools: a design guide, 2015. Higher noise levels of up to 55 dBA will only be acceptable where the School staff have control over the ventilation system, and it can be switched off locally as required for teaching. Noise levels during normal teaching and practical activities shall comply with Section 1.1.3 of BB93. It is a requirement to achieve the minimum exhaust rates given in 7.5.2.2 within the noise levels given in BB93, Section 1.1.3. IoA/ANC 'Acoustics of Schools: a design guide', 2015 gives guidance on assessing and limiting the higher noise levels allowed during process related local exhaust ventilation such as use of fume or dust extract.

7.5.2.4. Fume extraction is required for but not limited to:

a) Hot metal work and heat treatment processes

b) Laser cutters

c) 3-D printers

d) Surface cleaning and finishing and printed circuit board manufacturing (etching)

e) Soldering of circuit boards

f) For some paints and adhesives, including spray fix as used in art rooms.

7.5.2.5. Dust extraction shall be provided to all fixed machines provided in D&T or construction workshops that might produce dust.

7.6. Local Exhaust Ventilation (LEV) Systems

7.6.1. General Requirements

7.6.1.1. LEV systems local to individual machines shall either be interlocked with the machine so that they will not start without the LEV running or provided with a local switch adjacent to the machine.

7.6.1.2. The effectiveness of legacy LEV systems shall be assessed as required by COSHH and if they do not meet current standards, new LEV systems shall be provided. See HSE 258. LEV risk assessments and specifications should identify the processes, contaminants, hazards, sources to be controlled and exposure benchmarks. Exposure benchmarks should be based on EH40[9] and on CLEAPSS guidance on risk assessments for science and D&T.

7.6.1.3. Make up air shall not create draughts or disturb the airflow into LEV hoods and fume cupboards. Ventilation openings shall be designed to minimise such effects and they shall be sited away from LEV hoods and fume cupboards.

7.6.1.4. Wherever dust is produced, a risk assessment must be undertaken and, if necessary, a control measure shall be put in place, including for the emptying and disposal of dust from LEV systems.

7.6.1.5. The Contractor shall ensure that machine-based extract equipment is fit for purpose.

7.6.1.6. Clear management systems and proper, safe work routines including the use of PPE shall be included in operation and maintenance manuals and health and safety log books, as required in the Employer's Requirements Deliverables.

7.6.1.7. The Contractor shall ensure that the following requirements are met:

a) LEV systems are designed by qualified professional suppliers

b) LEV systems are supplied with performance data on installation. This shall include filter efficiencies. This is necessary so that subsequent testing can be compared with the performance on installation

c) Details of the statutory 14 monthly LEV equipment 'Thorough Examination and Test' (TExT) are included in the O&M manual and the Building Users Guide. All LEV systems across the D&T and science departments should have a TExT every 14 months. This should be carried out by a competent person. The checking of the extractor units on laser cutters, fume cupboards and other equipment shall be included in the TExTs

[9] EH40/2005 nWorkplace exposure limits|

d) A logbook is provided to record the results of the commissioning, the 14 monthly performance TExTs and the H&S file tests

e) Workplace Exposure Limits (WEL) for wood dust and other pollutants are recorded in O&M Manuals and the H&S file and procedures defined to keep levels as low as reasonably practicable

f) The O&M manuals and H&S File contain manufacturers and designers' maintenance schedules to ensure the systems perform as designed.

7.6.1.8. Details of the deliverables are set out in the Employer's Requirements Deliverables.

7.6.2. Laser Cutters and 3-D Printers

7.6.2.1. The use of laser cutters and 3-D printers can cause potential health and safety risks. Harmful fumes containing nanoparticles and Volatile Organic Compounds (VOCs) can be produced.

7.6.2.2. Laser cutters and 3-D printers must be housed in well-ventilated rooms and provided with efficient fume ventilation systems.

7.6.2.3. There are two types of systems that can be used as shown in Table 7-1.

Ventilation system	Description
Extract to Atmosphere (ETA)	Fumes are removed by negative pressure and discharged through an external flue above roof level
Filtration	Particulates are trapped in a HEPA filter and VOCs in a molecular gas filter. The clean air is returned into the room. These systems require regular maintenance and filter changes as recirculatory fume cupboards.

Table 7-1 Fume Ventilation Systems

7.6.2.4. Filter systems will need to be changed on average once or twice per school year, dependent on the filter size and frequency of use. This should form part of the general maintenance programme. The filter system must be capable of removing both nanoparticles and VOCs.

7.6.2.5. Both systems will require LEV tests, which measure filter effectiveness, at no more than 14-month intervals. Further guidance can be obtained from CLEAPSS and HSE.

7.6.2.6. The requirements to change filters and carry out LEV tests shall be included in O&M Manuals and the Building Users Guide, see paragraph 7.6.1.7.

7.6.3. Wood Dust Extract Systems

7.6.3.1. Wood dust extract systems vary, and different schools may require differing solutions. Wood dust can be hazardous and particulate matter is required to be cleared and filtered from the air. There are two types of extract systems which should be used:

a) Centralised dust extraction

b) Cmaller LEV units.

7.6.3.2. In some cases, a mixture of systems may be appropriate depending on the types of machinery and the way the spaces are used. See Table 7-2.

7.6.3.3. Centralised wood dust extract systems shall be provided for multi-materials prep rooms and adjoining practical spaces, vocational training and any office/workshop (premises). Low Volume, High Velocity (LVHV) LEV centralised systems shall be provided. However, individual machine-based extract systems shall be provided in teaching areas where this is identified in the School-Specific Brief. Type selection should be considered in tandem with risk assessment criteria.

7.6.4. Centralised Wood Dust Extract Systems

7.6.4.1. Centralised extract systems to machinery shall be designed to meet the following requirements:

a) The collection unit and extract fan are located so that the unit can be used quietly and can be easily emptied without disturbing class activities

b) The extract unit is located in a separate room to the teaching space, to contain the noise and dust; this may be the prep room. The shaker, fan and main branch ducts are also located in this space so that noise ingress into teaching spaces is minimised

c) The air inlet to the room containing the dust extract unit is acoustically attenuated to prevent noise causing disturbance to teaching areas, neighbouring properties, and outside areas

d) Vacuum hose connections are provided, instead of having a ‘sweeping up’ arrangement, and inertia type reels for vacuum hoses are provided in the prep room and the students’ work area

e) Automatic fire dampers are provided in the extract system and the associated plant room

f) The system is fitted with a variable speed fan and machinery dampers and interlocks, so that the system changes the flow rate when machines are switched on and off and allows hand tools to be connected. The interlocks provide automatic shut off of the extract system when the waste bag is full, and a warning is provided to the prep room when the bag is nearly full

g) A variable air-flow system should be provided in new installations to limit energy use and noise. Air flow depends on the number of machines in use

h) All branch ducts are designed for low resistance to limit noise as described in HSG 258.

7.6.4.2. See Section 2.21 of IoA/ANC ‘Design Guide on School Acoustics of Schools: a design guide’, 2015 for guidance on operational noise.

7.6.4.3. Issues to consider when designing LEV systems are shown below in Table 7-2.

Type	Characteristics	Noise	Advantages	Disadvantages
Fixed installations for whole area serving several machines	a. Inlets at each machine or dust source, preferably with dampers that can be closed when the inlet is not in use. b. Fixed ducting. c. A fixed filter or dust- collection system. d. A single fan unit. e. An outlet that might return air to the workplace or vent it to the outside. f. Dust collection unit and fans may be in the room, or in a separate room or in an external enclosure with ducting to the equipment. g. Unit may serve more than one room. h. Warning system required to tell user when dust collector needs emptying. i. Units and are best located in a separate space or external to the building for ease of maintenance and to limit noise.	Depends on design. Sound levels greater than 80 dB (A) caused by fixed flow rate make verbal communication difficult. Where the noise exceeds 80 dB (A) ear defenders are required. New installations should not have noise levels requiring ear defenders. Noise can cause distractions to the teaching environment and to neighbouring buildings, depending on location. Noise can be limited if unit is variable speed and housed in separate space. Also, by good quality ductwork with smooth bends.	Single point of dust collection makes dust handling and maintenance easier and safer - only one filter to clean or replace. The noise is low if the fan is outside the workplace and the duct does not carry sound. Low running costs due to single point of maintenance Low energy costs if variable speed.	Fan and filter units are large and need to be in a soundproof enclosure. High noise levels if the system is located in the workplace and/or if the duct velocity is too high or ductwork poorly designed so that it transmits sound. This may lead to ambient noise problems in rooms where quiet is needed. Extra electrical controls are required to ensure that the system starts up when any machine is in use and to vary the air flow according to the number of machines in use. Users will need training to operate dampers and controls. If the extraction unit fails, none of the machines connected to the system can be used. Relative inflexibility to easily move machines or connect and disconnect machines.
Independent installations at each machine	a. Fan unit is close to the machine producing the dust. b. Fan and machine are often electrically linked, so that the fan is powered whenever the machine is running. c. For dust control, the filter / dust-collection system is normally mounted in the same unit as the fan. d. Warning system required to tell user when dust collection needs emptying.	Can be a problem unless each fan unit is very quiet.	Units are often compact, being designed to fit under the bench or into the pedestal supporting the machine. Automatic starting of the dust control is easy. Failure of one unit does not affect use of any other machine.	Many dust-collection bags and/or filters to attend to. Many fans can generate much noise. Dust collection units must be changed in an occupied space. The relatively small filter area and size of unit can result in the filter becoming clogged and hence a lack of efficiency. Dust collection capacity can be small requiring regular emptying. These units are unlikely to cope with large volumes of waste such as those produced by wood planing machines.

Type	Characteristics	Noise	Advantages	Disadvantages
Portable systems	A mobile duct, filter, dust sack and fan unit, which can be moved between machines. The inlet may be general purpose or part of each machine.	A serious problem unless each fan unit is very quiet.	An economical solution for a workshop containing several machines with intermittent use.	General-purpose units are not always efficient and may not adequately control contaminants. Dust capture hoods may be ineffective unless designed for each machine. Difficult to make system and machine electrically interlocked. It is then debatable whether or not the system fulfils legal requirements. There is a high risk that LEV may not be used because of the effort of connecting up. Difficult to empty and connect and reconnect safely.
Extraction from portable power tools	A very flexible duct connected to a standalone dust collector or a small dust bag connected to the tool.	Portable power tools are often noisy anyway and the extra noise associated with the dustcollection system may be trivial.	Good for vocational training as this is the usual method of extraction found on site.	The dust-collection system may make the tool difficult to control. If a small dust bag is fitted, it can be filled after only a few minutes work and must be changed or emptied frequently. Dust capture may not be effective enough for indoor use. This type of system will not usually effectively protect others nearby unless used in a very well-ventilated space or an external workspace. If used inside PPE will probably be needed for those nearby as well as the user.

Table 7-2 Types of dust extraction (table adapted from CLEAPSS publication L225)

7.6.5. Reference Standards

7.6.5.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of the D&T spaces, wood dust extract ventilation and associated systems complies with the relevant parts of the following standards (or updated documents if relevant):

1. BS 4163 – 'Health and safety for design and technology in educational and similar establishments'

2. IGEM/UP/11 – 'Gas Installations for Education Establishments'

3. 'Acoustics of Schools: a design guide', IoA/ANC, 2015

4. HSG 258 – 'Controlling airborne contaminants at work: A guide to local exhaust ventilation'

5. CLEAPSS Guidance Document L225 – 'Managing Risk Assessment in Design & Technology'

7.7. Science Laboratory and Fume Cupboard Ventilation

7.7.1. Overview

7.7.1.1. The following section provides a minimum specification for the design and installation of any ventilation and associated systems in science laboratories and fume cupboards.

7.7.2. General Requirements

7.7.2.1. The general requirements for the science laboratories and fume cupboard ventilation systems shall be to:

a) remove contamination from the extract air caused by chemical processes

b) provide background ventilation for the occupants

c) ensure sufficient ventilation in areas where increased CO_2 and CO levels can be observed

d) ensure sufficient ventilation for combustion

7.7.3. Design Criteria

7.7.3.1. Science laboratories are sometimes used as conventional classrooms and shall be designed for such use (See Section 5: Ventilation of Teaching and Learning Spaces) as well as for use for practical activities when additional ventilation is required during experiments.

7.7.3.2. Practical experiments are carried out in science laboratories in the open teaching space as well as in fume cupboards. The ventilation design shall address the following:

a) the use of Bunsen burners

b) chemical fumes produced during experiments

c) the safe and effective use of fume cupboards

7.7.3.3. Table 7-3 below from BB101 gives the required minimum exhaust rates for various sized spaces.

Room type	Area (m2)	Minimum required ventilation rate
Laboratories and preparation rooms	>70	4 $l/s/m^2$
Laboratories and preparation rooms	37-70	11.42 –(0.106 x Area) $l/s/m^2$
Laboratories and preparation rooms	<37	7.5 $l/s/m^2$
Chemical stores	All	2 air changes per hour, 24 hours a day.

Table 7-3 Science Laboratories Minimum Exhaust Rates

7.7.3.4. The area based ventilation rates in $l/s/m^2$ given in Table 7-3 apply to spaces of 2.7m height or higher. The equivalent air change rate per hour (ach) can be calculated from ach = ($l/s/m^2$ rate) x 3.6/ (Room height (m)). For spaces below 2.7m in height, the equivalent air change rate to a 2.7m high space shall be used.

7.7.3.5. In science laboratories, a means shall also be provided to increase the exhaust rate to at least 5 $l/s/m^2$, by the use of openable windows and by boosting the extract rate to a higher rate and a higher noise level under override control of the staff member. This purge/boost ventilation allows the member of staff to reduce any CO_2 levels or fumes in the room, e.g., following a difficult experiment, or a spillage, or if the CO_2 warning level of 2800ppm is reached.

7.7.3.6. Noise levels during normal teaching and practical activities shall comply with Section 1.1.3 of BB93. It is a requirement to achieve the minimum exhaust rates given in Table 7-3 above for normal experimental conditions within the noise levels for practical activities given in BB93 Section 1.1.3. IoA/ANC 'Acoustics of Schools: a design guide', 2015 gives guidance on limiting the higher noise levels allowed during purge/boost and local exhaust ventilation such as use of fume cupboards.

7.7.3.7. Mechanical or hybrid ventilation systems shall be used to provide adequate ventilation during teaching and practical activities in science laboratories to provide the minimum exhaust ventilation rates given in Table 7-3 whilst meeting the cold draught criteria, see Section10.3. However, the cold draught criteria do not apply during purge ventilation as described in paragraph 7.7.3.6.

7.7.3.8. The levels of CO_2 during practical's can be higher than those allowed during teaching activities in Section 5: Ventilation of Teaching and Learning Spaces, but must comply with the gas safety requirements give in IGEM/UP/11 and paragraph 9.3.3.

7.7.4. Bunsen Burners

7.7.4.1. CO_2 levels can therefore be significantly elevated by the use of Bunsen burners; in a class of 30 pupils, CO_2 from 15 Bunsen burners is as high as that from respiration of 20 pupils.

7.7.4.2. Additional ventilation will be required when the whole class are using Bunsen burners or carrying out chemistry experiments that generate fumes. Reference should be made to the detailed guidance in the Gas Safety (Installation and Use) Regulations 1998, Regulation 2 (6) (b) and IGEM/UP/11, 'Gas Installations for Educational Establishments'.

7.7.5. Fume Cupboards

7.7.5.1. Fume cupboards are needed in some laboratories and in chemistry preparation rooms. They shall be installed and operated in accordance with the guidance in CLEAPSS Guide G9 and British Standards.

7.7.5.2. Semi-mobile fume cupboards (and where appropriate mobile fume cupboards) must be easily connected by science staff by means of docking stations and quick release service connections ideally set within the side of a teacher's demonstration desk. The connections shall not inhibit the safe use of the fume cupboards including for teacher demonstrations where students will need to gather round the fume cupboard.

7.7.5.3. The ventilation shall be designed so that the supply of incoming make-up air compensates for extraction when ducted fume cupboards are in use. Note: fume cupboards will generally balance themselves against supply and extract from natural ventilation paths in the same room but can be adversely affected by the pressures generated by stack ventilation. With regard to mechanical ventilation, that has a balanced supply and exhaust system, it is a requirement that the supply ventilation can be increased to provide 90% of the fume cupboard exhaust rate so that the room is maintained at a slightly negative pressure.

7.7.5.4. Fume cupboards shall be of the ducted type unless stated otherwise in the SSB. They shall be fixed in position in preparation rooms and be able to be pulled out from the wall on flexible connections in teaching spaces for demonstration purposes. Exceptions where recirculatory fume cupboards may be used are:

a) In refurbishment or remodelling where there is no practical means to run an external flue; or

b) Where this is recorded in the SSB; in this case, at least two ducted fume cupboards shall be provided: one in the chemical preparation room that shall be fixed in position and one in a laboratory where the School teaches ‘A’ level science which shall be a fixed or semi-mobile ducted type.

7.7.5.5. If re-circulatory fume cupboards are used, the rooms in which they are located shall be ventilated to the minimum exhaust rate of 4 $l/s/m^2$ of floor area, whenever the fume cupboards are in operation, with facility to purge vent to at least 5 $l/s/m^2$ as described in paragraph 7.7.3.6.

7.7.5.6. Both new and legacy re-circulatory fume cupboards shall comply with and be installed in accordance with BS EN 14175 and CLEAPSS Guide G9 standards for re-circulatory fume cupboards.

7.7.5.7. Recirculatory fume cupboards shall only be used as additional fume cupboards not in place of the minimum number of ducted fume cupboards required. See Annex 3.

7.7.5.8. If a re-circulatory fume cupboard is used in a preparation room, it shall have a vertical upwards discharge and the room shall have extract from high level to minimise pollutants in the occupied zone.

7.7.5.9. A risk assessment to HSG 258 is required for all fume cupboard installations.

7.7.5.10. Where fume cupboards are in use, the air speed local to the sash shall be as low as practicable. BS EN 14175 - 5 requires that the velocity of ventilation air shall not exceed 0.2m/s at a zone 400mm from the fume cupboard.

7.7.6. Preparation Rooms

7.7.6.1. In chemistry preparation rooms, ventilation at the minimum exhaust rate shall be continuous during normal working hours, with an override function for use out of these hours. Additional make-up air is required when a ducted fume cupboard is switched on. Ducted fume cupboards shall be used in preparation rooms wherever possible.

7.7.6.2. Airflow rates will be high in small preparation rooms and air velocity could be more than the normal face velocity of a fume cupboard in the closed position. At such high airflow rates, the fume cupboard can spill chemicals therefore a long air inlet slot and careful positioning of fume cupboards relative to windows and vents is needed in a small preparation room to keep the airflow velocities down in the space and to avoid chemical fumes being drawn out of the cupboard into the room.

7.7.7. Chemical Stores

7.7.7.1. Chemical stores require continuous ventilation 24 hours a day. Air supply shall be at low level and extract at high level. See Table 7-3.

7.7.8. Ventilation Controls

7.7.8.1. Air management systems with programmable controllers can accommodate a wide variety of room arrangements. Fume cupboard extract alongside room extract and supply shall be controlled locally to ensure airflow rates are kept at acceptable levels for varying equipment and room usage.

7.7.8.2. Supply-and-extract systems supplying the normal ventilation rate i.e., when the ducted fume cupboards are off shall reuse the heat from the room by mixing or heat recovery to minimise ventilation heat losses.

7.7.8.3. Black out blinds required for physics experiments can interfere with natural ventilation paths, and therefore this needs to be taken into account when designing a ventilation system. During black out experiments, the ventilation rate can be relaxed to 5 l/s/person.

7.7.9. Fume Cupboard Exhausts

7.7.9.1. Exhausts from fume cupboards shall discharge at a safe height above the highest part of the building. BS EN 14175-3 gives recommendations on the installation of fume cupboards. It recommends that the discharge shall be at 1.25 times the height or 3m above the highest point of the building and the minimum efflux velocity shall be 7m/s or preferably 10m/s. Where flues are lower than recommended the efflux velocity will need to be increased to overcome downdrafts and design calculations will be needed to prove that the flue height and efflux velocity comply with good practice as described in ASHRAE[10] and CIBSE design guidance.

7.7.10. Reference Standards

7.7.10.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of the science laboratory and fume cupboard ventilation systems and associated systems complies with the relevant parts of the following standards (or updated documents if relevant):

1. IGEM/UP/11 – ‘Gas installations for educational establishments’

[10] 2015 ASHRAE Handbook - HVAC Applications, Chapter 45, Building Air Intake and Exhaust Design

2. CLEAPSS Guide G9 – ‘Fume Cupboards in Schools’

3. BS EN 14175 – ‘Fume cupboards. Type test methods’

4. BS EN 14175-2 – ‘Fume cupboards. Safety and performance requirements’

5. BS EN 14175-3 – ‘Fume cupboards. Recommendations for the exchange of information and recommendations for installation’

6. BS EN 14175-5 – ‘Fume cupboards. Recommendations for installation and maintenance’

7. 2015 ASHRAE Handbook - HVAC Applications, Chapter 45, Building Air Intake and Exhaust Design

8. HSG 258 – ‘Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV)’

9. Gas Safety (Installation and Use) Regulations 1998, Regulation 2 (6) (b)

7.8. Ventilation for Special Education Needs and Disability (SEND)

7.8.1. General Requirements

7.8.1.1. The following is a minimum specification for the design and installation of ventilation in Special Schools and Designated Units.

7.8.1.2. The design of ventilation systems for vulnerable pupils in non-ambulant Special Schools shall:

a) minimise recirculation to mitigate risk of cross-infection; areas with complex health and hygiene requirements may require precise control of air flows with pressure regimes, depending on the needs of the pupils

b) ensure allergen and pollutant circulation is kept as low as necessary, this may require filtration depending on the needs of the pupils and the local external air quality.

7.8.1.3. The Contractor shall ensure that the ventilation for teaching spaces in a Special School or Designated Unit takes account of the typical occupant density (typically around 8 pupils compared to 30 in Mainstream School accommodation). A design rate per person is not always appropriate, although the general requirements and advice on ventilation shall be adopted.

7.8.1.4. The Contractor shall ensure that an assessment of the requirements of the occupants is undertaken before commencing the ventilation system design. This is to ensure that any specific needs of the occupants are catered for, as the requirements of SEND accommodation vary considerably depending upon the nature of the occupants.

7.8.1.5. Ventilation in SEND accommodation shall provide the minimum ventilation rates given in Table 7-4.

Designated areas	Minimum ventilation rate	Ventilation mode
Laundries, soiled holding or waste, and cleaners' rooms	3.8 l/s/m²	Mechanical extract with provision for natural or mechanical make-up as appropriate
Toilets, showers, changing areas	7.5 l/s/m²	Mechanically extracted to outside, provision shall be made for make-up air, which shall be heated and filtered. The systems shall be separate from any general school ventilation system.
Teaching spaces, physiotherapy, medical and sick rooms	2.3 l/s/m²	Ventilation systems shall be capable of controlling internal temperature and draughts. Sick rooms shall be provided with full fresh air with no recirculation.
Halls, gym and dining rooms	Dependent on density of occupation but based on 8 l/s/person or 2.5 ach whichever is the greater.	Ventilation shall be sufficient to limit CO_2 and control odours.

Table 7-4 Ventilation performance criteria for Special Schools and Designated Units

Note: *The area based ventilation rates in Table 7-4, in l/s/m2, apply to spaces of 2.7m height or higher. The equivalent air change rate per hour (ach) can be calculated from ach = (l/s/m2 rate) x 3.6/ (Room height (m)). For spaces below 2.7m in height, the equivalent air change rate to a 2.7m high space shall be used.*

7.8.1.6. Laundries, soiled holding or waste, and cleaners' rooms shall be ventilated by means of mechanical extract with natural or mechanical make-up air. Toilets for students with complex health needs and hygiene rooms shall be ventilated by means of mechanical extract to outside, with make-up air, heated and filtered. Toilets, showers, changing areas, laundries, cleaners' rooms and spaces holding soiled clothes or clinical waste shall be mechanically ventilated to achieve a slight negative pressure relative to adjacent spaces.

7.8.1.7. Ventilation design shall not compromise acoustic performance, particularly where students have additional sensitivities to noise.

7.8.1.8. Ventilation systems shall be controllable and adjustable, according to the needs of individual students. Air conditioning shall be avoided.

7.8.2. Infection Control

7.8.2.1. For schools where there are students with complex health needs, ventilation systems shall be designed for infection control and to maintain standards of hygiene. Staff shall be able to control ventilation for comfort, and draughts shall be minimised so as not to affect vulnerable and immobile students. Legionella is a higher risk to people with complex health needs, some of whom may be immuno-compromised. Particular attention needs to be paid to legionella prevention in domestic hot water systems in these schools.

7.8.2.2. Where mechanical ventilation is specified, the Contractor shall provide filtration, depending on external air quality and design exposure levels.

7.8.2.3. Some students in Special Schools or Designated Units may be very vulnerable to infection. In these cases, Health Technical Memoranda, specifically HTM 0301 Part A, published by NHS Estates shall be consulted and it is essential that infection control policies are in place and implemented. Managing cross-infection is a complex subject, but the risks of cross-contamination can be reduced through adequate source control.

7.8.3. Reference Standards

7.8.3.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of ventilation and associated systems for Special Schools and Designated Units shall comply with the regulations and take into account the guidance in the following reference standards (or updated documents if relevant):

1. HSE L8 – 'Legionnaires' disease. The control of legionella bacteria in water systems'

2. Health Technical Memorandum 03-01 – ‘Specialised ventilation for healthcare premises Part A: Design and validation’

8. Mechanical Air Conditioning Systems

8.1. General Requirements

8.1.1. Teaching spaces shall not be provided with mechanical comfort cooling, without prior approval from the Employer. Systems shall utilise passive measures such as reducing solar gain and internal gains to eliminate the need for comfort cooling.

8.1.2. Where some cooling is required, free cooling by use of thermal mass and/or providing a higher ventilation rate is the preferred option for the majority of rooms in a School.

8.1.3. Where active cooling is proposed, the contractor shall demonstrate that all other measures have been explored, in line with the cooling hierarchy, and found not to be feasible. This includes, but is not limited to:

a) minimising internal heat generation through energy efficient design by:

   i. minimising heat gain due to lighting

   ii. reducing loads by using low energy equipment

b) reducing the amount of heat entering a building in summer through:

   i. orientation, landscaping, trees and surface albedo

   ii. optimising insulation, fenestration and glazing G-Values

   iii. shading features, such as blinds (without limiting air flow through windows)

c) managing the heat within the building through exposed internal thermal mass and high ceilings

d) passive ventilation by cross flow and stack solutions (to be considered at early design stage) and/or optimised high and low level openings

e) mechanical ventilation, including limited periods of boost which exceed the upper indoor ambient room noise level, refer to paragraph 5.9 (mechanical ventilation may be proposed to mitigate the risks of cold draughts, but where the site allows, natural ventilation should be the preferred means to reduce the risk of overheating).

8.1.4. Active cooling systems (ensuring they are the lowest carbon options) shall be used for peak lopping but not full cooling. Interlocks shall be provided to the heating and/or cooling systems to prevent heating and cooling at the same time.

8.1.5. A non-technical description of any air conditioning or ventilation controls for summertime use shall be provided in the Building User Guide.

8.1.6. Air conditioning refers to the control of temperature and humidity in the air. In Schools, only comfort cooling without humidity control, where temperature only is controlled, may be used.

8.2. Refrigerant Based System

8.2.1. Where a refrigerant-based system is used the Contractor shall ensure that:

a) the amount of refrigerant in the system is minimised to reduce the potential environmental impact

b) condensing units are sited in accessible positions for maintenance

c) the length of refrigerant pipelines is minimised

d) pipework is insulated throughout its length and where exposed to sunlight is provided with suitable UV resistant insulation rather than a painted finish

8.2.2. All indoor AC units and DX coils shall be fitted with a condensate drain connected to the main drainage system via a running trap in a waste guaranteed to carry waste regularly.

8.3. Variable Refrigerant Flow (VRF) and Split Systems

8.3.1. Where VRF or split systems are used, the Contractor shall ensure that:

a) pipe lengths are minimised to reduce the volume of refrigerant

b) leak detection is installed to minimise refrigerant losses

c) maximum total pipe lengths from outdoor to indoor units, furthest indoor unit from the outdoor unit, maximum height difference between outdoor unit and lowest indoor unit are all within the recommended manufacturer's lengths

d) the equipment is easily accessible for maintenance

9. Gas Services

9.1. General Requirements

9.1.1. The design, installation and maintenance of any gas installations provided shall comply with the Gas Safety (Installation and Use) Regulations (GSIUR) and shall be in accordance with the guidelines set out in IGEM/UP/11 'Gas installations for educational establishments' and other applicable IGEM standards, relevant British Standards and UKLPG documents.

9.1.2. The Contractor shall ensure that the following requirements are met.

a) Gas supplies are interlocked with ventilation systems as required by the GSUIR and IGEM standards.

b) Gas installations are certified on completion to comply with the GSUIR, IGEM standards and British Standards and all HSE and UKLPG recommendations and requirements, as required in Employer's Requirements Deliverables.

c) Automatic Isolation Valves in accordance with IGEM/UP/11 are fitted to science gas supplies, and positioned near the teacher's desk/board, or next to main light switches or at the entrance to the laboratory.

d) Design and installation of emergency control valves (ECVs), additional emergency control valves (AECVs) and automatic isolation valves (AIVs) complies with IGEM/UP/11.

e) Where gas pipework runs in ceiling spaces or behind or inside furniture, a high and low level vent is provided to avoid a build-up of gas as described in IGEM/UP/11 and IGEM/UP/2.

9.1.3. Gas appliances can be of three types:

a) Type A appliances are those that do not require a flue to be fitted to them and include Bunsen burners, flue less appliances, e.g., some types of flueless gas fire, and most domestic and catering cookers/ranges

b) Type B appliances are those appliances that require a flue pipe and are referred to as open flued appliances (such as a gas fire, a kiln or some types of larger specialist cooking appliance, e.g., fish fryer ranges)

c) Type C appliances are referred to as room sealed (or balanced flue) and are typical of modern domestic or commercial gas boilers and may be used for heating

9.2. Gas Interlocks

9.2.1. An interlock is required between gas supply and mechanical ventilation to ensure that gas will not be supplied when there is an inadequate airflow. This is for safe operation of appliances and equipment and the safety of personnel.

9.2.2. For Type B appliances: Regulation 27(4) of GSIUR requires that any mechanical extract system that is required for safe operation of the appliances must be interlocked with the gas supply. IGEM/UP/19 provides more detailed requirements for interlock systems. It states that:

"For Type B appliances, environmental monitoring such as CO_2, temperature or humidity may be used in conjunction with variable speed drive (VSD) systems. However, fan flow/pressures switches or power monitoring shall always be used in conjunction with Type B catering appliances. CO_2, temperature or humidity monitoring is not acceptable as the main interlock for Type B catering appliances."

9.2.3. For Type A appliances: where an appliance is served by a mechanical extract system that is required for safe operation of the appliances, IGEM/UP/19 'Design and application of interlock devices and associated systems used with gas appliance installations in commercial catering establishments' 2014, requires that the mechanical extract system must be interlocked with the gas supply. IGEM/UP/19 states that:

"For new installations, CO_2 monitoring would normally be used in conjunction with either a fan flow/pressure switch or fan power monitoring but may be used alone with Type A appliances. For Type A appliances, environmental monitoring measuring CO_2 may be used in conjunction with other air quality sensors such as temperature or humidity to provide information to be included in an interlock system. It may also be used as part of a demand control ventilation system."

9.2.4. Type A appliances such as domestic cookers with their associated mechanical ventilation system(s) may therefore use CO_2 detectors or fan flow/pressures switches or power monitoring interlocks.

9.2.5. Section 4.2 of IGEM/UP/19 describes CO_2 and other interlock systems for catering establishments and should be referred to when designing CO_2 interlocks for food rooms in schools. See also Section 7.3 Food Room Ventilation.

9.2.6. For Type A appliances, a common extract duct from extraction canopies can be used with a wall mounted CO_2 interlock system, as IGEM/UP/19 requires the ventilation system to be interlocked and must be in operation before gas is available to cookers.

9.2.7. For Type B appliances a wall mounted CO_2 interlock can be used with a common extract duct from extraction canopies but ONLY **as a secondary interlock** and not as the primary interlock which shall be as described in IGEM/UP/19.

9.2.8. Table 9-1 summarises the choices of different types of gas safety interlocks for schools.

Appliance Type	Interlock System Application Appliance Type A	Interlock System Application Appliance Type B	Interlock System Application Appliance Type C	Comments
Flow switch or air pressure switch	Yes	Yes, as a *primary interlock*	Not needed	Simple system. Does not prove environmental conditions.
Mechanical ventilation fan power monitoring	Yes	Yes, as a *primary interlock*	Not needed	Simple system may be slightly better than above. Does not prove environmental conditions.
CO_2 monitoring	Yes	Yes, as a *secondary interlock* but only with a primary interlock	Not needed	For legal reasons not permitted alone with Type B. Provides positive proof/control of the environment for Type A. Suitable system for teaching spaces in which there are only Type A appliances. Easy to apply in schools having environmental control system.
VSD with CO_2 monitoring and control	Yes	Yes, as a *secondary interlock* but only with a primary interlock	Not needed	Reduces power consumption and fan noise. - Demand Controlled Ventilation. Most suitable system for teaching spaces in which there are only Type A appliances.

Table 9-1 Summary of interlock requirements according to appliance type

9.2.9. Central school catering must comply with IGEM/UP/19 and BS 6173.

9.2.10. Boiler plant rooms including gas, CHP and gas fired plant must comply with IGEM/UP/3, IGEM/UP/10, BS 6644 and other associated standards for different plant types.

9.3. Gas Safety Interlocking by Environmental/ CO_2 Monitoring

9.3.1. Where there are only Type A appliances, i.e. there are no flued gas appliances such as deep fat fryers, interlocking should be achieved by environmental monitoring of carbon dioxide as described in IGEM/UP/19.

9.3.2. Environmental CO_2 monitoring should be used in most food rooms, i.e. spaces that only contain Type A appliances and in science as Bunsen burners are classed as Type A appliances.

9.3.3. In accordance with IGEM standards, gas interlocks by environmental monitoring of CO_2 shall operate as follows.

a) During practical activities, the appliances shall not cause the CO_2 level to exceed 2800ppm, which will produce a high-level warning signal.

b) An automatic gas shut down shall initiate when 5000ppm of CO_2 is detected.

9.3.4. At 2800ppm supply and extract systems shall be automatically switched on or boosted and the teacher shall be warned that ventilation needs to be increased. Systems to control the ventilation to keep it under 2800ppm can include individual canopies vented externally, supply air fans and opening windows. Below 2800ppm these ventilation systems can be under automatic demand control with teacher or user override control so that noise levels can be easily controlled, and energy use can be minimised. Opening windows alone is not an adequate means to control CO_2 levels.

9.3.5. When practical activities are not taking place, and gas is not in use the ventilation in practical spaces shall be controlled to meet the normal CO_2 levels for teaching and learning spaces as described in Section 5.

9.4. Carbon Monoxide, Carbon Dioxide and Flammable Gas Detectors

9.4.1. Overview

9.4.1.1. Any carbon monoxide (CO) or carbon dioxide (CO_2) detection system shall comply with a standard suitable for its use and must be regularly maintained.

9.4.2. Carbon Monoxide Detectors

9.4.2.1. Inaccessible chimneys/flues shall be avoided. Chimneys/flues shall be designed and installed so that they are in a position that allows for suitable inspection and checking in the future. IGEM/UP/11 recommends CO detection systems are located in any occupied spaces through which or adjacent to which chimneys/flues pass. This protects against leakage from within chimneys which may not always be totally accessible for visual and other inspections. However, for new installations, this practice shall be avoided unless suitable and detailed plans for ongoing inspection and maintenance of the chimney/flue have been developed.

9.4.2.2. IGEM/UP/11 recommends that CO detectors are located adjacent to kilns, positioned in accordance with the detector manufacturer's instructions, as even during normal use they can produce significant levels of CO as part of the process of obtaining colours in the glazes.

9.4.2.3. There is no need for CO detection in boiler houses that have been correctly designed and ventilated in accordance with current industry practice (such as the guidance contained in IGEM/UP/10). Where a site-specific risk assessment identifies the need for CO detection in a boiler house, the equipment shall be fit for purpose and installed and located in accordance with the manufacturer's instructions and compliant with relevant standards. CO alarms compliant with BS EN 50291 are specifically designed and tested for domestic and recreational spaces. This standard is not intended for detectors for use in schools or workplaces.

9.4.2.4. Detectors complying with BS EN 45544-3[11] shall be used. Note that not all the requirements of this standard may be necessary as the standard covers much more arduous industrial environments than schools. The variety of applications

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[11] BS EN 45544-3, Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours - Part 3: Performance requirements for apparatus used for general gas detection.

for CO detection within **all** educational establishment departments requires the selection by a competent person of the most appropriate CO sensor/detector for that location. For example, it could be that a detector declaring compliance with only some aspects of BS EN 45544-3 would be appropriate within a boiler room adjacent to a corridor. Whereas more of the requirements or clauses might be relevant for a more process combustion orientated location.

9.4.2.5. CO detectors in new installations shall be hard wired.

9.4.3. Carbon Dioxide Detectors

9.4.3.1. CO_2 detectors used for gas safety interlocking shall be designed to operate in commercial catering environments. These are required in catering kitchens, science labs, design and technology heat bays and food rooms. They are required to give an audible alarm and be linked with an automatic gas shut off system, which will be fail-safe and require manual intervention in order to restore the gas supply.

9.4.3.2. Where CO_2 monitors are used as part of the ventilation control or alarm strategy, the monitors shall be placed in an area that reflects the general CO_2 levels within the practical area or cooking area. Typically, they should be fitted horizontally between 1 m and 3 m from cooking or practical areas and approximately 2.5 m above floor level. They shall not be located in high velocity air streams such as close to the edge of a canopy or adjacent to an air supply or extract position.

9.4.3.3. CO_2 detectors must be hard wired and installed in accordance with manufacturer’s instructions.

9.4.4. Flammable Gas Detectors

9.4.4.1. Flammable gas detection shall be provided in the boiler room if it is LPG fired or if it is not possible to lock the boiler room. However, all boiler rooms should be lockable. Particular attention needs to be given to the selection and location of flammable gas detection systems where LPG is supplied to boiler rooms[12].

[12] IGEM/UP/2 gives guidance on boiler rooms that may require flammable gas detection. Information on Risk Assessments is given in IGEM/UP/16.

9.5. Gas Systems in Food Rooms

9.5.1. Where there are only Type A appliances i.e., there are no flued gas appliances such as deep fat fryers, interlocking may be achieved by environmental CO_2 monitoring of carbon dioxide as described in IGEM/UP/19. See Section 9.3.

9.5.2. Reference should also be made to Section 7.3: Food Room Ventilation.

9.5.3. Reference should be made to the Annex 2I: ‘Controls’.

9.5.4. Where agreed by the Employer and the School, the Contractor may provide gasfree, electric based food teaching rooms. However, in most Schools a mixture of electric and gas cookers is traditionally required, to enable pupils to experience both gas and electric cooking. Rooms for teaching catering will need gas, as that is what is used in industrial kitchens.

9.6. Laboratory Gas Systems

9.6.1. Overview

9.6.1.1. Gas interlocking should be achieved by environmental CO_2 monitoring as described in IGEM/UP/19. See Section 9.2.

9.6.1.2. Reference should also be made to Section 7.7: Science Laboratory and Fume Cupboard Ventilation.

9.6.1.3. Reference should be made to the Annex 2I: ‘Controls’.

9.6.2. Reference Standards

9.6.2.1. In addition to the requirements set out within this section the Contractor shall ensure that the design and installation of gas services and associated systems complies with the relevant parts of the following standards (or updated documents if relevant):

1. All relevant IGEM standards published by IGEM, www.igem.org.uk including the following IGEM standards

   i. IGEM/UP/2, edition 3 – ‘Installation pipework on industrial and commercial premises’

   ii. IGEM/UP/3 – ‘Gas fuelled spark ignition and dual fuel engines’

iii. IGEM/UP/10, edition 4 – ‘Installation of flued gas appliances in industrial and commercial premises’

iv. IGEM/UP/16 – ‘Design for Natural Gas installations on industrial and commercial premises with respect to hazardous area classification and preparation of risk assessments’

v. IGEM/UP/11 – ‘Gas installations for educational establishments’, the safety requirements relating to appliances and associated ventilation and interlock systems in teaching environments are covered in detail in IGEM/UP/11

vi. IGEM/UP/19 – ‘Design, specification and application of interlock devices used within commercial and industrial applications including catering’

vii. IGEM/UP/1101 – ‘Guidance on gas installations for the management and staff within educational establishments’. This gives advice for school managers and staff which should be included in Building user guides.

2. BS EN 1266 – ‘Independent gas-fired convection heaters incorporating a fan to assist transportation of combustion air and/or flue gases’

3. BS 6172 – ‘Specification for installation, servicing and maintenance of domestic gas cooking appliances’

4. BS 6173 – ‘Specification for installation and maintenance of gas-fired catering appliances for use in all types of catering establishments’

5. BS 5440 – ‘Flueing and ventilation for gas appliances of rated input not exceeding 70 kW net’

6. The Gas Safety (Installation and Use) Regulations (SI No. 1866)

7. HSE L56 – ‘Safety in the installation and use of gas systems and appliances’. GSIUR, ACOP and guidance

10. Thermal Comfort

10.1. Overview

10.1.1. This section uses the comfort category descriptions from BS EN 15251, see Table 10-1. Note that a space may have different comfort categories for different thermal comfort criteria. For example, sports activities have a category IV for cold draughts, but a category III for the summertime overheating risk assessment.

10.2. Thermal Comfort Criteria

10.2.1. BS EN 15251 thermal comfort criteria are based on the categories shown in Table 10-1.

Category	Explanation
I - Equivalent to Category A of BS EN ISO 7730: 2005	High level of expectation and also recommended for spaces occupied by very sensitive and fragile persons with special requirements like some disabilities, sick, very young children and elderly persons, to increase accessibility
II - Equivalent to Category B of BS EN ISO 7730: 2005	Normal expectation
III - Equivalent to Category C of BS EN ISO 7730: 2005	An acceptable moderate level of expectation
IV - No equivalent category	Low level of expectation. This category shall only be accepted for a limited part of the year

Table 10-1 Categories of space/activity

10.2.2. BS EN 15251 gives comfort criteria for both mechanically cooled buildings and for ‘free running’ buildings. A ‘free running’ building is defined as a building, with either natural or mechanical ventilation, which is not actively heated or cooled.

10.2.3. The thermal comfort criteria for schools in this section are based on the adaptive thermal comfort standards for ‘free running’ buildings outside the heating season; PD CR 1752:1999; BS EN ISO 7730; and BS EN 15251; and CIBSE Guidance with local interpretation for children and Schools in England.

10.2.4. For Refurbished Buildings and Remodelled Areas, the minimum standard is Category IV where Category III cannot be met for reasons of practicality and due to the extent of refurbishment. However, after refurbishment the criteria shall not be worse than before refurbishment in any aspect affecting thermal comfort.

10.3. Operative Temperature Range

10.3.1. The Contractor shall ensure that there are sufficient temperature control mechanisms provided to enable the users to adjust the internal temperature, influence the environment, and maintain a satisfactory level of comfort throughout the year. Temperature, ventilation and lighting controls in schools shall be classroom based and simple to operate.

10.3.2. The Contractor shall design any heating system provided to achieve the operative temperatures in the heating season listed in Table 10-2.

Type of space/activity	ADS Code	Normal maintained operative temperature - °C	Maximum operative temperature during the heating season at maximum occupancy - °C
Stores not normally occupied	T1	5°C	N/A
Areas where there is a higher than normal level of physical activity (such as sports halls) and sleeping accommodation	T2	17°C	23°C
Toilets, circulation spaces and store rooms that are normally occupied	T3	17°C	24°C
Kitchen preparation areas	T4	20°C	N/A
Spaces with normal level of activity, including all basic teaching areas (including practical and ICT-rich spaces), study and social space, learning resources, halls used for exams, admin and staff areas, prep rooms.	T5	20°C	25°C

Type of space/activity	ADS Code	Normal maintained operative temperature - °C	Maximum operative temperature during the heating season at maximum occupancy - °C
Spaces with less than normal level of activity or clothing, including sick, MI or therapy rooms, changing rooms and gymnasia and dance and activity studios	T6	21°C	26°C
Special Schools and Designated Units, pupils have physical disabilities or profound and multiple learning difficulties	T7	23°C	25°C
Where pupils or adults may be wet and partially clothed for a significant length of time, such as swimming pools;	T8	23°C in changing rooms and no more than 1°C above or below that of the water temperature in pool halls subject to a maximum of 30^{0}C	28°C in changing rooms and no more than 1°C above that of the water temperature subject to a maximum of 30°C in pool halls
Where young children or those with physical disabilities may be wet or partially clothed for a significant length of time. More rapid air movement leads to greater chilling by evaporation and to compensate, a higher design temperature is required.	T9	25°C The air speed in these environments should be as low as possible and not exceed 0.15 m/s at 25°C	30°C

Table 10-2 Operative temperatures to be achieved during the heating season measured at 1.4m from the floor in the centre of the room

Note: *SEND pupils can be very sensitive to temperature and it may be necessary to adjust the normal operative temperature and maximum temperature in the heating season depending on the needs of the pupils.*

10.4. Local Thermal Discomfort Caused by Draughts

10.4.1. General Requirement

10.4.1.1. The design of any ventilation system provided, and its control shall avoid cold draughts in the occupied zone.

10.4.2. Natural Ventilation Systems

10.4.2.1. The decision of whether or not natural ventilation is suitable shall be based on the temperature difference on a cold still day during mid-season with the heating system switched off. This assessment does not need to consider the velocity of the supply air plume but only its temperature. However, higher air speeds for summer daytime purge cooling of classrooms can be a nuisance if they blow papers off desks.

10.4.2.2. When the outside air temperature is 5°C it must be possible to have the heating emitters switched off and still deliver air to the occupied zone (at seated head height) at a temperature not more than 5 K below the normal maintained operative temperature given in Table 10-2.

10.4.2.3. Table 10-2 Seated head height shall be taken as 1.1m above floor level for Primary School and 1.4m above floor level for Secondary School classrooms.

10.4.2.4. For Category I spaces the temperature difference must be less than 3°C whenever the natural ventilation system is in use.

10.4.2.5. The line plume calculator shall be used to estimate the temperature of air from high-level openings when it reaches the occupied zone or alternatively measurements can be made in test rooms or CFD models can be used.

10.4.3. Forced Draught Systems

10.4.3.1. In a mechanical system where the driving force for the supply air is a fan, the design shall meet the values given in Table 10-4 for the maximum temperature difference between the operative temperature of the room and the temperature of the supply air jet or plume and the maximum local air speed of the jet or plume for the different comfort categories for schools. Table 10-4 is based on the comfort criteria in BS EN 15251 for mechanical ventilation systems. The comfort categories for cold draughts for different spaces and activities given in Table 10-3 shall be used with Table 10-4.

Space/Activity	Minimum recommended comfort category for draught
Stores, corridors and circulation spaces that are not normally occupied spaces,	N/A
Areas where there is a higher than normal level of physical activity (such as sports halls) and sleeping accommodation	Category IV. Low air speeds required for Badminton competitions may necessitate ventilation systems being switched off
Toilets, circulation spaces and store rooms that are normally occupied	Category IV
Kitchen preparation areas	N/A

Space/Activity	Minimum recommended comfort category for draught
Spaces with normal level of activity, including all basic teaching areas (including practical and ICT-rich spaces), study and social space, learning resources, halls used for exams, admin and staff areas, prep rooms	Category III or Category IV where there is local manual control over the ventilation rate e.g. manually opened windows or room ventilation with on/off and variable speed control
Spaces with less than normal level of activity or clothing, including sick, isolation rooms, changing rooms and gymnasia and dance and movement studios	Category II
Special Schools and Designated Units, where needs of pupils may be complex and varied, including pupils with physical difficulties or profound and multiple learning difficulties	Category I
Where pupils or adults may be wet and partially clothed for a significant length of time, such as swimming pools	Category II
Where young children under 5 years old or those with physical disabilities may be wet or partially clothed for a significant length of time. More rapid air movement leads to greater chilling by evaporation and to compensate, a higher design temperature is required	Category I

Table 10-3 Comfort categories for cold draughts

10.4.3.2. Category IV shall only be used in classrooms and other teaching spaces where there is local control over the room ventilation with variable speed control with override control by the teacher. The air quality criteria regarding CO_2 levels must still be met.

Category of space / activity	Winter ΔT (Min maintained operative temp - plume local air temp)	Winter Maximum air velocity (m/s)	Summer and mid-season ΔT ($T_{room, operative}$ - plume local air temp) When T_{room} ≤25ºC or T_{comf}	Summer and mid-season Maximum air velocity (m/s)
I	1.5	0.15	1.5	0.15
II	2	0.2	2	0.2
III	3	0.25	3	0.25
IV	4	0.3	5	0.3

Table 10-4 Recommended draught criteria for mechanical ventilation systems to provide thermal comfort

10.4.3.3. Table 10-4 assumes an activity level of 1.2 met, a clo value of 1.1 in winter 0.9 in mid-season and 0.7 in summer, and a minimum maintained operative temperature as in Table 10-2 in winter, mid-season, and 23°C in summer.

10.4.3.4. The values in Table 10-4 apply to the supply air plume which delivers air to the occupied zone. The occupied zone shall be taken as from 0.6m to 1.4m above floor level.

10.4.3.5. It is likely that mechanical or hybrid ventilation systems will be needed to provide adequate ventilation without cold draughts during teaching and practical activities in science laboratories and design and technology spaces. However, the cold draught criteria do not apply during purge ventilation.

10.4.3.6. Higher speeds and larger temperature differences are permitted in winter for boost/purge ventilation in practical spaces under the control of the teacher e.g. in science or food. Opening windows shall therefore be provided, preferably providing cross ventilation, to food and science rooms to maximise airflow in summer peak conditions and to purge the space of fumes and heat.

10.4.3.7. For summertime cooling purposes, higher maximum air speeds are allowed and often preferable (draught becomes pleasurable breeze), but only under the condition that the teacher or the occupants have direct control over the openings or fans.

10.4.3.8. CFD (Computational fluid dynamics) modelling is not expected to estimate room air speeds. Manual calculations based on manufacturers' information can be used to predict the speeds and they can be measured with an anemometer.

Grille manufacturers supply the necessary tables to predict velocity at the occupied zone. Temperature will be based on the temperature of the jet and the appropriate entrainment coefficients. If required to measure air velocity, it shall be measured with an omni-directional anemometer with a 0.2s time constant.

10.4.3.9. The criteria for maximum local air speed and minimum local temperature of the supply air plume can be related mathematically by the method given in BS EN ISO 7730 to obtain a Predicted Mean Vote (PMV) that is related to PPD (percentage of people dissatisfied). This requires the clo[13] value of the clothing and the metabolic rate of the occupants to be known. By using this formula, equivalent conditions to those given in Table 10-4 can be obtained that give the same or a better PPD, e.g., a slightly higher air speed can be used with a slightly higher supply air temperature.

10.5. Performance Standards for the Avoidance of Overheating

10.5.1. The adaptive thermal comfort method from EN 15251 together with the guidance in CIBSE TM52 '*The Limits of Thermal Comfort'* (Technical Memorandum) and CIBSE KS16 '*How to Manage Overheating in Buildings'* (Knowledge Series) has been adopted by DfE to address the problem of overheating in Schools. The adaptive comfort criteria only apply to 'free running' buildings i.e. those without mechanical cooling and with means for the occupants to locally alter conditions i.e. to increase the ventilation rate by means of opening windows or by local room controls. Most schools are 'free running' outside the heating season.

10.5.2. To manage overheating successfully using adaptive thermal comfort it is necessary to allow relaxation of formal dress in hot conditions to encourage individual adaptation to conditions. Where pupils cannot regulate their temperature because of illness or physical disabilities, special measures must be taken to accommodate their need for a closely controlled thermal environment and to help them to regulate their temperature e.g. by providing local cooling for their specific needs. This advice shall be given to the Schools and included in Building user guides.

10.5.3. The personal factors identified which contribute to the perception of thermal comfort, cannot be directly influenced as part of the design. The provision of adequate ventilation for good indoor air quality and the perception of occupant control will together overcome some personal factors. Such factors as dress codes, activity scheduling, etc., shall be considered within the briefing process and discussed with the School management team in order for them to better understand how they influence thermal comfort and to help establish policies on such matters. The School

[13] The clo is a measure of the thermal insulation of clothing. 1 Clo = 0.155 m2K/W

management team will then be better able to reduce the risk and impact of overheating in their buildings.

10.5.4. All occupied spaces shall be provided with ventilation for warmer weather, preferably by using cross flow natural ventilation or ventilation systems with equivalent ventilation effectiveness and night cooling. This will minimise ventilation opening sizes and eliminate the need for mechanical cooling. Crossventilation strategies normally require smaller ventilation openings than for single-sided ventilation reducing draughts and making it easier to meet the acoustic requirements for sound insulation of the building envelope.

10.5.5. The design shall allow air movement to be increased during the summer through opening windows or vents, switching on fans, or increasing the rate of mechanical ventilation. Ceiling fans may be used, except in a Special School accommodating pupils who are visually sensitive to the movement or flickering reflections from such fans.

10.5.6. Buildings shall be assessed for overheating and ventilation openings shall be sized using dynamic thermal modelling and the CIBSE DSY1 2020 (50th. percentile range) weather file most appropriate to the location of the School building[14].

10.5.7. Mechanical ventilation shall not be the sole method of summertime ventilation in occupied spaces and there shall be opening windows or vents, with sufficient effective opening area.

10.5.8. In the absence of detailed thermal modelling, openable windows or vents for summertime ventilation shall be sized so that the effective area, A_{eff} is at least 3% of the floor area. (Note that depending on the type of opening, this can imply a physical opening area of approximately 5% of the floor area.) Some designs will result in more effective area than others and smaller effective areas may be possible if the design includes some degree of cross ventilation, atrium assisted stack ventilation or fan-assistance which will increase the airflow through openings. In all cases, the rooms need to have enough opening area and flow to comply with the summertime overheating criteria below. See Section 11.3 for definition of A_{eff}.

10.5.9. There are significant differences between the ventilation effectiveness of various types of windows or ventilation openings. See CIBSE AM 10 '*Natural Ventilation in Non-Domestic Buildings'* (Applications Manual) and Section 11.3: Ventilation Opening Areas and BB101.

[14] See CIBSE Technical Briefing and Testing report on the new weather files http://www.cibse.org/getmedia/ce7a77e8-3f98-4b97-9dbc-7baf0062f6c6/WeatherData_TechnicalBriefingandTesting_Final.pdf.aspx

10.5.10. Controls shall be provided to enable the teacher to temporarily override the mechanical ventilation in each room to switch it on or off.

10.5.11. Where internal blinds are fitted to windows, these shall not interfere with ventilation. Care shall be taken to avoid flutter caused by ventilation airflow.

10.5.12. CIBSE has published criteria in TM52 to assess overheating in free-running buildings, based on the adaptive comfort model. The requirements set out in this section are based on these criteria.

10.5.13. This approach follows the methodology and recommendations of European Standard EN 15251 to determine whether a building will overheat, or in the case of an existing building whether it can be classed as overheating. The criteria are based on a variable temperature threshold that is related to the outside runningmean dry-bulb temperature.

10.5.14. The designer shall carry out an Overheating Risk Assessment (ORA) of 'free running' designs by following the procedure set out in CIBSE TM 52. The design of mechanically cooled buildings shall be in accordance with the CIBSE guidelines for air-conditioned buildings.

10.5.15. The designer shall calculate the indoor operative temperatures for each of the months where the building is in free-running mode on a frequent (e.g. hourly or half-hourly) basis. The simulation tool used shall be capable of calculating Operative Temperature, T_{op} and Running Mean Temperature, T_{op} and T_{rm} are defined in TM52. T_{rm} is a running mean of external air temperature and changes on a daily basis. Calculations shall realistically account for the occupancy pattern of the building, heat loads of equipment, and the adaptive behaviour of the occupants. See Section 11 for design criteria to be used in ORA calculations.

10.5.16. The performance standards are based on the adaptive thermal comfort standards described in BS EN15251, CIBSE TM52 and KS16.

10.5.17. For all free-running School buildings, the ORA shall be carried out based on the Categories given below in Table 10-5.

Type of Space or Activity	New Build	Refurbishment
Teaching and learning, drama, dance, exams, multi-purpose halls	II	III/IV
Practical activities such as cooking	N/A	N/A
Sports halls not used for exams	III	IV
Working areas, e.g. kitchens	N/A	N/A
Offices	II	III/IV
Atria, circulation, reception and corridors - not continuously occupied	III	IV
Areas for pupils with complex health needs[a]	I	I

Table 10-5 Adaptive thermal comfort category to apply

10.5.18. In the case of pupils with complex health needs, an assessment of the individual needs must be made. Adaptive comfort thresholds may not be applicable and fixed temperature thresholds may need to be used. This category applies only to Designated Units or Special Schools for non-ambulant pupils or those with medical conditions.

10.5.19. The values for the maximum acceptable temperature (T_{max}) being calculated from the running mean of the outdoor temperature (T_{rm}) and the suggested acceptable range, as given in Table 10-6 below, are as follows:

$$T_{comf} = 0.33\,T_{rm} + 18.8$$

and $T_{max} = T_{comf} + (\text{acceptable range } ^0\text{C})$

10.5.20. Therefore, for category II as defined in Table 10-6, below, where the acceptable range is 3^0C:

$T_{max} = 0.33\,T_{rm} + 21.8$ (See CIBSE KS16 or TM52 for definition of T_{rm}).

Category	Explanation	Suggested acceptable range °C
I	High level of expectation and also recommended for spaces occupied by very sensitive and fragile persons with special requirements like some disabilities, sick, very young children and elderly persons, to increase accessibility.	+2 / -3 °C
II	Normal expectation	+3 / -4 °C
III	An acceptable moderate level of expectation	+4 / -5 °C
IV	Low level of expectation. This category should only be accepted for a limited part of the year	>+4 / <-5 °C

Table 10-6 Suggested applicability of the categories and their associated acceptable temperature range for 'free running' buildings (from BS EN 15251:2007, prEN 16789-1: 2015)

10.5.21. The three criteria for overheating are all defined in terms of ΔT, the difference between the actual operative temperature in the room at any time (T_{op}) and T_{max} the limiting maximum acceptable temperature. ΔT is calculated as $\Delta T = T_{op} - T_{max}$ (°C)

ΔT is rounded to the nearest degree (i.e. for ΔT between 0.5 and 1.5 the value used is 1°C, for 1.5 to 2.5 the value used is 2°C and so on)

10.5.22. Three criteria that have been developed to indicate when overheating is likely to be problematic. These criteria should be applied outside the heating season and for the hours of 09:00 to 16:00, Monday to Friday, from 1st May to 30th September, including the summer holiday period as if the School was occupied normally through the summer (a lunchbreak 12pm to 1pm with no internal heat gains during this period may be allowed for in classrooms). The three criteria are:

a) the number of hours for which an adaptive thermal comfort threshold temperature is exceeded (total hours of exceedance)

b) the degree to which the operative temperature exceeds the adaptive thermal comfort threshold temperature (daily weighted exceedance)

c) the maximum temperature experienced at any occupied time (upper limit temperature)

10.5.23. The first of these criteria (Criterion 1) defines a minimum requirement for the overheating risk assessment. The two additional criteria (Criterion 2 and Criterion 3) are primarily measures of short-term discomfort and should be reported for information only. If a School design fails to meet Criterion 2 or Criterion 3 then designers should consider potential overheating mitigation measures and indicate which are viable for the project. The use of these three performance criteria together aims to ensure that the design is not dictated by a single factor but by a combination of factors that will allow a degree of flexibility in the design.

Criterion 1 - Hours of Exceedance (H_e):

For Schools, the number of hours (H_e) that ΔT is greater than or equal to one degree (K) during the period 1st May to 30th September for the defined hours inclusive shall not be more than 40 hours.

10.5.24. Criterion 1 provides an understanding of how often a building in any given location is likely to exceed its comfort range during the summer months (1st May- 30th September). It can provide useful information about the building's thermal characteristics and potential risk of overheating over the range of weather conditions to which it will be subjected. Simple hours of exceedance are something that designers are familiar with and provide a good assessment of acceptability over the summer. The defined hours used are the entire period from 1st May to 30th September for the defined hours of 09:00 to 16:00 excluding weekends. Full occupancy is assumed through the holiday period.

Criterion 2 – Daily Weighted Exceedance (W_e):

To allow for the severity of overheating the weighted Exceedance (W_e) shall be less than or equal to six in any one day.

Where $W_e = \sum h_e \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$

Where the weighting factor wf = 0 if $\Delta T \leq 0$, otherwise wf = ΔT and h_{ey} = time in hours when wf = y

10.5.25. This criterion sets an acceptable level for the severity of overheating and sets a daily limit of acceptability and is based on Method B – 'Degree hours criteria' in BS EN15251; 2007. It is the time (hours and part hours) during which the operative temperature exceeds the specified range during the occupied hours, weighted by a factor which is a function depending on by how many degrees the range has been exceeded. The value of the weighting factor is based on the observed increase in the percentage of occupants voting 'warm' or 'hot' on the ASHRAE scale (overheating risk) with each degree increase in ΔT, the temperature above the comfort threshold temperature.

10.5.26. The value of six is an initial assessment of what constitutes an acceptable limit of overheating on any single day. This initial assessment was made from observations of the temperature profiles from case studies of a range of freerunning buildings that are perceived to perform well at one end of the range and poorly at the other in regard to limiting overheating. For further information, see CIBSE TM 52.

Criterion 3 - Upper Limit Temperature (T_{upp}):

To set an absolute maximum value for the indoor operative temperature the value of ΔT shall not exceed 4K.

10.5.27. Criterion 3, the threshold or upper limit temperature sets a limit beyond which normal adaptive actions will be insufficient to restore personal comfort and the vast majority of occupants will complain of being ‘too hot’. This criterion covers the extremes of hot weather conditions and future climate scenarios.

10.5.28. These criteria should be the basis of the thermal modelling of the building, with Criterion 1 defining the minimum requirement for assessing the risk of overheating of School designs.

10.5.29. In addition, the asymmetric radiation from hot ceilings in single storey teaching spaces shall be less than 5K in summertime. In order to achieve this hot air must not be trapped at ceiling level and there must be an adequate means to extract hot air from the ceiling zone. For example, cross ventilation can provide adequate airflow across the ceiling and prevent a layer of hot air from building up beneath the ceiling.

10.5.30. Where, after consideration of such measures and taking account of other factors that could restrict the use of natural ventilation (e.g. air pollution, traffic noise) the designer deems that the heat load is such that cooling is required, the designer should consider low carbon cooling systems in preference to conventional air conditioning. Such systems could include using cool water from boreholes or drawing in air through earth tubes.

10.5.31. Schools shall be designed without the use mechanical cooling in general teaching spaces. The spaces shall be designed to accommodate ICT equipment heat gains of up to 15W/m² in classrooms, or 25W/m² in practical spaces without the use of mechanical cooling. Practical spaces are generally larger and have a lower occupancy gain per square metre than general teaching spaces which helps to compensate for a higher equipment heat gain.

10.5.32. Where the Contractor decides to use of mechanical cooling, for example at times of peak summertime temperatures in areas of particularly high equipment heat load, this shall be justified on heat load and energy efficiency grounds and agreed with the Employer. For example, in teaching spaces where the heat gains exceed 25W/m^2 mechanical cooling may be considered. See Section 11.5.2 for further details on the calculation of internal heat gains.

10.6. Assessment of Performance in Use

10.6.1. Overview

10.6.1.1. Air temperatures rather than operative temperatures shall be used when communicating with the School and to assess thermal comfort in buildings in use, as these are easier for the occupants and the facilities management team to understand. If there appears to be a failure using the criteria based on air temperatures described below then the Contractor or a heating expert should be asked to consider if the building is overheating. This will require investigation of operative temperatures and comparison with design predictions.

10.6.1.2. The Contractor is required to monitor the indoor environment by recording temperature and CO_2 as well as energy consumption as described in Annex 2I: Controls. Performance in use temperatures for assessment of summertime conditions shall be monitored in typical north, south, east and west facing classrooms and in other key spaces, such as: atria, dining spaces, libraries, learning resource centres, admin and head teacher's offices, server rooms and reprographics rooms, and recorded as part of Building Performance Evaluation, See GDB Section 2.14.6: Building Performance Evaluation (BPE) and seasonal commissioning.

10.6.2. Performance in Use Standard for Overheating

10.6.2.1. The following performance in use (PIU) criteria shall be used:

a) It shall be possible to demonstrate within spaces that are occupied for more than 30 minutes at a time that, during the school day, the average internal air temperature does not exceed the average external air temperature measured over an occupied day by more than 5ºC; both temperatures being averaged over the time period when the external air temperature is 20ºC, or higher, except when the diurnal temperature range[15] (lowest temperature from the previous night to the maximum daytime temperature the following day) is less than 4ºC.

[15] The diurnal temperature is typically 7°C and is > 4°C on approximately 2/3rds of nights, i.e. except when there are anti-cyclonic conditions.

b) The buildings shall be able to achieve temperatures within the acceptable range when windows, fans and ventilation systems are operated to reduce summertime temperatures, and the space has the intended number of occupants, numbers and types of computers, data projectors and other ICT equipment.

c) Note: these overheating criteria are for the thermal comfort of occupants and are not applicable for equipment such as in server rooms. The extra heat loads from cookers in food and Bunsen burners in science that occur intermittently should be considered separately.

10.6.2.2. If a space fails the PIU criteria above and the internal recorded air temperatures exceed T_{max} for Cat III, the Contractor shall examine the temperature records and investigate whether or not the building is overheating and if the building is performing as designed.

10.6.2.3. To compare predicted design and measured temperatures the Contractor will need to measure operative temperatures as well as air temperatures. This can be done using a small black bulb thermometer or specialist electronic instrumentation. See CIBSE KS16 for further information.

10.6.2.4. The Contractor shall inform the facilities management team that there may be a difference between the air temperature measured in a room and the design temperature (operative temperature).

10.7. Thermal Comfort for Special Education Needs

10.7.1. For comfort conditions for people with special requirements such as those with physical disabilities, BS EN ISO 7730 refers to BS EN ISO/TR 14415:2005. Where pupils have special needs that affect their temperature response, or for very young pupils an assessment of their particular needs will be required which may mean that higher categories of comfort criteria may be needed in particular areas of a school or across a whole school.

11. Design Calculations for Ventilation and Thermal Comfort

11.1. Overview

11.1.1. Ventilation and thermal comfort design for teaching and learning activities shall be proved by modelling for the occupied period.

11.1.2. The modelling assumptions affect the calculation results significantly. For this reason, DfE projects are required to use the following default assumptions regarding the internal conditions in the occupied spaces of the School:

a) Occupied hours assumed 09:00-16:00, Monday to Friday

b) Occupancy, lighting and small power set to zero during lunch hour (12:00-13:00) in all classroom areas

c) The School is assumed to be occupied throughout the summer period for modelling of overheating (this provides a degree of future proofing)

d) An external ambient CO_2 concentration of 400ppm

11.1.3. At the detail design stage for New Buildings and major refurbishment or Remodelling, dynamic thermal simulation tools shall be used to assess ventilation, energy performance, summertime overheating and the effect of night cooling. These form part of the Environmental Strategy Report and the Design Calculations described in the Employer's Requirements Deliverables.

11.2. Ventilation Calculations

11.2.1. CO_2 levels shall be below the required values given in Section 5: Ventilation of Teaching and Learning Spaces. Calculations at concept design stage and scheme design stage need to be carried out for summer, winter and mid-season design conditions to prove that the design will operate satisfactorily throughout the year.[16]

11.2.2. In addition to the ventilation design for normal teaching and learning activities, the ventilation for specialist needs such as science or D&T must be considered.

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[16] See GVA/15 CIBSE Guide A: 'Environmental Design 2015' Section 4.2 'Ventilation and air quality' including equations 4.1 and 4.2

11.2.3. For a natural ventilation system, the Contractor shall follow the design steps given in CIBSE AM10.

11.2.4. Designs must provide sufficient openable areas in suitable locations for winter, mid-season and summer conditions; and means by which the occupants can control the openable areas must be provided. The designer should consider the results of the overheating analysis, which may show that higher airflow rates are required for either daytime or night time cooling.

11.3. Ventilation Opening Areas

11.3.1. There are two types of ventilation openings in the thermal envelope of a building, those that are intentional, known as 'purpose provided openings' (PPOs) and those that are unintentional, known as 'adventitious openings.

11.3.2. Successful ventilation design requires the correct sizing and location of PPOs provided for natural, hybrid and mixed mode ventilation systems. In order to do this the Contractor shall determine the effective area of PPOs.

11.3.3. For clarity, this specification and BB101 adopt the definitions recommended by the CIBSE Natural Ventilation Group for free area, effective area and equivalent area[17]. See BB101 Annex D: Definition of opening areas. Effective area shall be used for the sizing of ventilation openings.

11.3.4. Contractors shall stipulate effective area (A_{eff}) on their drawings and ventilation specifications as required in the Employer's Requirements Deliverables. Manufacturers should report A_{eff} as a matter of good industry practice to aid selection of the most appropriate PPO. The effective area of windows and ventilators is obtained by testing the appliances in accordance with BS EN 13141 (2004) and should be quoted by manufacturers. In the absence of empirical data from manufacturers, a calculation tool[18] can be used to estimate A_{eff}. It is necessary to use these tools with care and to consider clear opening dimensions rather than structural openings, taking into account reductions in opening dimensions due to frames, mullions, cills, reveals and adjacent windows.

11.3.5. For turbulent flow through a PPO as normally occurs in natural ventilation openings in buildings the airflow is governed by the following equation

[17] *A review of ventilation opening area terminology*, B.M. Jones, M.J. Cook, S.D. Fitzgerald, C.R. Iddon, Energy and Buildings 118 (2016) 249-258.

[18] see the Discharge Coefficient Calculator available on www.gov.uk

$$Q = A_{eff} \sqrt{\frac{2\Delta P}{\rho}}$$

Q = turbulent uni-directional Airflow rate (m^3/s)
A_{eff} = effective area of PPO (m^2)
ΔP = pressure drop across the opening (Pa)
p= density of the air (kg/m^3)

This equation applies where flow is fully turbulent and the coefficient of discharge (C_d) does not depend on the airflow velocity. Where this is not the case as in the case of a single PPO comprised of many small openings in parallel e.g. an insect mesh, then caution is required, and measurements are needed to establish the relationship between airflow rate and pressure difference.

11.3.6. For fully turbulent flow the effective area of a PPO, A_{eff} is defined as the product of its discharge coefficient and its free area:

$$A_{eff} = A_f \ x \ C_d$$

A_f = Free area of the PPO (m^2), this is simply the physical size of the aperture of the ventilator and does not reflect the airflow performance of the ventilator.

C_d = Coefficient of discharge of the PPO. Note that for windows this value changes dependent upon the opening angle and shape.

11.3.7. Some dynamic thermal modelling software uses equivalent area, this term simply compares the PPO opening of effective area (A_{eff}) in question with an opening, which is circular and sharp-edged:

$$A_{eq} = \frac{A_{eff}}{C_{do}}$$

A_{eq} = Equivalent area m^2)

C_{do} = Discharge coefficient of a sharp-edged circular orifice. Designers should check their software documentation for values of C_{do} used, as these can vary between 0.60 and 0.65

11.3.8. The Contractor shall take into consideration that, the more complicated and/or contorted the airflow passages in a ventilator, the less air will flow through it.

11.3.9. If airflow occurs both into and out of a space through a single opening on one side of a building (bidirectional flow), the PPO coefficient of discharge will be reduced to around 40% of the value for unidirectional flow, in part because only half of the ventilation opening is available for airflow into the building. This will impact on the effective area of the PPO. The is explained on pages 45 and 46 of CIBSE AM10 'Natural Ventilation in Non-domestic Buildings', 2005 where it states that in the buoyancy flow equation 4.12 the value of C_d is reduced typically from 0.6 to 0.25. Some software programmes, e.g., IES, already allow for this reduction in flow.

11.3.10. Obstructions to the flow of air (e.g. deep external sills and recesses) must be taken into account, as these will have the effect of reducing the airflow through the opening.

11.3.11. Examples of obstructions include cills, recesses and blinds. They can be seen as another airflow obstruction coefficient, and their presence means their impact on the PPO free area should be accounted for to achieve the required effective area.

11.4. Mechanical Ventilation

11.4.1. Where hybrid ventilation is being proposed, the mechanical ventilation element needs to be modelled correctly. If it is supply and extract ventilation, then a fixed or demand-controlled ventilation rate of outside air should be incorporated in the model. If the system is extract only with openable windows, the model should be set up with a zone exhaust and not an exchange rate to outside. Note: For thermal modelling and overheating assessment purposes, mechanical ventilation is classified as 'free-running' in the absence of mechanical cooling and tight temperature control.

11.5. Thermal Comfort Calculations

11.5.1. Weather File for Overheating Risk Assessment

11.5.1.1. CIBSE/Met Office hourly weather data Test Reference Years (TRYs) and Design Summer Years (DSYs) are available for 14 locations across the UK.

11.5.1.2. The CIBSE DSY1 2020 weather file most appropriate to the location of the School building shall be used for the summertime thermal comfort assessment.

This does not necessarily mean the nearest location and the file should reflect the most compatible climatic characteristics.

11.5.1.3. DSY consists of a single continuous year of hourly data, selected from the 20-year data sets (1983-2004) to represent a year with a hot, but not extreme, summer. The selection is based on the daily mean dry-bulb temperatures during the period April to September, with the third hottest year being selected. This enables designers to simulate building performance during a year with a hot, but not extreme, summer.

11.5.2. Internal Gains for Overheating Risk Assessment

11.5.2.1. Occupancy rates vary depending on the activity present in the room. For a typical classroom 32 occupants shall be allowed with each having a sensible heat gain of 70 W and a latent heat gain of 55W (in Primary School settings, a lower sensible heat gain of 60W/pupil may be allowed).

11.5.2.2. Lighting gains in classrooms shall be considered to be 7.2 W/m^2 unless calculations e.g. if daylight displacement or product selection show that lower gain rates are justified. These calculations must include all heat gains such as parasitic loads from dimmers and ballasts.

11.5.2.3. If daylighting is being used to lower the lighting gain, then this must be justified as being within the software's capability and that it has been properly implemented. If the blinds are included in the window transmission values, then the lights should be assumed to be on.

11.5.2.4. ICT usage is dependent on the room type being investigated. Typically, a classroom will have a maximum ICT gain of 10 W/m^2, with dedicated ICT rooms and practical rooms with more powerful computers having up to 25 W/m^2. In some rooms, lower or higher equipment gains may be applicable. The DfE ICT equipment heat gain calculator can be used to estimate the heat gain from ICT equipment in teaching spaces. The calculator allows for the diversity of use and loads.

11.5.2.5. For the purposes of modelling summertime overheating to determine the required size of summertime natural ventilation openings to prevent summertime overheating, the maximum average air speed through the vent should be assumed to be less than 0.8 m/s.

11.5.2.6. Food rooms should be modelled with the same internal heat loads as a standard classroom. The additional load associated with cookers should be assumed to be removed by extract hoods where they are fitted and in use.

11.5.2.7. Opening windows shall be provided, preferably to provide cross ventilation, to food, science rooms and other practical spaces to maximise airflow in summer peak conditions.

12. Public Health Engineering Services

12.1. Overview

12.1.1. Public health engineering includes above and below ground drainage and domestic hot and cold-water services.

12.1.2. Any new or extended system must be fully integrated with existing systems even if these are out of scope of the project.

12.2. Drainage Systems

12.2.1. Foul Drainage Above-ground

12.2.1.1. The Contractor shall design, supply, install, test and commission all necessary aboveground soil & waste drainage systems required to drain all of the building's sanitary fittings and waste.

12.2.1.2. Wherever possible new draining runs should be connected to the nearest foul drainage outfall from the site to give a 60 year system design life. Where it is not possible to connect into the outfall from the site any existing drain into which a new drainage system is connected shall be:

- In a suitable state of repair
- of the correct size to allow for the increased capacity, and
- have the correct fall to take account of the lower flow rates from modern sanitaryware to avoid blockages

12.2.1.3. Condition of existing drains shall be assessed via CCTV up to the main utility connection point. Any repairs required shall be inspected and validated by a drainage test upon completion to ensure compliance with building control requirements.

12.2.1.4. Pumped drainage shall not be connected into existing gravity fed drainage systems.

12.2.2. System Description

12.2.2.1. The Contractor shall ensure that the following requirements are met:

a) A system of soil and waste is provided to collect the soil and waste from WCs, sinks, showers and wash hand basins throughout the Buildings to convey this to the below ground foul water drainage system

b) A soil and waste system is provided, based on the single stack principle, with anti-syphon pipework used only where necessary to prevent both induced and self-syphonage occurring thereby reducing the likelihood of trap seal loss

c) Throughout the system, access points are provided on all vertical soil stacks at each floor level and in horizontal runs at changes of direction to assist in the maintenance of the system and to aid in the clearing of blockages

d) All stub stacks incorporate an access cap

e) All soil stacks rise to roof level where they safely discharge to atmosphere with a durable and secure domical cage which is resistant to bird nesting and movement by vermin

f) Automatic Air Vents (AAVs) are only used by agreement where there is no practicable way to provide a roof stack (AAVs are only permitted for isolated rooms). Heads of drains in kitchens shall be taken to air wherever possible

g) Air admittance valves are permitted for isolated rooms where providing a roof stack is not possible

h) Ventilation stacks do not terminate less than 900mm above the top of any openable window or natural ventilation opening and within a horizontal distance of 3m and terminate 450mm above the roof level

i) Where drainage and discharge stacks pass through occupied spaces, they are acoustically insulated to prevent noise breakout into the space

j) The stacks serving laboratory sinks are HDPE or cast iron incorporating chemical resistant EPDM couplings

k) Either all laboratory pipework is polypropylene, and a dilution trap fitted before the below-ground drainage connection or a polypropylene dilution trap is fitted to each laboratory sink

l) No other waste is connected into the above ground drainage runs in a science laboratory.

m) For kitchens, a suitable method of dealing with fats, oils and grease (FOG) discharge is provided; the system is adequately ventilated and meets the requirements of the Local Water Authority. Grease interception and/or dispersion may be required. Any grease traps provided are fitted external to the catering spaces, suitably ventilated to roof level if required, and in an accessible position. Any floor gulley’s and floor traps are easy to maintain

n) Waste storage areas have an impervious floor and have the provision for washing down and draining the floor into a system suitable for receiving polluted effluent. Areas outside the waste enclosure drain away from the enclosure.

12.2.3. Performance Criteria

12.2.3.1. The Contractor shall ensure that:

a) appliances drain quickly, quietly and completely at all times without nuisance or risk to health

b) discharge is conveyed without crossflow, backfall, leakage or blockage

c) air from drainage systems does not enter the building

d) pressure fluctuations in pipework do not vary by more than plus or minus 38mm water gauge and traps retain a water seal of not less than 25mm

e) systems can be adequately tested, cleaned and maintained

12.2.4. Routes

12.2.4.1. The Contractor shall ensure that pipe routes are the shortest practicable, with as the number of bends kept to the absolute minimum and no bends in wet portions of soil stacks.

12.2.5. Access Points

12.2.5.1. The Contractor shall ensure the following are provided:

a) Rodding and access points at all changes of direction to enable the whole system to be maintained

b) Access points at the foot of all soil and ventilation pipes, local access points and horizontal anti-syphon pipes above fitment flood level

c) Access/ rodding points located externally or in unoccupied spaces such as cleaner's stores

12.2.6. Rainwater Drainage

12.2.6.1. The Contractor shall:

a) Design, supply, install, test and commission all necessary above ground rainwater drainage systems required to drain all of the building's roofs, terrace balconies, and paved areas receiving rainfall

b) Select roof outlets to suit the particular roof construction arrangement or system, as the construction of the roof can greatly affect the outlet type used

c) Size gutters and downpipes according to the design rainwater volumes for the particular location; Consideration shall be given to the area of the roof, the number of outlets or downpipes, the rainfall intensity, the strength and direction of wind, and any run off from adjacent walls.

12.2.7. Design Parameters

12.2.7.1. The Contractor shall ensure that:

a) The roof drainage system is designed to provide a level of protection against flooding equal to a Category of storm for the particular building with a return period calculated on the advised building life and protection category, in accordance with BS EN 12056-3:2000

b) The Design Rainfall Intensity for Road and Paved Areas is 50mm/hour

12.2.8. System Description

12.2.8.1. The Contractor shall ensure that the following requirements are met:

a) Rainwater pipework is robust and durable

b) Internal rainwater pipework is avoided to avoid leakage. If internal pipes are selected, they are routed to avoid noise sensitive areas and will drop to connect to the underground surface water drainage system

c) Access points and rodding eyes are incorporated into the system to allow full access for maintenance. Syphonic systems are self-cleaning and therefore do not require rodding points

d) External rainwater pipework is located and sized to suit the building form.

12.2.9. Drainage Below Ground

12.2.9.1. The Contractor shall design, supply, install, test and commission all necessary below-ground foul and surface drainage systems required to drain all of the buildings' soil vent pipes, stub stacks and rainwater pipes.

12.2.9.2. Manholes shall not be located in areas likely to be used as pitches.

12.2.10. Foul Water System

12.2.10.1. The Contractor shall ensure that the following requirements are met:

a) Foul water drainage comprises a network of manholes which discharge into the nearest available utility sewers directly by gravity wherever possible and avoiding the use of sewage ejectors, pumps and holding tanks

b) Each foul water drain point connects directly to the external foul water drainage system. Where this cannot be accommodated, particularly in congested areas, internal manhole locations are discussed and agreed with the Employer and are suitably located to receive the drains

c) Each internal manhole incorporates fully recessed double seal covers with a stainless-steel edge strip and incorporates the final floor finishes within the cover

d) Manholes shall be located externally or in unoccupied spaces

e) Where drains pass through structural faces such as beams a rocker pipe is installed to facilitate ground movement. Rocker pipes are installed on all drain entries into manholes.

12.2.11. Surface Water System

12.2.11.1. The Contractor shall ensure that the following requirements are met:

a) Surface water drainage systems collect rainwater from the rainwater pipes and discharge to the surface water drainage system then into either soakaways or the nearest utility sewer network systems

b) Each surface water drain point connects directly to the external surface water drainage system. Where this cannot be accommodated, particularly in congested areas, internal manhole locations are discussed and agreed with the Employer and are suitably located to receive the drains

c) Each internal manhole incorporates a fully recessed double seal cover with a stainless-steel edge strip and incorporates the final floor finishes within the cover

d) Manholes are located externally or in unoccupied spaces

e) Manholes are not located in areas that are likely to be used as pitches

f) Where drains pass through structural faces such as beams a rocker pipe is installed to facilitate ground movement. Rocker pipes are installed on all drain entries into manholes.

12.3. Domestic Water Services

12.3.1. Cold Water Services

12.3.1.1. The Contractor shall design, supply, install, test and commission a potable/nonpotable cold-water service system capable of providing an adequate supply of potable and/or non-potable water to draw off points throughout the building.

12.3.1.2. The system will be designed to the following parameters:

a) Maximum velocity of water in pipework - 2 m/sec

b) Maximum water temperature in accordance with L8[19]

12.3.2. System Description

12.3.2.1. The Contractor shall ensure that the following requirements are met:

a) The cold-water mains are sized to serve the diversified water demand of the school

b) The cold-water main is connected to a sectional GRP twin compartment insulated tank to allow for tank maintenance whilst maintaining the water supply to the building. This tank is sized to provide storage of 3 l/occupant for nursery and Primary Schools, and 5 l/occupant for Secondary Schools

c) Where it is known that the school's pupil intake will be phased, the tank capacity is variable and such that the school can easily make adjustments to the stored volume

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[19] Legionnaires' disease. The control of legionella bacteria in water systems Approved Code of Practice and guidance, L8, HSE.

d) The tank is located in a separate plant room from heat producing equipment

e) The incoming cold-water main is sub-metered at entry to the building and also at the tank inlet allowing monitoring from the Building Management System (BMS)

f) The BMS is able to show: the daily, weekly, monthly and total consumptions for all the water sub-meters as separate items; the temperature of incoming mains water and tank storage water to be recorded on the BMS as live values with trend logging recorded for a period of 10 days on a rolling basis

g) A pressurised hot and cold-water supply system is provided by a booster pump set located adjacent to the cold-water tank. The set shall be configured to run as duty-standby operation. Each pump shall be fitted with anti-surge protection and connected to the low-level probe to the tank to ensure the pumps do not run dry

h) A booster set is provided consisting of:

   i. inverter driven booster pumps

   ii. expansion vessel

   iii. pressure vessel

   iv. safety valves

   v. speed control

12.3.2.2. Pressure regulating valves shall be provided to balance and equalise the pressures throughout the system.

12.3.2.3. The mains or boosted potable cold-water service shall be distributed throughout the building via ceiling level/voids and dedicated service risers to serve sanitary appliances and equipment and shall not run adjacent to any other piped services carrying hot water. These shall serve the following fittings:

a) Wash hand basins sinks and showers

b) WCs

c) Category 5 break tanks, where required to serve fittings with a category 5 fluid rating (category 5 break tanks shall be fitted with a sub-meter on their incoming supply and include tank temperature monitoring from the BMS) alongside the device for scheduled water changeover. See clause 12.3.4.1 d.

d) Mechanical quick fill, plant and equipment.

12.3.2.4. The complete installation shall be thermally insulated for frost protection and for anti-condensation purposes.

12.3.2.5. The taps to wash hand basins shall incorporate a timed flow control in line with Annex 2A: ‘Sanitaryware’. All sanitary fitting supplies (except WCs) will incorporate flow regulators ensuring the system is balanced and minimises water consumption.

12.3.2.6. The taps to sinks shall be non-percussive and appropriate to their intended use. They shall be WRAS approved or approved by the Employer and to relevant British Standards.

12.3.2.7. An electro-magnetic water conditioner shall be installed within the cold-water storage tank room on the boosted cold-water supply to prevent scale/calcium build up within the system where the calcium carbonate content of the incoming mains water supply is greater than 200mg/l or 14 on the Clark scale.

12.3.3. Drinking Water Outlets, Fountains and Bottle Fillers

12.3.3.1. The Contractor shall ensure that the following requirements are met:

a) Drinking water outlets and fountains are served from a potable water tank or mains fed

b) Drinking water outlets and fountains are clearly and correctly marked as drinking water. Water supplies fed from storage tanks not designed for potable water provision shall be clearly labelled as “not drinking water”

c) Drinking water fountains or bottle fillers shall be designed to permit users to recharge water bottles using spigots and the supply system should incorporate a push button or ‘dead’ handle system to minimise spillages and prevent the water supply being left on

d) Drinking fountains shall be plumbed in and floor mounted. All plumbing and drainage shall be concealed. Fountains shall be stainless steel with built-in bottle filler, fastened back to the wall

e) Bottle fillers shall be suitable for bottle sizes up to 1 litre.

12.3.4. Science Laboratories and Refuse Areas

12.3.4.1. For water supplies in science accommodation the following requirements shall be met:

a) Water supplies in new science accommodation serving sinks and dishwashers used for science equipment shall be designed to cater for fluid category 5 back pressure and back siphonage. Supplies shall be from a dedicated cold-water storage tank (maximum capacity 100 litres per science space, including studios and prep rooms) with an air gap, and pump if necessary. The tank and pump shall be accessible for ease of maintenance

b) When refurbishing or remodelling science accommodation the Contractor shall agree the fluid category and the protection against back-syphonage and pressure with the local Water Company; a fluid category 4 type installation may be acceptable. Adapters fitted to taps to provide an air gap are not acceptable in science as they prevent many experiments from being carried out

c) Water supplies in each science lab shall be provided with central isolation, located at the teaching wall.

d) Water supplies from the Category 5 break tank serving all science accommodation shall include a device for scheduled water changeover within the system using an end of line programmable (adjustable for time and temperature) automatic flushing and recording device (mains powered and hard wired), such as Kemper KHS or similar. Monitoring/programming of this device shall be possible from the BMS head end. This is to prevent water stagnation and to assist the school in managing water quality for this low water use area of the building.

12.3.4.2. Refuse areas shall be provided with wash-down facilities from an adequately protected water supply (Category 5). The stored volume shall be designed to a minimum i.e 100 litres.

12.3.4.3. Refer to Section 2: Common Requirements for full requirements for cold water services' pipework, pumps and fittings.

12.3.5. Hot Water Services

12.3.5.1. The Contractor shall design, supply, install, test and commission a centralised direct fired or calorifier system to provide hot water to meet maximum demand at all draw-off points within the building. Point of use electric water heaters may be used where a centralised supply is not appropriate e.g. a wash hand basin or sink in a remote location.

12.3.5.2. The Contractor shall ensure that:

a) The cold feed for the Hot Water System (HWS) is supplied by the central coldwater system with a back-flow prevention device

b) The domestic hot water is distributed throughout the building via ceiling level/voids and dedicated service risers to serve sanitary fittings, refer to paragraph 12.3.2.3

c) The hot water distribution return service water temperature is maintained at a minimum temperature of 55ºC

12.3.5.3. To minimise the risk of scalding, the Contractor shall ensure for Primary Schools, Special Schools and Designated Units, that all wash basins to these areas will additionally be provided with fail-safe thermostatic mixing valves to limit the outlet temperature to 43ºC. The Contractor shall ensure that all showers will be provided with thermostatic mixing valves set at 43ºC. The Contractor shall ensure that taps to kitchen sinks and cleaner's sinks shall receive the water at the full stored water temperature.

12.3.5.4. The system shall be designed to the following parameters:

a) Maximum velocity of water in pipework: 2 m/sec

b) Maximum storage water temperature: 65°C.

12.3.5.5. Refer to Section 2: Common Requirements for full details for hot water services pipework, pumps and fittings.

12.3.6. Reference Standards

12.3.6.1. In addition to the requirements set out within this section, the Contractor shall ensure that the design and installation of the public health engineering systems shall comply with the relevant parts of the following standards (or updated documents if relevant):

1. The Water Supply (Water Fittings) Regulations

2. The Building Regulations AD H and AD G

3. BS 8558 – ‘Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages’

4. BS EN 806 – ‘Specifications for installations inside buildings conveying water for human consumption’

5. BS EN 752 – ‘Drain and sewer systems outside buildings’

6. BS EN 1610 – ‘Construction and testing of drains and sewers’

7. BS EN 12056 – ‘Gravity Drainage systems inside buildings’

8. BS EN 12056-1 – ‘Gravity Drainage systems inside buildings. (General and performance requirements)’

9. BS EN 12056-3 – ‘Roof Drainage, Layout and Calculation’

10. BS EN 12056-2 – ‘Gravity Drainage systems inside buildings. (Sanitary pipework, layout and calculation). Calculations to be based on System III Single Discharge Stack with Full Bore Discharge Pipes’

11. BS EN 12056-5 – ‘Gravity Drainage systems inside buildings. (Installation and testing)’

12. BS 8000-13 – ‘Workmanship on Building Sites. Code of Practice for Above Ground’

13. BS EN 12354-1 – ‘Building Acoustics. Estimation of acoustic performance in buildings from the performance of elements’

14. HSE L8 – ‘Legionnaires' disease. The control of legionella bacteria in water systems Approved Code of Practice and guidance’

13. Handover Requirements

13.1. Overview

13.1.1. The handover requirements are set out in the Employer's Requirements Deliverables. The following section outlines the handover requirements in relation to mechanical services. A 7-day period of 'soak testing' shall follow on from the successful commissioning and testing activities.

13.2. Soak Testing

13.2.1. The Contractor, prior to Completion, shall carry out a 'soak test' of all the mechanical services in their normal/auto operation mode, as if the building were occupied and in use. This shall be programmed to occur after completion of all setting to work, commissioning and testing of the mechanical services and is to prove their reliability and correct calibrations over a continuous period of 7 days. Practical Completion will not be granted until a successful soak test as described here has been achieved. It is not necessary to install additional dummy heat or cooling loads into rooms to prove system performance at the maximum design loads. All mechanical systems shall be fully energised and placed in their normal/auto operation mode with all normal occupied time settings applying to:

a) Heating system

b) Domestic hot and cold water

c) Drinking water services

d) Gas services

e) Ventilation systems

f) Control systems

g) Energy metering and monitoring systems

h) Cooling systems

13.2.2. The soak test shall meet the following requirements:

a) The test shall be included in the programme for the Works and shall continue until seven continuous days of plant operation have occurred without fault or failure of any component / function

b) During the soak test period the Contractor shall monitor all functions (pressures/temperatures/CO_2 levels/starts per hour/energy and water use) and log the trends using the microprocessor controls equipment where installed

c) Each type of space served by the plant and equipment shall be monitored using temperature data loggers (supplied by the Mechanical or Electrical Contractor) or the BMS system to verify performance

d) Any specified noise performance surveys shall also be carried out during the soak test period

e) All data and monitoring results shall be provided to the Employer in Excel spreadsheet format (disc and hard copy) along with details of any faults arising and corrective action taken

f) Should the soak test fail for any reason, then the results shall be null, and void and the test period shall re-commence upon rectification of the problem/failure

g) All costs associated with the soak test, such as test equipment, attendance and supervision, shall be at the Contractor’s expense. Any costs incurred as a consequence of having to restart the soak test shall be at the Contractor’s expense

h) The soak test results shall be included in the Health and Safety File.

13.3. Documentation

13.3.1. A user-friendly Building user guide including details of all user controls shall be provided.

13.4. Commissioning and Building Performance Evaluation

13.4.1. The Contractor shall ensure that the building services engineering systems are fully tested and commissioned in line with all relevant current regulations, standards and guidance documents including those detailed in the Reference Standards, Section 13.6.

13.4.2. The building services systems shall be commissioned such that where systems interact with each other they are commissioned at the same time in order to simulate this interaction.

13.4.3. The Contractor shall undertake seasonal commissioning and performance testing/proving during the 12 months defects period in order to fine tune the systems for optimum performance and energy consumption in accordance with BSRIA BG 44/2013.

13.4.4. The Contractor shall conduct pre-commissioning, commissioning and seasonal commissioning on all aspects of the heating system and main plant in line with BSRIA BG 2/2010, BSRIA BG 44/2013 and the CIBSE commissioning code.

13.4.5. The Contractor shall provide a notice period of 1 week to the Employer's engineering representative for witnessing.

13.4.6. The Contractor shall record the results of the commissioning and performance testing in line with BSRIA Building Applications Guide BG2/2010 and provide these as part of the operation and maintenance manual documentation.

13.4.7. The Contractor shall carry out the Building Performance Evaluation (BPE) in accordance with Section 2.14.6 of the GDB.

13.5. Demonstration and Training

13.5.1. The Employer will appoint and/or nominate an appropriate candidate(s) to receive training by the Contractor on the building services engineering systems. The Contractor shall ensure that all building services engineering systems, controls adjustment procedures, optimum settings and maintenance procedures are demonstrated to the Employer's appointed representative/s. The functioning/calibration of the installed energy sub-metering shall be demonstrated along with the automatic uploading of data using the iSERV methodology to the national benchmarking database. See Annex 2H: 'Energy'.

13.5.2. The Contractor shall provide training for the appointed representative to receive training and demonstration on the energy monitoring system.

13.5.3. The Contractor shall ensure that the operation and maintenance manuals are available during the training and demonstration to ensure that the appropriate and correct documentation has been included.

13.6. Reference Standards

13.6.1. The Contractor shall ensure that the handover, documentation and commissioning of the building services engineering installation and design shall comply with all relevant regulations as well as the following (or updated documents if relevant):

1. CIBSE Commissioning Codes
2. BSRIA BG 2/2010 – ‘Commissioning Water Systems’
3. BSRIA BG 44/2013 – ‘Seasonal Commissioning’
4. CIBSE KS09 – ‘Commissioning variable flow pipework systems’
5. BSRIA BG49/2015 – ‘Commissioning Air Systems’

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Reference: DfE-00078-2020

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