Imperial College London

BUILDING ENGINEERING SERVICES PARTICULAR REQUIREMENTS

ICL BESPR-9: 2023

Revision history

This section details the amendments issued since the first publication.

Version no.	Revision date	Revision title	Brief summary of changes
ICLBESPR-1: 2014	November 2014	Particular Requirements	First edition
ICLBESPR-2: 2015	February 2015	Particular Requirements	Addition of Sections 20, 22, 24, and 27
ICLBESPR-3: 2015	April 2015	Particular Requirements	Addition of sections. Section re-numbering
ICLBESPR-4: 2015	September 2015	Particular Requirements	Addition of Section 1 in the General section.
ICLBESPR-5: 2015	December 2015	Particular Requirements	Addition of Section 19 in the Mechanical section. Camera types updated in Section 9.2.3.
ICLBESPR-6: 2016	June 2016	Particular Requirements	Revisions to Section 6 in the Mechanical section.
ICLBESPR-7: 2017	November 2017	Particular Requirements	Revisions include: Sections 1, 2, 7, 8, and 9 in the Electrical section, and all sections within Mechanical section.
ICLBESPR-8: 2019	January 2019	Particular Requirements	Addition of Sub-section 2.19 and Section 3 in the Mechanical section. Revisions to Sections 3 – 18 in the Mechanical Section.
ICLBESPR-9: 2023	March 2023	Particular Requirements	Re-structured and re-written to reflect requirements to achieve: • The College's net zero carbon objective; • Improved quality assurance based on BSRIA BG 6/2018 – Design framework for building services; and • Clearer section structures for any future revisions.

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1.1 Small Power Supplies

1.1.1 General

When designing the number of socket outlets to be connected to individual circuits, due account shall be taken of the nature of the work to be undertaken in the area(s) served, and the possible disruption that would result from a single circuit failure or interruption. On no account shall the number of sockets served from a single ring circuit protected by a 32-amp protective device, exceed 10 No. single or 2 gang outlets, subject also to ensuring that the circuit voltage drop does not exceed the required limit.

All small power circuits are to be wired in singles with a minimum cable cross section area of $4mm^2$.

Twin and earth cables are not to be used in any Electrical installation for the College. Any proposal to use twin and earth cables should be agreed and signed off by the College's Estates Engineering, Energy and Environment Team.

To comply with Part M Building Regulations switches, outlets and controls are to contrast visually with their backgrounds. This can be achieved by way of installing black or grey Inserts around these items.

1.1.2 Workstations

The number of socket outlets serving a single office workstation to be agreed with the end user, subject to a minimum of 2 No.2 gang switched socket outlets where the end user has no specific requirements. The socket outlets are to be presented in such a manner as to be easily accessible to the workstation user.

All socket outlets to be double pole switched.

Where a desk management system is proposed, this shall comply with the current edition of BS 6396: (Electrical systems in office furniture and office screens –Specification).

Subject to a maximum of eight, the number of fused connection units to be connected to a single 16-, 20- or 32-amp radial circuit shall be such that the simultaneous starting current of equipment connected to the circuit shall not cause the circuit protective device to operate.

1.1.3 Laboratories

Socket outlets intended for use on laboratory benches (that is mounted on or above the bench) shall be arranged such that circuits serving one side of each bench run are connected to the same phase and also if the desks are installed back to back, both should be on the same phase.

1.1.4 Areas Containing Sinks or Basins

Socket outlets proposed to be located in an environment where it is considered that there is a significant risk of accidental contact with wet services, shall comply with the following arrangements as necessary to reduce that risk to the minimum:

- Where sinks or basins are present, no socket outlets shall be positioned less than 500mm from the closest edge of a sink or basin.
- Socket outlet circuits to be protected by a residual current device.

1.1.5 Freezer Supplies in Freezer Rooms

Freezers that are provided for research or process-based function are to be served from circuits connected to a dedicated distribution board, positioned local to, or preferably within the area in which the freezers are located and labelled as such.

In order to limit the number of freezers that may be lost as a result of a distribution board failure, no more than 20 No. freezers are to be connected to a single distribution board.

Freezers are to be served from radial circuits serving not more than two freezers in total. The distribution board shall be sized to accommodate the known freezer load and include spare capacity for future expansion based on a minimum allowance of 25%, rising to 100% according to the space available for additional freezers to be installed.

Circuit protective devices and circuit arrangements, to be selected to ensure that circuit protective devices do not operate as a result of freezers starting simultaneously i.e. as in the case of a supply resumption following a power failure.

1.1.6 Labelling of Socket Outlets and Distribution Boards

All socket outlets are to be labelled with the circuit reference to uniquely identify where they are fed from. Every distribution board should have all the outgoing circuits labelled using a DYMO labelling machine and placed in the space provided within the board. This labelling does not replace the issue of providing a distribution board schedule in accordance with the recommendations of the IEE wiring regulations. The schedule should be laminated and glued to the inside door of the distribution board.

1.1.7 Communications Wiring Centre (CWC) Rooms

Each CWC room shall be provided with a dedicated distribution board, complete with type C miniature circuit breakers (MCB's). The final circuit provision from this distribution board shall be as follows (Note: ICT as referred to below shall mean Imperial College London, Information and Communication Technology Department):

Designer and/or contractor:

- 2No. 16amp unswitched BS EN 60309-1 (BS 4343) socket outlets per cabinet. (Location to be confirmed by ICT). Socket outlets to be as manufactured by MK Electric, selected from their `Commando` range
- 1No. 13amp 2 gang switched socket outlet. (Height and location to be agreed with ICT).
- A clean earth bar complete with a test link connection. Number of connections available to equal number of cabinets installed plus an allowance for future cabinets, as agreed with ICT.
- All cabinets to have their frame connected to the clear earth bar
- All socket outlets to be labelled with a circuit reference.
- Warning labels noting the presence of a clean earth system (in accordance with BS 7671).
- 1No. 63 amp switched interlocked BS EN 60309-1 (BS 4343) socket outlet to be provided per router location (it is recommended that this supply is served from the distribution board in the CWC room). Socket outlets to be as manufactured by MK Electric, selected from their `Commando` range.

Data wiring cabling contractor:

- 2No. power track busbars per cabinet, switched, with 10No. 13amp socket outlets on each, (as Mayflex 10-way EN 60309 (BS4343) vertical power strip, 16amp) or equivalent.

The illustration in Figure 1 – CWC Earthing Schematic is an example of an earthing connection within the CWC room.

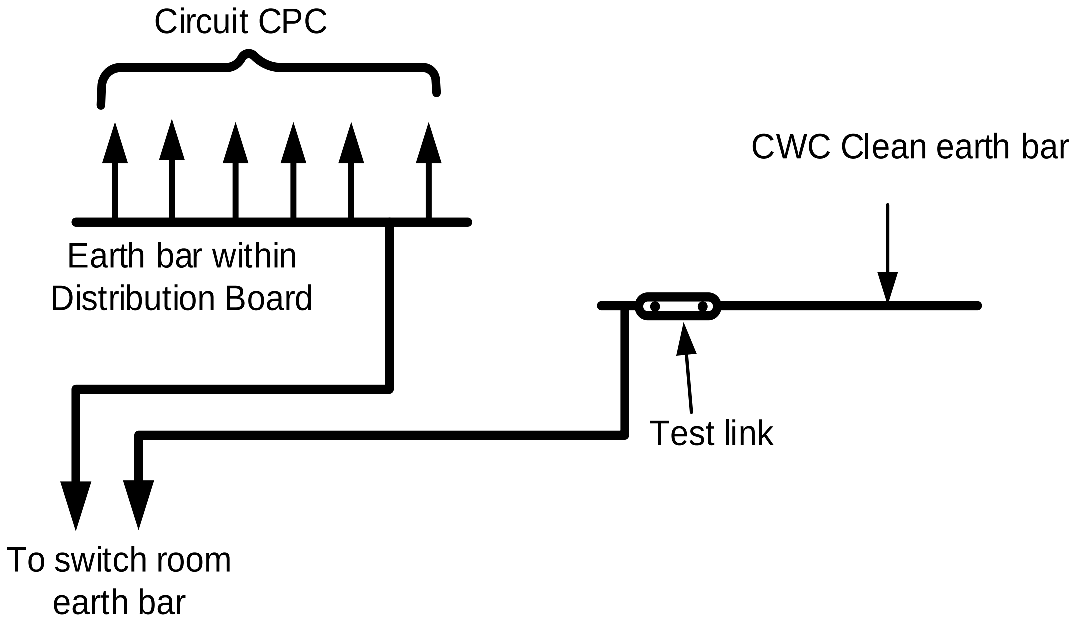

Figure 1 – CWC Earthing Schematic

1.1.8 Power Supplies Mechanical Services

All power supplies to mechanical services should be done either by the motor control centre panel or a dedicated mechanical distribution board.

Should there be a need to deviate from these requirements, this should be discussed with the Estates Operations Engineering, Energy and Environment Team before an exception report is presented to the College's Head of Engineering, Energy and Environment.

1.2 Lighting and Emergency Lighting

1.2.1 Design and Installation Principles

1.2.1.1 General

The design, equipment selection and installation of all lighting and emergency lighting systems shall be:

All lighting circuits are to be wire in singles with a minimum cable cross section area of 2.5mm².

- Sourced from one of our 5 approved lighting suppliers
- Capable of delivering the required level of illumination
- Energy efficient in its operation
- Offer durability and reliability in its operation, at a competitive cost
- Complimentary to the aesthetics of the space in which it is installed, both in appearance and in its function

All lighting schemes shall be designed to create a suitably illuminated task area and ambient lighting of the surrounding area. Lighting levels as set out in **Error! Reference source not found.** shall be applied to all College projects. In a ll other respects, the requirements of the CIBSE Code for Lighting, and associated CIBSE Lighting Guides, are to be applied to the design of lighting schemes.

Lighting calculations are to be undertaken in order that the appropriate light source, type and quantity thereof are used.

Presence detectors shall be of either passive Infra-red or microwave type and where appropriate shall incorporate a photocell to enable maximum utilisation of daylight harvesting. Presence detectors shall be selected from the following manufacturers:

- Any of the College's approved lighting suppliers;
- BEG Luxomat; or
- Ex-Or.

Emergency lighting shall be designed in accordance with relevant standards.

To assist in achieving the designed lighting levels the luminaires are required to be dimmable, this will also allow the space to be flexible in its design and potentially lengthen the life expectancy of the luminaires.

The operational requirements of the space, together with health and safety issues shall at all times be the primary consideration in the final design of the lighting control methodology.

Table 1 – Lighting Levels

Area	Lighting Level (Lux)		Uniformity
	Without Task Lighting	With Task Lighting	
Internal Areas			
General Office	400**	350	≥0.6
Classrooms	500	-	-
Practical rooms and Labs	500	400***	≥0.6
Containment Level 3 Suites	750	-	≥0.6
Containment Level 3 Lobbies	500	-	-
Containment Level 3 Corridors	350	-	-
Lecture Theatres	500	-	-
Art Rooms	500 - 750	-	-
Jewellery Workshop (Localised)/Precision work area	1000	-	-
Kitchen	500	-	-
Library Reading Area	500	-	-
Library Counters	500	-	-
Library General Areas	300	-	-
Library Shelves	200	-	-
Language Lab	300	-	-
Entrance	200	-	-
Dining/Refectory	200	-	-
Toilets	200	-	-
Stairs, Corridors and Lobbies	150	-	-
Stores and Plant Rooms	100-200	-	-
Retail Areas	300-500	-	-
Conference Room	400	-	-
External Areas			
Car Park (Open)	20 – 50	-	-
Car Park (Covered)	50 – 200	-	-
Pedestrian	20 – 100	-	-
Covered pavement and Steps	75	-	-
Services areas	50	-	-
Sales areas	50 – 200	-	-
Ramp and Corners	75 – 200	-	-

Area	Lighting Level (Lux)		Uniformity
	Without Task Lighting	With Task Lighting	
Vehicle entrance and exit	100	-	-
Control Booths	200	-	-

** The task area should always be illuminated at required specified illumination level as shown in Table 1 – Lighting Levels.

*** This illumination level should only be used for the general lighting if the task lighting is part of the overall lighting design i.e., the designers and contractors should have an input/knowledge of the type of task lighting to be used.

1.2.1.2 Light sources

LED light source is Imperial College's standard for lighting solutions for lamps and luminaires indoors and outdoors. Internally, dimmable luminaires shall be used, for external lighting it is not mandated that LEDs be dimmable.

All LED luminaires are to have a colour temperature of 4000K except for bedrooms. The option for tuneable white LED should be considered if this will add value to the space and increase user's satisfaction, but this should be discussed and agreed with the Engineering, Energy and Environment Team. For areas with no natural daylight tuneable white is the standard option.

Where a particular application can only be satisfied by linear fluorescent or other alternative a payback analysis is to be undertaken showing a comparison between each option. The results of the analysis together with a recommendation are to be submitted to the Head of Engineering, Energy and Environment for approval. (Add colour temperature).

Proposals to use light sources other than LED are to be the subject of an Exception Report.

1.2.1.3 Laboratories

Attention shall be given to reducing shadowing over laboratory benches. Task lighting is an acceptable way of mitigating this problem, another solution is to position ceiling mounted luminaires in a suitable pattern that compensates for the shadowing effect.

The College has laboratory environments ranging from Containment Level 1 to Containment Level 3. The type of luminaire selected must be suitable for the operations carried out within the laboratory in which it is to be installed in.

i.e. sealed luminaires are not usually necessary for Containment Level 1 and 2 laboratories, however, each individual application must be considered on its own merits.

Although manual switching is required within Laboratory's, daylight dimming commissioned to maintain a constant lux level at the working surface is permissible with the end-user's agreement.

1.2.1.4 Work Area Task Lighting

Over-lighting of some areas needing high local levels of illumination can often be avoided by the use of task lighting. However, this will be subject to agreement with the end user.

Task lighting should be integrated within the primary lighting solution to ensure that adequate levels of ambient lighting are to be provided to create a pleasant and safe working environment, regardless of whether or not task lighting is operating.

Wherever possible, use local task/display lighting to illuminate key features such as notice boards, reception/security desks, lift entrances and key exit points in public/lobby areas, avoiding the need to provide higher than necessary overall levels of illumination.

1.2.2 Operation

1.2.2.1 General

It is essential to ensure that the operating mode is agreed with the end user at the design stage and reflect this in the switching/control arrangements.

Switching/controls should be arranged so that artificial lighting is only in use when the space is occupied. Except where safety considerations take priority, automatic control is the default option.

Where it is agreed that (see below) manual switching only is provided, this should be clearly labelled, easily accessible and adjacent to each exit from the space.

Where feasible, daylight dimming is to be utilised to maintain a constant illumination level at the relevant working plane.

To derive maximum benefit from natural daylight, ensure that lighting adjacent windows is controlled separately to that further into the room.

Identify access and circulation routes and arrange the lighting control to these areas such that where these occur in open plan areas, 'blanket' coverage is avoided, and adjacent areas are not illuminated unnecessarily.

1.2.2.2 Manual switching

Except where safety considerations take priority, automatic control is the default option.

Where manual switching is proposed, the switching arrangements should enable occupants to control the lighting efficiently by applying the following general principles.

- Switches to be sited locally and adjacent to all exits to the area served and be labelled accordingly.
- 2-way switching to be provided where appropriate and to reduce travel distances to switches.

1.2.2.3 Automatic Control

Some form of automatic control is the default option.

Presence detection with automated dimming is the default option with more complex dimming/scene setting arrangements only being applied where the specific use of the space demands it.

It is essential that when designing schemes using presence detectors, that they provide the necessary coverage.

1.2.2.4 System Selection

The method of automatic lighting control is to be selected from the following:

1) Local Control; or
2) Centralised Control.

Except where the specific use of the space demands timed control or dimming and/or scene setting, local control will usually satisfy the requirement for automatic control.

For both local and centralised control, the system designer is required to ensure that escape route lighting is maintained in accordance with statutory requirements and this document, including in the event of a control system failure.

1) **Local Control**

Presence detection and where applicable photocells not linked to the College's Building Management System (BMS), or any other centralised lighting control system.

Local Control Modules and Drivers compatible with DALI (digitally addressable lighting interface) are to be used in order to achieve programmable local control.

Presence detection is also to be considered for Store Rooms and other areas where lights may inadvertently be left switched on, and/or where there is no inferred ownership to switch the lighting off.

Plant Rooms are to be switched locally by way of an illuminated switch(s) close to the entrance.

Note (re: small offices)

Care to be taken to ensure that an adequate payback is achieved (see 'Manual switching' above) and nuisance switching is avoided. Small offices in the context of this requirement can be defined as those spaces that have sufficient area only to accommodate no more than two people.

Workshops and Laboratories [Note: CBS facilities are excluded from this document]

Workshops and Laboratories generally present some of the highest levels of personal risk and all forms of lighting control shall be arranged such that this risk is not increased. The lighting control strategy shall therefore be developed to ensure that a 'safe' level of lighting is continuously maintained during periods of occupancy. However, in the interests of energy efficiency it is desirable that automatic control is considered for a proportion of the lighting where possible for Labs, in agreement with the end user(s), the Head of Engineering, Energy and Environment.

The basic principle to be applied for labs shall comprise manual control to all work area lighting (i.e., benches etc.), with local automatic control to general circulation areas.

As for workshops all the lighting shall be controlled manually.

2) **Centralised Control**

Time setting, override, dimming, scene setting etc., arrangements are to be controlled by the College's Trend Building Management System (BMS), in conjunction with a Ligo interface unit. This could also include presence detection, day light control etc. Lighting circuits shall be controlled via contactors/Lighting Control Modules (LCM's), connected to a BMS outstation. This connection may be available on a fan coil unit if it is installed in the same area as the lighting, or a dedicated outstation may be required.

- The BMS Trend system is capable of but not limited to:
    - Providing volt free contacts
    - 0-10V for dimming
    - On/off, scene settings (i.e. 10%, 50%, 100% etc.)
    - Controls through day light sensing, PIR, occupancy detection, etc.
    - Time zone settings for different days of the week.
- Light switches to be of a momentary push to make type. Where 2-way or 2-way and intermediate switching would normally be utilised, switches will instead be wired back to a common input on the BMS controller for each group being switched.
- Dimming control shall be achieved by means of individual push to make momentary switches, where 33%, 66% and 100% luminance levels may be selected.
- The number of presence detectors to be connected to a common BMS controller input to be determined by the Controls Specialist.

In the time setting mode, switching times can be specific to individual areas so that an area may receive one or more 'off' signals to correspond to the times when the facility is closed and unoccupied.

Operation of a local manual switch or presence detector will re-activate the lighting.

1.2.3 Evacuation Lighting

1.2.3.1 Security Alert

To assist in the safe evacuation of a building as part of an emergency procedure, in which the emergency lighting system has not been achieved (such as for a security alert), lighting achieving a minimum 10% illuminance will continue to be available to escape routes under the control of override presence detectors with additional manual override switching provided to enable all automatic control to be overridden if required. To prevent the automatic control being overridden permanently, a time delay switch is to be used, or if controlled via the Trend system, the delay may be written into the software.

Where the absence of adequate external ambient lighting may hinder the safe evacuation of the building, additional artificial lighting shall be provided to a minimum lux level of no less than that recommended by the appropriate British Standard for internal emergency escape routes.

The provision of security alert lighting applies to all lighting schemes, regardless of the control option employed.

Primary lighting luminaires which also perform an emergency lighting function may be utilised as part of the security alert system but are required to operate independently of the emergency lighting methodology. That is, their operation must not depend on the failure of the primary lighting system.

1.2.4 Emergency Lighting

Emergency lighting shall be designed and installed in accordance with the relevant Standards.

A method of testing emergency lighting shall be provided for installations. Automatic test systems do not meet the College's requirements; manual key switches are therefore to be used. The test methodology and location of the test switches is to be agreed with the Head of Engineering, Energy and Environment and College Head of Fire Safety.

1.2.5 Luminaire Installation

Where luminaires are mounted within a suspended ceiling, and it is intended that the luminaire is to be supported from the suspended ceiling grid, the following shall be adopted:

- The installing contractor shall ensure that the suspended ceiling is capable of safely accepting the total weight of the installed luminaires and all associated components.
- The installing contractor shall provide secondary support (such as safety chains) adequately secured to the building structure and capable of safely supporting the total weight of the luminaire in the event of the collapse or failure of the suspended ceiling or associated supporting grid.

1.2.6 External Lighting

All luminaires specified for external use shall be protected against dust, weather and corrosion. The luminaires must be mounted in plane in which they are intended by the manufacturer. All external luminaires shall be impact resistance, tamper proof and should either be IP65 or IP67 rated, depending on the installed location. Both glare and high lighting pollution should be design out or minimized to an acceptable level. All external luminaires are to be controlled by photocells.

Time control via the BMS is to be considered in order that the luminaires are operational during appropriate times only.

1.2.7 Handover

At handover, light levels are to be demonstrated and a functional demonstration of all the lighting/emergency lighting systems and associated controls shall be undertaken in the presence of the Estates Development & Projects, Project Quality Assurance & Compliance Manager.

1.3 Earthing

1.3.1 Introduction

This document sets out the Particular Requirements for earthing the College's main HV and LV electrical distribution equipment. At the South Kensington campus, the HV networks are privately owned by Imperial College and operated on their behalf by a third party. A third party also operates the College owned CHP plant, which is embedded into the 11kV system. Therefore, it is important for Designers and contractors to understand and adhere to this established practice and, under no circumstance, introduce dissimilar earthing systems. At other campuses where the Imperial College supply is usually taken at LV the HV network provider will largely determine the earthing requirements. A typical arrangement for substation earthing at the South Kensington campus is shown in Figure 2.

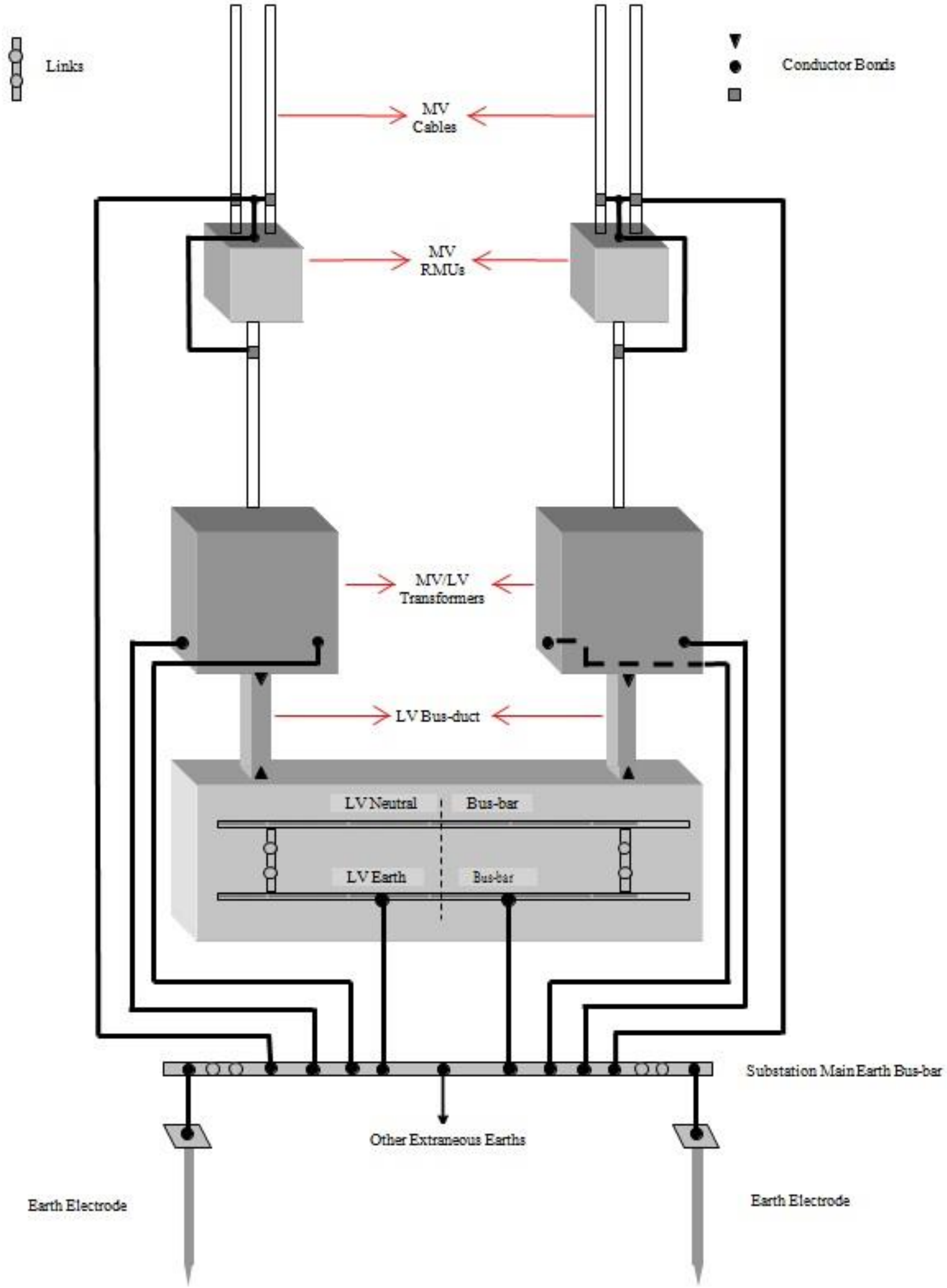

Figure 2 – Typical Substation Earthing Arrangement

1.3.2 HV System Earthing

South Kensington Campus – 11kV System

1.3.2.1

The HV input is at 11kV comprising of four feeders exclusively supplying the College from the Duke Street 132/11kV substation. The 11kV system is solidly earthed at the transformer secondary winding star point.

1.3.2.2

The zero-sequence impedance Z0 at the 11kV Intake Switchboard is 1.87ohms. (I0 = 3.4kA). The main intake switchboard is bonded to the Mechanical Engineering substation main earth bar and is connected to the general mass of earth via electrodes and the building rebar.

1.3.2.3

Continuity of the HV earth is made at each substation via the steel wire armour (SWA) of the HV feeder cables. Where practical, two additional earth electrodes shall be connected to the substation earth bar, each with a target earth resistance of ≤ 10 ohms.

1.3.2.4

At each substation the incoming cable SWA shall first be bonded to the switchgear earth bar via the cable gland earth tag. For ring main units (RMUs) a separate earth conductor shall be connected from the switchgear earth bar to the substation main earth bar. Where the HV switchgear is of the panel type an earth bar running the length of the switchboard shall be provided and two connections each ≤ 95mm² Cu XLPE insulated or bare conductors, made to the substation earth, one at each end.

1.3.2.5

Transformers are provided with two earth terminals, and these shall be bonded directly to the substation main earth bar. If the transformer is controlled by a close coupled RMU the HV switchgear earth can be bonded directly to the transformer earth conductor.

1.3.2.6

Connections shall not be made to a transformer earth terminal unless it has a further connection directly to the substation main earth bar i.e. the transformer tank shall not be used as an earth continuity path.

1.3.2.7

If the substation is located away from ground or, basement level, then the main HV earth shall be provided by the feeder cable SWA. In addition, separate, insulated, earth conductors ≥ 95mm² Cu shall be run with each feeder cable and bonded to the incoming HV switchgear earth bar and at the other end to either a) the corresponding switchgear earth or b) the nearest ground, or basement level, substation main earth bar providing it is part of the same HV network.

1.3.2.8

Substations located at roof level with close proximity to lightning protection conductors shall be provided with bonds to the lightning grid using direct routes and avoiding, where possible, unnecessary bends.

South Kensington Campus – 6.6kV System

1.3.2.9

The 6.6kV network is supported from the 11kV system via two 10MVA transformers and is isolated from the 11kV earth by virtue of the Dy11 transformation. The star windings of these transformers are solidly earthed to the College earth mass and separate earth electrodes.

1.3.2.10

In addition, the two 4.75MVA CHP generators are each separately earthed via 5A 10s neutral earthing resistors. These are in circuit only when the machines are running up to speed; once synchronised they are disconnected and the 6.6kV earths described in 3.2.9 become effective.

1.3.2.11

The zero-sequence impedance Z0 at the 6.6kV CHP Switchboard is 0.543ohms. (I0 = 7.02kA). The CHP intake switchboard is bonded to the CHP main earth bar and the Mechanical Engineering substation main earth bar via the main earth bars in the 11/6.6kV transformer enclosures at Dalby Court.

1.3.2.12

Other earthing requirements shall be as described in paragraphs 3.2.3 through to 3.2.8 inclusive.

1.3.3 Transformer Enclosures

1.3.3.1

Where transformers are located in outdoor enclosures all metal posts, palings and chain link fencing or other forms of metalwork construction shall be bonded together and then to the substation main earth using 2 x XLPE insulated conductor ≥ 70 mm² Cu. Gates shall be bonded to the enclosure earthing system using braided Cu conductor and suitable clamps.

1.3.3.2

Enclosures for cast resin transformers shall be bonded to form a continuously earthed assembly and then bonded to the transformer earth bosses using 2 x XLPE insulated conductors ≥ 95mm² Cu. Incoming HV and LV cables or bus-duct shall be bonded to the enclosure metalwork using XLPE insulated conductor ≥ 95mm² Cu.

1.3.4 LV Main Earths

South Kensington Campus

1.3.4.1

Whether supplied from the 11kV or 6.6kV network, the main LV earth busbar is usually incorporated in the LV switchboard, which is then bonded to the substation main earth. Therefore, the HV and LV earths are effectively bonded together.

1.3.4.2

Earth systems shall be TN-S. Systems utilising combined neutral and earth conductors (CNE) shall not be used at the South Kensington campus.

1.3.4.3

A separate earth conductor, ≥ 300mm² Cu, shall be installed between each transformer section of the switchboard earth bar and the substation main earth busbar.

1.3.4.4

All sub-circuits on the LV sub-distribution system shall, where necessary, be provided with a separate earth conductor, sized in accordance with BS 7671. The earth conductors shall form a continuous bond to the substation main earth.

1.3.4.5

The range of zero sequence impedance, Z0, at the main LV busbars is 0.007 to 0.012 ohms. Actual fault levels for individual substations are available on request from Imperial College Estates Engineering, Energy and Environment Team or the College's HV maintenance contractor – Earl Power.

1.3.5 LV Neutral Earths

South Kensington Campus

1.3.5.1

The neutral connection to earth shall be made within the main LV switchboard and be affected by removable links at each incoming transformer circuit breaker. The connection to the switchboard earth bar shall be via copper links of c.s.a. not less than the earth bar, or neutral busbar, whichever is greater.

1.3.5.2

The arrangement of 1.3.5.1 enables restricted earth fault (REF) current transformers (CTs) to be installed at each transformer incoming panel. Neutrals shall not be earthed at transformer star points as this would require an additional CT at the transformer.

1.3.5.3

The single point earthing achieved by 1.3.5.1 facilitates all power sources, transformers and generators, to be controlled by 3-pole, solid neutral circuit breakers.

1.3.6 Generator Earths

HV

1.3.6.1

If the generator(s) forms part of a CHP system operating synchronised with the grid supply, then the earthing arrangement shall be as described in 1.3.2.10 above.

1.3.6.2

If the generator(s) operates in Island or Stand-by mode, then each generator shall be separately earthed via an earthing resistor. Typically, the resistor will be rated at about 200A – 10s, but the system fault study shall verify that discrimination can be achieved with downstream protection devices for I0 currents.

1.3.6.3

The earthed end of the earthing resistor shall normally be bonded to the nearest substation main earth. If the nearest main earth is too distant, then a local earth electrode shall be installed with an earth resistance ≤ 10 ohm.

LV

1.3.6.4

As the neutral earth is provided as described in paragraph 4 any generator connected to the system is bonded to earth at the switchboard and no provision shall be made for a neutral earth connection at the generator.

1.3.6.5

REF can be installed as in 1.3.5.2.

1.3.6.6

With this arrangement there is no requirement for circuit breakers with switched neutrals.

1.3.7 Extraneous Metalwork and Other Earths

1.3.7.1

Metal cable ladder rack, tray work, trunking, conduits and supporting metalwork shall be bonded to the substation main earth.

1.3.7.2

Distribution gear within substations shall be bonded to the main earth bar

1.3.7.3

Lightning conductors and earthing pits shall not be sought as a means to provide the earthing requirements of paragraph 1.3.2.3. Bonding to lightning earthing grids shall only be made for substations located at roof level as described in paragraph 1.3.2.8.

1.3.8 Substation Main Earth Bars

These shall be of proprietary type with links suitable for isolating earth electrodes and be of a cross sectional area ≥ 300mm² Cu.

1.3.9 Other Campuses and Sites

1.3.9.1

The network asset owner will determine this. If not a TN-S system a TN-C-S is often offered as an alternative. Combined protective conductor and neutral systems (TN-C) extended into the College's installation are not permitted. Currents on the outer conductor of cables produced for this arrangement are likely to cause interference with sensitive scientific instruments e.g. electron microscopes.

1.3.9.2

Greenfield sites requiring substations to provide exclusive supplies to Imperial College premises shall be earthed as described above for the main South Kensington campus. An exception would be the provision of separate HV and LV earths where required by the network provider. In this case a buried earth system comprising of electrodes supplemented, if necessary, by bare copper conductors with a measured earth resistance ≤ 1ohm shall be installed for the LV earth. Bonding of HV and LV earths will be at the discretion of the network provider.

1.3.9.3

Electrical installations shall be in accordance with BS 7671.

1.4 Design Criteria for Main Electrical Power Equipment

1.4.1 Main Electrical Equipment

1.4.1.1 Introduction

The purpose of this section is to provide design criteria for designers and contractors responsible for the procurement of switchgear installed within Imperial College.

The strategy is to ensure that:

- The College's maintenance team can maintain and/or install additional circuits in switchgear without necessitating the isolation of adjacent live circuits; and
- Connections can be made to data system outputs without necessitating the disruption or isolation of the primary power circuit.

Proper consideration is given to switchroom size and layout to fulfil objectives above.

1.4.1.2 HV Switchgear

1.4.1.2.1 Overview

Multi-panel switchboards or ring main units (RMUs) control the College's 6.6kV and 11kV networks. Both networks are connected as ring circuits but operate as radial feeds. Each ring has a third feeder coupled, where possible, at a node representing one half of the total ring current. The distribution feeders are protected against over-current and earth faults at the main switchboards and do not rely on intermediate downstream protection.

Therefore, incoming circuits on intermediate switchgear panels are not equipped with protection relays and are used for manual sectionalising only. This replicates the function of the ring switches on RMUs.

Multi-panel switchboards are used in substations where a third feeder interconnection is made and/or other switched HV functions are required e.g., PFC Capacitors and remotely switched transformer feeders.

RMUs are used in substations utilizing plain transformer feeders and offer cost and possible space savings over multi-panel switchboards. Further savings are made if the RMUs can be close coupled to the transformers and some substations within Imperial College are equipped with up to 3 x 1600kVA transformers connected in this way.

1.4.1.2.2 HV Multi-panel Switchboards

These shall be procured from Imperial College London Approved Suppliers / Components List manufacturers and incorporate the following:

- 12kV minimum rms working voltage;
- 630A minimum circuit breaker and busbar rating;
- 25kA – 3s symmetrical fault rating;
- Micom P122 or Sepam1000 protection device on transformer feeders only. Device equipped with auxiliary relays to receive LV intertrip and lockout signals;
- Vacuum breaking medium;
- Bus-section circuit breaker;
- All circuit breakers to be independent manual closing control and fitted with 30V DC trip coil for local manual and protection trips;
- All circuit breakers to have lockable electrical trip control switches; and
- One set of auxiliary contacts shall be wired out on the transformer panels to provide an inter-trip signal to the transformer LV circuit breaker, which also acts as an interlock to prevent closure of the LV circuit breaker until the HV circuit breaker is closed.

1.4.1.2.3 HV Ring Main Units (RMUs)

These shall be procured from Imperial College London Approved Suppliers / Components List manufacturers and incorporate the following:

- Through symmetrical fault rating 25kA 3s;
- Independent manual ring switch operation with minimum 630A rating for load switching and through fault making capacity;
- 200A rated vacuum or SF6 circuit breaker for controlling outgoing transformer feeder;

- Circuit breaker symmetrical breaking capacity of 21kA 1s;
- Non-TLF protection e.g., Schneider VIP 300 unit or discrete relay as in 1.4.1.2.2;
- 30V DC shunt trip coil;
- One set of auxiliary contacts shall be wired out on the transformer panels to provide an inter-trip signal to the transformer LV circuit breaker, which also acts as an interlock to prevent closure of the LV circuit breaker until the HV circuit breaker is closed; and
- Suitable for close coupling to the transformer. Close coupled RMUs to have ground braced framework and not rely on the transformer LV flange for sole support.

1.4.1.3 Transformers

These shall be procured from Imperial College London Approved Suppliers / Components List manufacturers and be as follows:

- KNAN Midel liquid cooled type;
- Nominally 11/0.398kV but if operated from the Imperial College;
- 6.6kV network 6.6/0.398kV, both at full load output;
- Vector Group Dyn11;
- Suitable for mounting close coupled RMU;
- The following shall be fitted:
    - Liquid temperature gauge with maximum temperature indicator and alarm and trip contacts;
    - Pressure relief device with trip contacts;
    - Marshalling cubicle for accessory small wiring;
    - Off-circuit HV tapping's at ± 2.5% and ± 5% with lockable switch;
    - Transformers in excess of 1600kVA, LV busbar flanges for coupling busbar ducting of copper conductors shall be used; and
    - All transformers shall be of copper winding.

In exceptional circumstances it may be desirable to install cast resin transformers with the following fittings:

- Nominally 11/0.398kV but if operated from the Imperial College;

- 6.6kV network 6.6/0.398kV both at full load output;
- Vector Group Dyn11;
- Thermocouple winding temperature system with 2 thermocouples/winding and monitoring module providing temperature indication, alarm and trip signals;
- IP23 enclosure. The IP index may be reduced if ONAN cooling cannot be achieved but clearances to live conductors must be such to comply with the IP standard “finger” test. Forced cooling of the enclosures shall be avoided;
- Access to core and windings shall be limited by either a) interlocked doors with keys released by both HV and LV circuit breakers or b) removable panels with fastenings operated with special tools;
- Off-circuit HV tappings at ± 2.5% and ± 5% by means of bolted links;
- Transformers in excess of 1600kVA, LV busbar flanges for coupling busbar ducting of copper conductors shall be used; and
- All transformers shall be of copper winding.

1.4.1.4 LV Switchgear

These shall be procured from Imperial College London Approved Suppliers / Components List manufacturers. Switchboards shall be of Form 4 Type 7 construction in accordance with Section **Error! Reference source not found.** a nd incorporate the following:

- Air circuit breakers (ACBs) on all incoming and bus-section switches. The incoming ACBs to be equipped with Alstom P123 relays and, if transformer incomers, they shall have facility for restricted earth fault (REF)*, trip lockout with contacts to intertrip HV circuit breaker and auxiliary relays to accept trip and alarm signals from the transformer liquid temperature device and trip signal from the over-pressure device and, separately, trip receive from HV circuit breaker;
- The REF function shall be provided with stability resistors and voltage suppression Metrosil units each calculated for the discrete application;
- Incoming panels and outgoing circuits rated 50kW or greater, including spares, shall have Socomec meters equipped with RS 485 Comms output modules only. Socomec A40 meters shall be used for the incoming circuits and Socomec A20 meters used for the output circuits.

- These meters will be equipped with RS485 communications output modules only “daisy chained” using screened twisted pair & drain wire cable (Belden or equivalent) and terminated in a separate marshalling cubicle. The data will be monitored via Modbus.
- Modbus is the preferred metering connectivity protocol. Where meters produce a pulse, a pulse to Modbus converter is required and converted to a Modbus address. This is done by using a Modbus pulse collector (e.g., part IME Conto IF4C001 IMP Pulse Acquisition module.
- A Modbus pulse collector will be used to integrate the meter onto the Modbus network. Where a Modbus pulse collector is used the meter multiplication factor will be added to the MODM/D/1VIQ NOT the Modbus pulse collector.
- Meters on sub-distribution panels supplied from switchboards described above shall be equipped similarly, except the incoming meter shall be omitted;
- No protection or metering required on bus-section breakers;
- A separate cubicle shall be provided for the termination of all metering outputs and external control circuits. Safe access shall be possible with the switchboard live;
- At the South Kensington Campus incoming and bus-section circuit breakers shall not be interlocked. At remote campuses LV interlocking is at the discretion of the HV network owner;
- Outgoing switches up to and including 630A shall be fuse-switch type;
- 30V DC auxiliary supply (shared with HV equipment);
- Outgoing switches equal to or greater 800A shall preferably be ACB type However, switches in the range 800A – 1250A can be MCCB type if it can be shown that discrimination can be achieved with downstream devices;
- Preferred switches are of Schneider manufacture;
- Harmonic analysis needs to be done to determine the size of the PFC unit;
- If the panel has two sections, each section should have a PFC unit sized accordingly; and
- The College is to attend and sign off FAT testing for all LV switch panels.

1.4.1.5 Cable Systems

HV Cable

- XLPE, Cu, SWA with LS0H over sheath, sized 240mm² for all main feeders and 95mm² for all transformer feeders, except when close RMU coupled.
- Cleated to ladder rack and not tie wrapped.

LV Cable & Conductor Systems

- XLPE, Cu, SWA with LS0H over sheath, multicore.
- XLPE, Cu, AWA with LS0H over sheath, 1c for transformer incomers equal to or less than1600kVA.
- Transformer incomers > 1600kVA to be connected by Copper busbar trunking.
- Cables to be cleated to ladder rack or tray. Tie-wraps may use on earth conductors or cables, 50 mm² or smaller only.

1.4.1.6 Auxiliary Equipment

Battery & Charger

- 30V DC with charger failure alarm for remote signalling (BMS).

Substation Cooling

- Natural ventilation preferred. If forced air is required is naturally vented input and forced output.
- Temperature alarm required for remote signalling (BMS).

1.4.1.7 Earthing

This section shall be read in conjunction with Section 1.3 Earthing.

Wall mounted main earth bar to be provided. If immediate ground access is available two earth electrodes are to be provided with target earth resistance of 10 ohms each. The following bonding shall be made at all South Kensington substations:

- Panel HV switchgear, one bond at each end.
- RMU, one bond. This may be to transformer if close coupled.

- Transformers 2. One on each lug or boss.
- LV Switchgear, one bond at each busbar section.
- LV Neutral Earth within switchboard to main earth bar via removable links. One link for each transformer incomer.
- Incoming HV cable armoured. One bond per cable.
- All outgoing cable earth conductors bonded to main switchboard earth bar.

For other Imperial College campuses, the requirements of the local electricity operator shall be adhered to. Where LV earths are the responsibility of Imperial College, then earth electrodes less than or equal to 1 ohm shall be provided and permission to bond to the HV earth sought from the electricity operator.

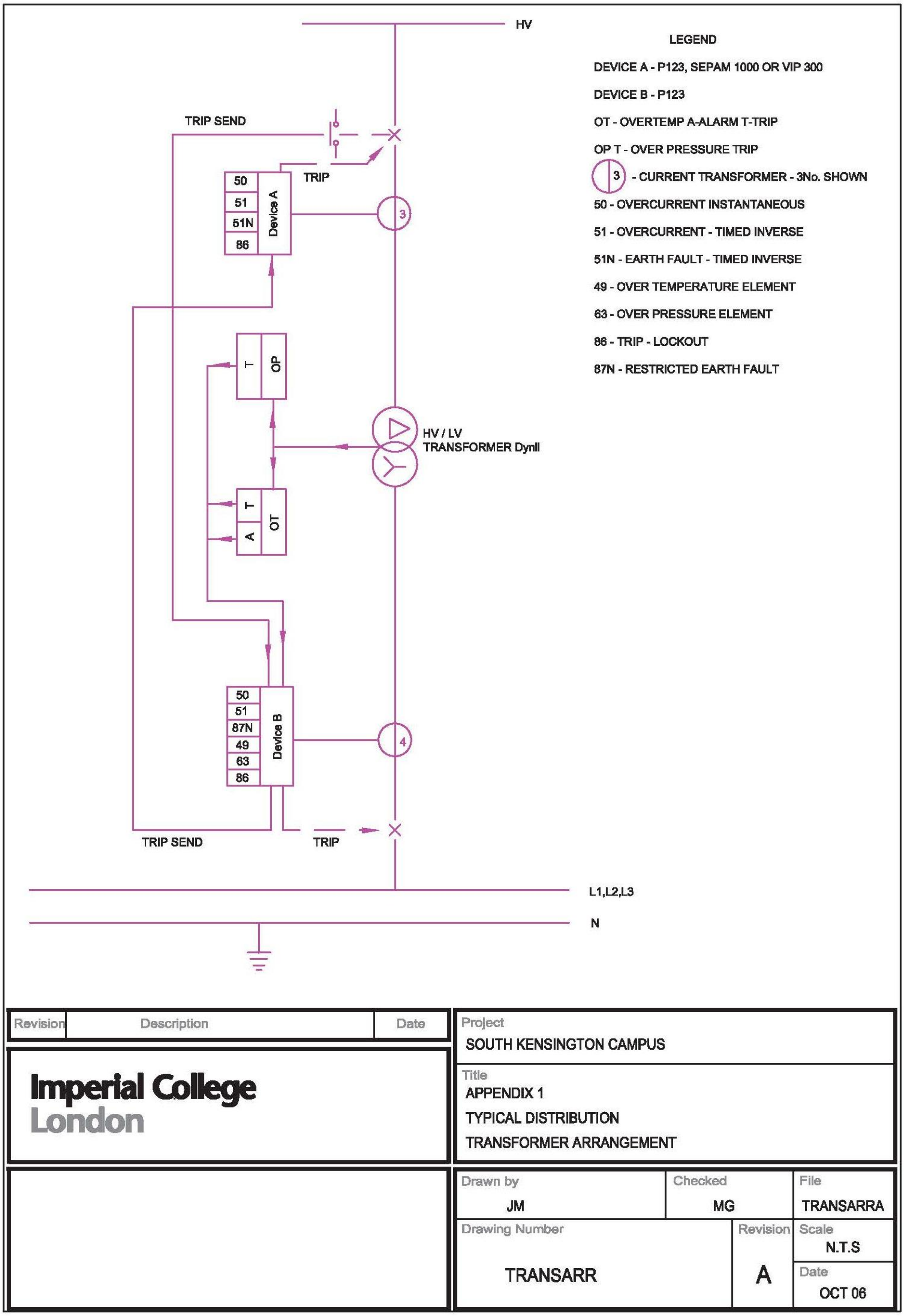

Figure 3 – Typical distribution transformer arrangement

1.4.2 Separation Form for LV Panels

1.4.2.1 Purpose

The purpose of this document is to provide design criteria for designers and contractors responsible for the procurement of LV switchgear installed within the Imperial College.

The strategy is to ensure that:

- The College's maintenance team can maintain and/or install additional circuits in switchgear without necessitating the isolation of adjacent live circuits; and
- Connections can be made to data system outputs without necessitating the disruption or isolation of the primary power circuit.

Proper consideration is given to switchroom size and layout to fulfil objectives above.

1.4.2.2 Switchgear Form of Separation

LV switchboards will be manufactured in accordance with BS EN 61439-2. The form of separation shall be defined in accordance with the BEAMA guide, which forms the National Annex to BS EN 61439-2.

The standard for the College has been set at Form 4 type 7 of the BEAMA guide.

All main LV, sub main, MCCB panels boards and distribution busbars shall be of copper conductors.

All Raising busbar and main busbar systems shall be of copper conductors.

It is appreciated that this form of construction is the most rigorous and the following factors should be taken into account when specifying switchboards to this standard.

However, this standard can be lowered for residential and office buildings only where the isolation of the switch is not critical. Hence allowing maintenance and/or installing of additional circuits by isolating the panel through managed shutdowns.

1.4.2.2.1

Termination of the cables may be made in suitable chambers (cable boxes) externally mounted to the main panel construction.

1.4.2.2.2

The cable boxes shall take account of the cable lay-up and containment configuration and shall be suitable for top, bottom or dual entry as necessary.

1.4.2.2.3

Care shall be exercised to ensure that the cables of adjacent circuits have free alignment with their respective cable box to enable proper termination of cable glands. This may require staggering the cable entry points along the main (lengthwise) axis of the switchboard.

1.4.2.2.4

It shall be possible to make off and access the cable core terminations without the dismantlement of any of the outgoing circuit breaker, fuse or control gear and adjacent circuits, whilst retaining the separation requirement.

1.4.2.2.5

Where circuits require more than one cable, connected in parallel to overcome derating or voltage drop considerations, the cable termination boxes shall be adequately sized and comply with paragraphs 1.4.2.2.1 to 1.4.2.2.4 inclusive.

1.4.2.3 Data and Metering Cables

Imperial College has a basic requirement to provide remote energy metering using Modbus protocol from switchboard instrumentation, which is then configured as per information in the metering section 9.4.1. The College seeks to extend the parameters monitored to exploit the data available from the instrumentation and provide accurate for the network. To facilitate this, the following features shall be incorporated into new switchboards:

Signals derived from instruments for remote monitoring shall be wired out to a separate compartment free of low voltage rated components. Data terminal blocks located within switchgear cubicles fitted with door interlocks preventing access before the power circuit is isolated will not be accepted.

1.4.2.3.1

The Compartment(s) shall be suitable for direct termination of data cables and the internal wiring shall be compliant with the standard of the transmitted data e.g., RS 485, with Modbus protocol.

1.4.2.4 Switchroom Design

It is important that the impact of complying with this strategy is fully recognised when designing the switchroom layout. Inadequate space allowance will not be accepted for non-conformance with this strategy.

1.4.2.5 Compliance

Any non-conformance with this document will not be accepted unless the Imperial College Estates Operations Engineering, Energy and Environment Team has approved it in writing. Any request for waivers shall be accompanied by supporting documentation and drawings.

If difficulty is anticipated in complying with this strategy, then it shall immediately be brought to the attention of the Imperial College's Head of Engineering, Energy and Environment.

1.4.3 LV Electrical Panels rated up to 800A

1.4.3.1 Purpose and Scope

This Particular Requirement provides the technical requirements for the College's LV electrical switch and panel boards for busbar ratings of 400A and below, this does not include Motor Control Centre Panel's (MCCPs) and final distribution boards for power and lighting. For main intake switchgear and switchboards with ratings 400A and above the 1.4.2.2 will apply, where the minimum separation requirement is Form 4, Type 7. However, it is appreciated that, for downstream applications where shutdowns are permissible, this requirement can be eased. Some discretion is permitted for determining the actual separation value dependent upon the user function. For example, if the board is supplying a suite of research facilities, then the separation should be more stringent than a suite of offices enabling routine maintenance to be carried out at a convenient time.

All proposals shall be submitted to the Estates Operations Engineering, Energy and Environment Team for approval at an early stage of the design.

1.4.3.2 Form of Separation

For general MCCB panel boards up to 630A the form of separation shall not be less than Form 2 Type 1 (2b) and for MCCB panel boards up to 800A or in research environments not less than Form 4 Type 1 (4a).

1.4.3.3 Configurations

Normally the switchboards/panels will be fed from a single source switch mounted in a main switchboard in accordance with Section 1.4. Up to 630A rating the controlling device will be a fuse switch and up to 800A an MCCB. Therefore, the incoming switch on the switchboard/panel shall not have a protection device but should be provided with four pole isolation and should be capable of making and breaking normal full load current. It is the responsibility of the designer to ensure that the rating of the fuse or set point of the MCCB on the upstream device is selected in accordance with the switchboard/panel rating. No outgoing switch shall be selected that cannot discriminate with the main incoming protection device, nor shall the switchboard/panel fault rating be lower than the fault rating delivered by the controlling switch.

Where it is necessary to provide two, separate source, incoming supplies a bus-section switch shall be provided having the same rating as the incoming switches. Normally the incoming and bus-section switches will be provided with a key interlock to enable two out of three switches to be closed. Occasionally it will be necessary to omit the interlocks to meet the requirements of the user where it is desirable to transfer the load source without interruption. It then becomes the responsibility of the Imperial HV Operator to control the operation of these switches and they shall be labelled accordingly. Currently our HV networks are operated by external service providers, who will provide the labels. Where it is considered necessary to omit bus-section interlocks, prior authorisation will be required via an Exception Report submitted for joint approval by the Head of Engineering, Energy and Environment and Head of Maintenance.

1.4.3.4 Outgoing devices

Outgoing devices may be either fuse switches or MCCBs with a fault rating of not less than 40kA.

1.4.3.5 Metering

Metering shall be in accordance with the Metering section within this document.

1.5 Electrical Load Calculations

1.5.1 General

The appropriate load calculations shall be included for all designs presented to the college for comment and/or information.

Designers are required to enter the appropriate values into the attached template(s), duplicating templates as necessary, according to the size and complexity of the distribution system.

Related Document:

IC Load Balance Sheet.xls – Excel file.[1]

1.6 Connection of Large Electrical Loads

1.6.1 Introduction

The purpose of this section is to provide guidance criteria for the connection of large electrical loads where:

- There is possibility of exceeding statutory voltage limits at the point of utilisation; and
- The security of supply is jeopardised by exceeding the system design resilience.

This applies at the Imperial College South Kensington campus, where the HV and LV networks are owned and maintained by the College and, for outlying sites, where the College is responsible for operating and maintaining its own HV network.

[1] This file will be packaged in a folder along with this BESPR document. For any enquiries please contact the Engineering, Energy and Environment Team.

1.6.2 Voltage Limits

The LV network at the South Kensington campus is presently regulated to 415/240V, three phase, and 50Hz at the distribution transformer LV terminals. This shall be deemed the supply point nominal voltage in accordance with The Electricity Safety, Quality and Continuity Regulations 2002. The connection of any additional load shall not produce a voltage drop in excess of 4% of the nominal voltage at the fixed point of utilisation in accordance with BS 7671, Requirements for Electrical Installations.

At new locations, the nominal supply voltage shall be regulated to 398/230V, three phase, 50Hz at the distribution transformer LV terminals.

Any load, potentially exceeding these voltage drop limits, shall be immediately brought to the attention of the Imperial College Estates Operations Engineering, Energy and Environment Team.

1.6.3 Supply Security

The criteria applied to the South Kensington campus is as follows.

For teaching, research and administration complexes redundant capacity is provided to enable one transformer to be taken out of service without loss of supply to any of the connected loads. Normally, this is achieved by dual redundancy i.e. two units, each rated to supply the total prospective load. Alternatively, where essential loads are supported by UPS systems, backed up with standby generation, this may be relaxed to three units, each rated to supply 66% of the total prospective load. The second alternative is to be considered where transformer and switchgear ratings exceed practical values or, where unacceptable fault levels arise.

For other areas, principally hostel accommodation; the dual redundancy rule is relaxed. However, if dual redundancy is not applied, a second standby supply from a separate source (usually an adjacent substation) may be required. This criterion is presently applied to the Princes Gardens complex, which comprises a mixture of accommodation and other College facilities.

Any load potentially jeopardising these security criteria shall be immediately brought to the attention of the Imperial College Estates Operations Engineering, Energy and Environment Team.

1.6.4 Requirement for New Substations

Where it is necessary to provide a new substation to meet the criteria of items 1.6.2 and 1.6.3 above it shall be located as near as possible to the main load centres. The substation shall be designed to accommodate all HV switchgear, transformers and LV switchgear within a common area and to include, if possible, any necessary Motor Control Centres (MCC). If the motor loads are not located near the substation, then the MCC(s) shall be positioned to optimise the motor distribution cabling in order that voltage drops do not exceed 15% at the motor terminals during starting.

If it is necessary to provide standby generation then the installation shall be located as close to the substation as possible, including the fuel bunkering.

When a new substation is required, it shall be first agreed with the Imperial College Estates Operations Engineering, Energy and Environment Team.

2 Mechanical

2.1 Design Criteria

The designer shall agree the deliverables with the project manager at the start of project, using the BSRIA BG 6/2018 – Design framework for building services proforma. These may include but are not limited to drawings and / or models, reports, calculations, etc.

Designers and contractors are responsible for quality assurance of these deliverables and works, providing reasonable skills and care and fit-for-purpose designs and installations that are compliant to regulations, standards, and industry guidance. Refer to Building Services Research and Information Association (BSRIA) BG 4/2007 – Design checks for HVAC and BG 2/2006 – Design checks for public health engineering for required standards and examples for quality assurance.

This section of the document shall be read in conjunction with the Imperial College London (Imperial College London) Building Temperature Protocol (BTP).

2.1.1 Energy and Sustainability

Where planning application is required, the designers shall produce an energy statement in accordance with the Mayor of London (Greater London Authority / GLA) – Energy assessment guidance and / or the relevant planning authority's guidance. This shall be reviewed with the project manager as part of an early stage (Royal Institute of British Architects / RIBA Stage 1 Preparation and briefing or Stage 2 Concept design) engineering review meeting (ERM).

Regardless of whether a planning application is required for the works, the designers shall adhere to the following energy hierarchy.

1) **Reducing demands** – this involves the following in order of precedence.
    - **Passive design**, which includes both:
        - Architectural planning, such as building orientation, massing, form factor, rooms layout, etc.; and
        - Building fabric measures, such as choice of façade system, external shading, fabric performances (e.g., U-values, amount

and orientation of glazing and their g-values, and such), etc. In other words, adopt a fabric-first approach;

- **Active design**, i.e., energy efficient building services;
- Demand reduction features shall be introduced at the earliest design stage of a development;

2) **Supplying energy efficiently** – once demand for energy has been minimised, remaining demand shall be met in the most energy efficient manner possible. For instance, the designer shall investigate and consider local heat network if available, etc.; and
3) **Use of low or zero carbon (LZC) technologies** – feasibility and opportunities for utilising on-site LZC technologies shall be assessed, and, where appropriate, maximised.
4) **Monitor, verify, and report on energy performance** – to determine and verify design vs as-built building energy performance.
   - Where the project / building is referrable to the GLA, energy performance monitoring and reporting is required for at least five years post-construction and must be submitted via the GLA's 'be seen' energy monitoring online portal;
   - Refer to the Mayor London's London Plan Guidance – 'Be seen' energy monitoring guidance for details; and
   - In other cases, refer to Sections 2.7.6.1 Soft Landings, 2.7.6.5 Building Performance Evaluation, and 2.7.6.7 Continuous Commissioning for the process to determine if this requirement applies and the extent.

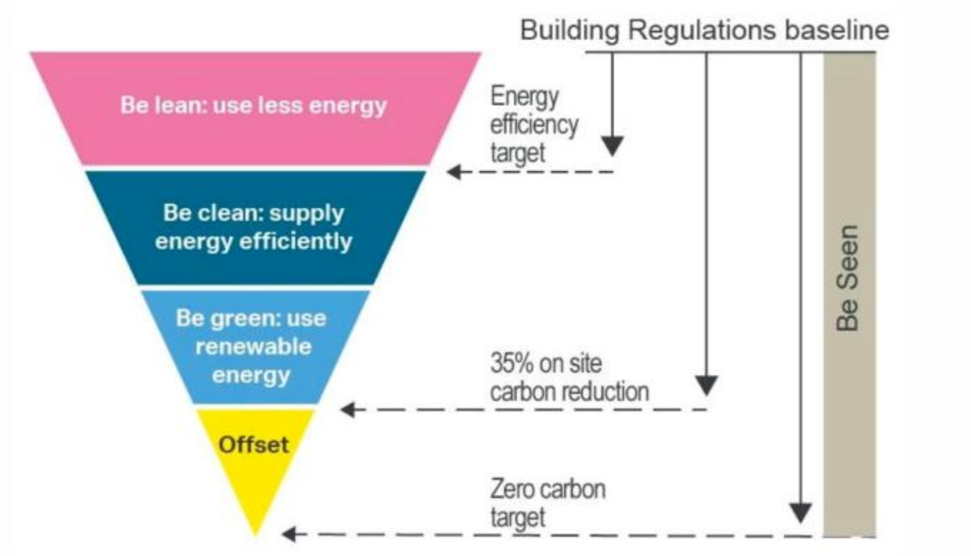

Figure 4 – The London Plan energy hierarchy (excerpt from Mayor of London – Energy assessment guidance, required for all projects referrable to the GLA and included as reference for other projects)

Refer to the Energy section in this BESPR for further information.

2.1.2 External and Internal Design Conditions

All engineering systems shall be designed in accordance with the criteria set out in the sub-sections below. Where the specific facilitie(s) / project(s) contain situations that are not covered below, the designer shall propose design criteria for the College's Engineering, Energy and Environment Team's review and acceptance.

Note that these criteria are not applicable if there is no change to existing / legacy spaces. In these situations, the applicable design criteria shall be that of the original installation.

2.1.2.1 External Design Conditions

Table 2 – External design conditions

Season	Purpose	Design temperature °C		Source
		Dry bulb (DB)	Wet bulb (WB)	
Summer	Loads calculation	28.1	19.2	CIBSE Guide A 2015 London weather data at 0.4%(1)
	Selection of air-cooled heat rejection	35	-	BS EN 14511-2(2)
Winter	Loads calculation	-3	-3.6	CIBSE Guide A 2015 London weather data at 99.6%
	Air handling unit (AHU) frost protection element selection	-4	-4	College requirement

Notes:

(1) Chartered Institution of Building Services Engineers (CIBSE) Guide A – Environmental design.

(2) BS EN 14511-2 – Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors: Part 2 Test conditions.

Where natural ventilation has been proposed by the designers as the most appropriate solution and accepted by the College, the designers shall discuss and agree with the College's Engineering, Energy and Environment Team on applicable external design conditions (for example, whether climate change design criteria are applicable, etc.).

2.1.2.1.1 Noise

External noise emitted by mechanical plants shall be designed, installed, tested, and commissioned to the following.

- Applicable planning requirements, such as:
    - National Planning Policy Framework on noise;
    - Department for Environment, Food, and Rural Affairs (DEFRA) – Noise policy statement for England;
    - Mayor of London's London Plan – Policy for reducing and managing noise; and
    - Relevant local authority's planning requirements on noise (usually in the form of a supplementary planning document);
- BS 8233 – Guidance on sound insulation and noise reduction for buildings;
- Other industry standards and guidance as applicable, etc. For example:
    - For halls of residence, Institute of Acoustics (IoA) – Professional practice guidance on planning & noise, new residential development;
    - For teaching spaces, Education & Skills Funding Agency (EFSA) Building Bulletin (BB) 101 – Guidelines on ventilation, thermal comfort, and indoor air quality in schools, etc.

2.1.2.1.2 Air

Ventilation intakes and exhausts shall be designed to prevent recirculation on exhaust air onto intakes. As a minimum, separation distance per BS EN 13779 – Ventilation for non-residential buildings, performance requirements or a minimum 5m shall be provided between intakes and exhausts.

Where the exhaust air is of higher pollution level[2] (such as kitchen exhaust, fume cupboards / FCs exhaust, microbiological safety cabinets / MSCs exhaust, etc.), there are additional requirements. The following are some examples.

For kitchen exhaust:

- Relevant local authority's planning policy (for instance, Hammersmith and Fulham's supplementary planning document, Royal Borough of Kensington and Chelsea planning policy CL5, etc.). The City of Westminster's Prevention of odour and fume nuisance from commercial kitchen systems guide also contains useful reference technical information;
- Department of Environment, Food, and Rural Affairs (DEFRA) – Guidance on control of odour and noise from commercial kitchen exhaust systems;
- EMAQ+ – Control of odour and noise from commercial kitchen exhaust systems; and
- Successive legislation, policy, standard or guidance, etc.

For FCs and MSCs exhaust:

- Applicable regulations and planning authority's policy;
- Health & Safety Executive (HSE) HSG258 – Controlling airborne contaminants at work, guide to local exhaust ventilation (LEV);
- BS EN 14175 – Fume cupboards;
- BS 5726 – Recommendations and guidance on information exchange, siting, and use of microbiological safety cabinets (MSCs);
- BS EN 12469 – Performance criteria for microbiological safety cabinets (MSCs), etc.

All (except for recirculatory FCs and MSCs) MSCs' and FCs' exhaust shall be ducted to the outside atmosphere, through either a stack or chimney at a height above roof level, ensuring pollutants dispersion away from the building and people. Designers shall produce and provide to the College's its design

2 BS EN 16798-3 – Energy performance of buildings, ventilation for buildings, non-residential buildings performance requirements contains useful reference classifications of air quality for this purpose.

calculations to demonstrate compliance, which may require specialist advice and / or dispersion modelling.

Stack discharge velocities shall not normally be less than 7m/s, and a design figure of 10m/s is preferable.

Designers shall determine from the user brief what emission products are expected in the exhaust air and consult the relevant planning authority (such as Environment Agency, local authority, etc.) as well as the College's Engineering, Energy and Environment Team in these situations.

Refer to Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant for boilers, combined heat and power (CHP), and other combustion plant flues / chimneys.

2.1.2.2 Internal Design Conditions for Summer and Winter (Occupied Hours)

Table 3 – Internal design conditions for different room types

<table>
<tr><th colspan="2" rowspan="2">Room types</th><th colspan="6">Environmental conditions</th><th colspan="3">Ventilation provisions</th></tr>
<tr><th>Winter design temperature</th><th>Summer design temperature</th><th>Humidity</th><th>Source</th><th>Noise rating (NR) level</th><th>Source</th><th>Supply</th><th>Extract</th><th>Source</th></tr>
<tr><td colspan="2">Computer labs</td><td>20°C ± 2°C</td><td>24°C ± 2°C</td><td>Uncontrolled</td><td>The College's BTP</td><td>35</td><td>CIBSE Guide A (teaching spaces)</td><td colspan="2">Minimum 10l/s per person</td><td>Building Regulations Approved Document Part F2 – Ventilation, non-dwelling (ADF2)</td></tr>
<tr><td colspan="2">Corridors & stairwells</td><td>18°C</td><td>Uncontrolled</td><td>Uncontrolled</td><td>The College's BTP</td><td>45</td><td>CIBSE Guide A</td><td colspan="2">Not required</td><td>CIBSE Guide A</td></tr>
<tr><td colspan="2">Communications wiring centre (CWC) rooms</td><td colspan="2">See note 3 below</td><td>Uncontrolled</td><td>The College's Information and Communications Technologies (ICT) standard</td><td>45</td><td>CIBSE Guide A</td><td colspan="2">Required where an uninterruptible power supply (UPS) or battery back-up is part of the installation.

Provisions as per BS EN 62485-2. See note 4.</td><td>BS EN 62485-2 – Safety requirements for secondary batteries and battery installations, stationary batteries</td></tr>
<tr><td rowspan="2">Halls of residence</td><td>Bedrooms</td><td rowspan="2">20°C ± 2°C</td><td rowspan="2">As per Building Regulations Approved Document Part O – Overheating (ADO) and CIBSE TM59 (See note 5).

Design shall be compliant to ADO, including non-mechanical elements such as fabric, glazing, etc.</td><td rowspan="2">Uncontrolled</td><td rowspan="2">The College's BTP and CIBSE TM59</td><td colspan="2">As per IoA ProPG Planning & Noise – New residential development. See note 6.</td><td colspan="3">Ventilation (both background and purge ventilation) per ADO, ADF1 (note 7), CIBSE TM59, and CIBSE TM60 (See note 8 below).</td></tr>
<tr><td>Common rooms</td><td colspan="4">To be designed based on room activities (i.e., study space, social / games area, kitchen, or others), and per IoA ProPG Planning & Noise – New residential development. See note 6.</td><td>Refer to ADO, ADF1, CIBSE Guide A, and / or other relevant regulations and standards.</td></tr>
</table>

3 For temperature and humidity requirements for CWC rooms, please refer to ICT Network Infrastructure Standards document which can be found on the following link: https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/ict/public/V1.5-appendix-C-CWC.pdf

4 Purpose of ventilating a battery location or enclosure is to maintain the hydrogen concentration below the 4 % vol hydrogen Lower Explosion Limit (LEL) threshold.

5 CIBSE Technical Memorandum (TM) 59 - Design methodology for the assessment of overheating risk in homes.

6 Institute of Acoustics (IoA) Professional Practice Guidance on Planning & Noise – New residential development. For bedrooms, between 07:00 to 23:00 – 35dB LAeq, 16hr, and between 23:00 to 07:00 – 30dB LAeq, 8hr and 45dB LAmax, F. See the referred document for details.

7 Building Regulations Approved Document Part F1 – Ventilation, dwellings (ADF1).

8 CIBSE TM69 - Good practice in the design of homes.

Room types	Environmental conditions						Ventilation provisions		
	Winter design temperature	Summer design temperature	Humidity	Source	Noise rating (NR) level	Source	Supply	Extract	Source
Healthcare facilities	Per National Health Service (NHS) or Department of Health (DoH) guides, standards, and requirements depending on activities in the space								DoH Health Technical Memoranda (HTMs), Health Building Notes (HBNs), and other documents
Laboratories (labs) (exclude computer labs)	Per users' specific / specialist requirements (see note 9 below)			User design brief	40	CIBSE Guide A	Per user's specific / specialist requirements and at least 6 air changes (ach). See note 10 below.		User design brief and corresponding regulations & standards. See note 10 below.
Lecture theatre	20°C ± 2°C	24°C ± 2°C	Uncontrolled	The College's BTP	30	CIBSE Guide A	Minimum 10l/s per person		Building Regulations Approved Document Part F2 (ADF2) –

9 Where no specific requirement exists for either winter or summer design temperatures, ICL BTP shall apply.

10 The supply and extract ventilation provisions shall work together as a system to achieve the particular functional and safety goals of the laboratories. Requirements for laboratory ventilation varies depending on usage. Guidance on provisions include but are not limited to the following.

Table A – Guidance on ventilation provisions requirements for different types of laboratories		
Types of laboratories	**Reference**	**Link (if applicable)**
Animals	Home Office – Code of practice for the housing and care of animals bred, supplied, or used for scientific purposes	https://www.gov.uk/government/publications/code-of-practice-for-the-housing-and-care-of-animals-bred-supplied-or-used-for-scientific-purposes
Biological containment	BS EN 12128 – Containment levels of microbiology laboratories, areas of risk, localities, and physical safety requirements HSE Advisory Committee on Dangerous Pathogens (ACDP) – Management and operation of microbiological containment laboratories	N/A
Cleanrooms	BS EN ISO 14644 – Cleanrooms and associated controlled environments	N/A
Fume cupboards (FCs)	ICL - Code of practice (CoP) for selection, installation, use, maintenance and decommissioning of fume cupboards (FCs)	https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/safety/public/lev/Code-of-Practice-for-Fume-Cupboards.pdf
Healthcare laboratory	Department of Health (DoH) Health Technical Memorandum (HTM) 03-01 – Specialised ventilation for healthcare premises	N/A
Microbiological safety cabinets (MSCs)	ICL - Code of practice (CoP) for selection, use and maintenance of microbiological safety cabinets (MSCs)	https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/safety/public/lev/MSC-CoP-ISSUE-2.pdf
Pharmaceutical	Medicines and Healthcare products Regulatory Agency (MHRA) – Rules and guidance for pharmaceutical manufacturers and distributors 2017 (The Orange Guide)	N/A

Risk assessment shall be conducted by designers and presented to ICL safety team to determine whether local exhaust ventilation (LEV) is required. If required, see note 16 for LEV provisions requirements.

Room types		Environmental conditions						Ventilation provisions		
		Winter design temperature	Summer design temperature	Humidity	Source	Noise rating (NR) level	Source	Supply	Extract	Source
										Ventilation, non-dwelling
Office / write-up areas (see note 11 below)	Mechanically cooled	20°C ± 2°C	24°C ± 2°C	Uncontrolled	The College's BTP	35 (cellular) 40 (open plan)	BCO Guide (see note 11)	Minimum 10l/s per person		ADF2
	Not mechanically cooled	20°C ± 2°C	Per ADO and CIBSE TM52 (see note 12)	Uncontrolled	The College's BTP and CIBSE TM52			Ventilation per ADO, ADF2, and CIBSE TM52.		
Seminar rooms	Mechanically cooled	20°C ± 2°C	24°C ± 2°C	Uncontrolled	ESFA BB101 (see note 13)	35	ESFA BB93 (see note 14)	Minimum 10l/s per person		ADF2, and ESFA BB101
	Not mechanically cooled	20°C ± 2°C	Per ADO and ESFA BB101	Uncontrolled	ESFA BB101			Ventilation per ADO, ADF2, and ESFA BB101.		
Showers / changing rooms		21°C ± 2°C	24°C ± 2°C	Provide adequate ventilation	CIBSE Guide A	45	CIBSE Guide A	8 ach	10 ach	The College's requirements
Storerooms		Per users' specialist / specific requirements	Uncontrolled or per users' specialist / specific requirements	Uncontrolled (unless there are users' specialist / specific requirements)	User design brief	45	The College's requirements	90% of extract volume if mechanically ventilated	Per users' specialist / specific requirements	User design brief
Toilets		18°C	Uncontrolled	Uncontrolled	The College's BTP	45	CIBSE Guide A	8 ach	10 ach	The College's requirements
Workshops		16°C to 19°C (See note 15 below)	See note 15 below	Uncontrolled	CIBSE Guide A	55	CIBSE Guide A (factories, light work)	As required for the workshop activities or 10l/s per person based on occupancy, whichever the largest. Risk assessment shall be conducted by designers and presented to The College's safety team to determine		CIBSE Guide A

11 British Council for Offices (BCO) - Best practice in the specification for offices (BCO Guide). For speculative office spaces available for commercial lettings, reference shall be made with regards to the BCO Guide and comparisons illustrated to enable ICL to make informed decisions on the specifications.

12 CIBSE TM52 – The limits of thermal comfort, avoiding overheating in European buildings.

13 Education & Skills Funding Agency (EFSA) Building Bulletin (BB) 101 – Guidelines on ventilation, thermal comfort, and indoor air quality in schools.

14 Education & Skills Funding Agency (EFSA) Building Bulletin (BB) 93 – Acoustic design of schools, performance standards.

15 16°C to 19°C applicable to occupied zone only. When appropriate (for example, in semi-exposed locations where it is not practical to heat to 16°C to 19°C), local spot heating shall be provided as an alternative. Cooling will not be provided to workshops in general. Where the designer deems that cooling is required, it shall provide the evidence and rationale for ICL to review.

Room types	Environmental conditions						Ventilation provisions		
	Winter design temperature	Summer design temperature	Humidity	Source	Noise rating (NR) level	Source	Supply	Extract	Source
							whether local exhaust ventilation (LEV) is required. See note 16.		

16 Local exhaust ventilation (LEV) provision shall comply with the ICL - Local exhaust ventilation policy (https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/safety/public/lev/lev-policy/Policy-on-LEVv-final-review-2016-(2).pdf), Health & Safety Executive (HSE) HSG258 – Controlling airborne contaminants at work, guide to local exhaust ventilation (LEV), and Building Engineering Services Association (BESA) TR40 – Guide to good practice for local exhaust ventilation.

2.1.3 Design Calculations

The designer shall produce and provide to Imperial College London its design calculations to demonstrate compliance to regulations, standards, codes of practice, industry guidance, and the above criteria.

The designer shall refer to the following for required standards and examples of the calculations.

- BSRIA BG 30/2007 – A guide to HVAC building services calculations;
- BSRIA BG 1/2006 – Applying HVAC building services calculations;
- CIBSE Guide G – Public health and plumbing engineering;
- Institute of Plumbing (IoP) – Plumbing engineering services design guide; and
- Other relevant regulations, guides, and standards.

The above guides and BSRIA BG 6/2018 – Design framework for building services shall be used to inform the relevant calculations required and to be provided to Imperial College London at specified project stages, based on agreement with the Imperial College London Engineering, Energy and Environment Team made at start of the project(s).

Calculations include but are not limited to the following.

HVAC

- Ventilation provisions (include fire safety ventilation systems such as smoke extract, stairs pressurisation or stairs smoke vent, etc.);
- Heating and cooling loads;
- Psychrometric;
- Plant selection (such as heating and cooling sources);
- Ducts and pipes sizing;
- Control elements sizing and selection (such as variable air volume / VAV boxes, control valves, etc.);
- Fans and pumps selection;
- System pressurisation sizing and selection;
- Acoustics calculations (for the selection of appropriate mechanical equipment and attenuations); and

- Energy performance.

Public health

- Plumbing and drainage provisions;
- Plant selection (such as hot water heaters, plate heat exchangers, domestic hot and cold water storage tanks, drainage sumps, etc.)
- Pipes sizing;
- Pumps selection;
- Natural gas supply and pipes sizing; and
- Specialist services (such as vacuum, compressed air, medical gases, laboratory gases, etc.)

In accordance with BSRIA BG 30/2007, BG 1/2006, and other references mentioned above, the designer shall set out and provide to Imperial College London the margin of error used in its design calculations, complete with its assumptions and explanations. These can include, for example (but are not limited to):

- Factors of safety or allowances for variations between design and final installation;
- Fan, pump, and pipe heat gain / loss; and
- Inputs, such as design user equipment specifications, design façade specifications, and others, to load calculations.

2.1.3.1 Space Heating and Cooling Loads

2.1.3.1.1 Rules of Thumb Reference

For early design stages or simpler projects, it may be acceptable to utilise industry references and benchmarks as parts of the design calculations – particularly on heating and cooling demands.

The designer shall agree with the Imperial College London Engineering, Energy and Environment Team if this applies.

One such industry reference and benchmark is the BSRIA BG 9/2011 – Rules of thumb guidelines for building services, parts of which are excerpted below for convenience. Other industry accepted guides and standards, such as CIBSE Guide F – Energy efficiency in buildings, etc., may also be used if justified.

Table 4 – Typical 'rule of thumb' heating and cooling loads for new buildings per BSRIA BG 9/2011 (or CIBSE Guide F or other guides)

Space type	Rule of thumb	
	Heating load (W/m² of gross internal area / GIA)	Cooling load (W/m² of GIA)
Offices	70	87
Retail	100	140
Data centre	-	1500

These and other benchmark figures shall only be used within their limits, for instance:

- At early design stages like Royal Institute of British Architects (RIBA) Stage 0 Strategic definition or Stage 1 Preparation and briefing;
- For simple projects with low risks (often with low cost);
- As a reference scale / ballpark figure to guide conversations with users and stakeholders, etc.

2.1.3.1.2 Space Heating and Domestic Hot Water Loads

The designer shall calculate space heating loads for the project(s) using the method stated in:

- CIBSE Guide A – Environmental design;
- BS EN 12831-1 – Energy performance of buildings, methods for calculating design heat load, space heating; and
- Other relevant regulations, standards, and guidance.

Where older buildings are involved, the designer shall take into account of the additional infiltrations (compared to new building stocks) that may be present.

Refer to Section 2.5.1 System Design and Provisions for requirements on domestic hot water (DHW) services.

2.1.3.1.3 Space Cooling Loads

In general, air conditioning / comfort cooling systems (where provided) shall be designed to accommodate the following cooling loads.

Table 5 – Typical internal gains assumption for space cooling load calculations

Room category		Requirement		
		In early design stages (up to approximately RIBA Stage 3 Spatial coordination, or per BSRIA BG 6/2018 and above guides)		**In later design stages where the designer obtains more information**
Lighting	Office	In general: 10 to 12W/m^2	Where there is new lighting installation(s) for the project: Target 6W/m^2 for Cat A & B (assuming daylight dimming) per BCO Guide (see note 11 above)	As design load (per lighting calculation outputs)
	All other areas	Per early lighting design estimates, or industry standard design benchmarks appropriate for the type of space		
Equipment / small power	Office	In general: 25W/m^2	Where new equipment is being fitted: Per BCO Guide	As design load (per diversified small power allowance on electrical design)
	All other areas	Per tabulation of equipment heat gain information from users (in the form of room datasheets, see note 17); or If users cannot provide this information, industry standard design benchmarks appropriate for the type of space		Per tabulation of detailed equipment heat gain information (in the form of room datasheets, see note 17) from users, with user consulted diversity applied
Occupants	Office	80W sensible / 60W latent per person (per CIBSE Guide A)		
		For number of occupants: Use Imperial College London space planning norms appropriate for the types of offices (see note 18). Consult users on expected usage patterns and / or occupant diversities. If users cannot provide this information, use industry guidance such as CIBSE Guide A or BCO Guide.		**For number of occupants:** Use desks / workspace layout.
	All other areas	Per CIBSE Guide A as appropriate for the type of space and occupant activities		
		For number of occupants: Obtain information in the following order of priority – room datasheets, Imperial College London space planning norms, and CIBSE Guide A. For example, where occupant data are available in room datasheets, it shall take precedence over the Imperial College London space planning norm, and so forth.		**For number of occupants:** Use room datasheets.

17 Use ICL standard room datasheets (https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/estates-projects/public/resources/forms/ep07medatasheet.xls).

18 ICL space planning norms (https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/estates-projects/public/space/sm02spacenorms.pdf).

Table 6 – Typical external gains assumption for space cooling load calculations

<table>
<tr><th rowspan="2">Type of loads</th><th colspan="3">Existing buildings</th><th colspan="2">New buildings</th></tr>
<tr><th colspan="2">In early design stages (up to approximately RIBA Stage 2 Concept design, or per BSRIA BG 6/2018 and above guides)</th><th>In later design stages</th><th>In early design stages (up to planning application, approximately RIBA Stage 2 Concept design, or per BSRIA BG 6/2018 and above guides)</th><th>In later project stages towards practical completion</th></tr>
<tr><td>Solar and fabric gains</td><td>In general, per existing building and fabric design.</td><td rowspan="2">For capital projects:
• Calculate whether façade improvements (solar & fabric gains reduction and / or reduction of infiltration) provide sufficient payback in terms of energy reduction; and
• Determine whether consequential improvements are required per Building Regulations Approved Document Part L2 – Conservation of fuel and power, buildings other than dwellings (ADL2).

Where these apply, refer to Table 7 below.</td><td rowspan="2">Per agreed building and fabric design from previous design stages, incorporating updates.</td><td rowspan="2">Baseline: Per required in ADL2, Section 4 Limiting heat gains and losses.

Recommended: As a minimum, per the notional building described in Department for Levelling Up, Housing and Communities (DLUHC) – National calculation methodology (NCM) modelling guide (for buildings other than dwellings in England) 2021. See note 19.

Design team shall evaluate and demonstrate whether further measures to reduce solar and fabric gains provide sufficient payback in terms of energy and carbon reduction.

Best practice: Net zero carbon targets. Some of the best practices available include:
• Passivhaus standard; and
• The London Energy Transformation Initiative (LETI) standard.
Refer to the corresponding standards for details[20].

Summary of key performance indicators from the above baseline, recommended, and best practice standards has been included in Table 7 below for quick reference.</td><td rowspan="2">Per agreed building and fabric design from previous stages, incorporating updates.

Building airtightness shall be tested and updated accordingly, per Building Regulations Part L requirements.</td></tr>
<tr><td>Infiltration</td><td>In general, per CIBSE Guide A (i.e., corresponding values in tables 4.16 to 4.24 in the 2015 version, or subsequent appropriate values in future Guide A updates).</td></tr>
</table>

19 The Building Regulations Part L notional building is a theoretical building to which the actual building's performance is compared. The notional building is the same size and shape as the actual building and has standardised properties for fabric and building services. The **notional building's standardised specifications** for **fabric and building services** are **better than** the **baseline limits in ADL2**.

20 These include:

- For Passivhaus, Passivhaus Trust – Claiming the Passivhaus standard, technical briefing document, Passivhaus Trust – Passivhaus retrofit in the UK, etc.; and
- For LETI, LETI – Climate emergency design guide, LETI – Climate emergency retrofit guide, LETI – Design archetype 04 commercial offices, etc.

Table 7 – Typical key energy performance indicators for new and applicable existing buildings

Building elements	Baseline (new and existing buildings)[21]	Recommended (new and existing buildings)[22]	Best practice references				
			New buildings			Existing buildings retrofit	
			Passivhaus		LETI (for commercial offices)	EnerPHit (Passivhaus standard for retrofits) (cool temperate climate zone[23])	LETI (retrofit)
Walls U-value	0.26W/m^{2}K	0.18W/m^{2}K (side-lit)	~0.13 - 0.18W/m^{2}K (based on examples from completed projects)		0.12 - 0.15W/m^{2}K	≤0.15W/m^{2}K	To be provided in future revisions, as current LETI retrofit standards only apply to homes / domestic retrofits.
Roofs U-value	0.18W/m^{2}K (flat roof) 0.16W/m^{2}K (pitched roof)	0.15W/m^{2}K (side-lit)			0.10 - 0.12W/m^{2}K	≤0.15W/m^{2}K	
Floors	0.18W/m^{2}K	0.15W/m^{2}K (side-lit)			0.10 - 0.12W/m^{2}K	≤0.15W/m^{2}K	
Windows / glazed elements	1.6W/m^{2}K 0.48 g-value (side-lit) 0.42 g-value (top-lit)	1.4W/m^{2}K (side-lit) 0.29 g-value & 60% visible light transmittance (VLT) (side-lit)	-		1.0W/m^{2}K (triple glazing) 1.2W/m^{2}K (double glazing)	≤1.05W/m^{2}K	
Doors	1.6W/m^{2}K	1.6W/m^{2}K	-		1.2W/m^{2}K	-	
Building airtightness (not applicable to existing buildings)	8m^3/h per m^2 at 50Pa	3m^3/h per m^2 at 50Pa (side-lit)	≤0.6 ach at 50Pa[24] (~0.4 - 1m^3/h per m^2 at 50Pa[25, 26])		<1m^3/h per m^2 at 50Pa	≤1 ach at 50Pa[24]	
Specific heating demand per year	-	-	≤15kWh/m^2 per year	**Or** specific heating load ≤10W/m^2	≤15kWh/m^2 per year (all building types)	≤25kWh/m^2 per year	
Specific cooling demand per year	-	-	≤15kWh/m^2 per year (non-domestic buildings only)		-	-	
Specific primary energy demand per year (for entire building)	-	-	≤120kWh/m^2 per year		≤70kWh/m^2 per year (net leasable area / NLA) ≤55kWh/m^2 per year (gross internal area / GIA)	≤135 + (specific heating demand per year – 15) kWh/m^2 per year	

21 Per required in ADL2, Section 4 Limiting heat gains and losses. See Table 4.1 for limiting fabric U-values and building airtightness, Table 4.3 for reference glazing systems for solar gain calculation, etc.

22 See in DLUHC – NCM modelling guide (for buildings other than dwellings in England) 2021 Table 1 for fabric U-values, Table 4 for glazing specifications, Table 3 for building airtightness, etc.

23 Climate zones as defined by Passivhaus standards; see Passivhaus Trust – Passivhaus retrofit in the UK. UK Passivhaus Trust recommends applying the cool temperate zone for London. Figures in this column apply to cool temperate zone, except for building airtightness and specific primary energy demand – which apply for all climate zones.

24 Tested using the n50 method per BS EN ISO 9972 – Determination of air permeability of buildings with fan pressurisation method as opposed to the typical Air Tightness Testing & Measurement Association (ATTMA) methods.

Table 8 – Example of completed Passivhaus projects

Key performance indicator	University of Leicester Centre of Medicine (George Davies Centre)[25]	Exeter Council's St Sidwell's Point Leisure Centre (and swimming pool)[26]
Specific heating demand per year	15kWh/m²	Space heating Pool hall <40kWh/m² All other areas <20kWh/m² Pool water heating <73kWh/m² Domestic hot water heating <56kWh/m²
Specific cooling demand per year	1kWh/m²	Gym <22kWh/m²
Specific primary energy demand per year	116kWh/m² per year	Electricity <120kWh/m² All primary energy <375kWh/m²
Building airtightness	1m³/h per m² at 50Pa or 0.34 ach at 50Pa	<0.4m³/h per m² at 50Pa
U-values	0.13W/m²K	Unknown (but likely <0.18W/m²K)

25 Source: CIBSE Journal April 2016 – The UK's largest Passivhaus: University of Leicester's Centre for Medicine (https://www.cibsejournal.com/case-studies/the-uks-largest-passivhaus-university-of-leiesters-centre-for-medicine/), UK Passivhaus Trust – Students learn from the largest UK commercial Passivhaus (https://www.passivhaustrust.org.uk/news/detail/?nId=693), and University of Leicester – About: George Davies Centre (https://le.ac.uk/about/history/campus-history/george-davis).

26 Source: CIBSE Journal September 2019 – Designing the UK's first Passivhaus swimming pool (https://www.cibsejournal.com/technical/testing-the-water-designing-the-uks-first-passivhaus-swimming-pool/), Building Magazine February 2022 – Dive into the UK's first Passivhaus leisure centre (https://www.building.co.uk/buildings/take-a-dive-into-the-uks-first-passivhaus-leisure-centre/5116092.article), and Exeter Council – Case for Passivhaus & building biology in leisure buildings.

2.1.3.2 Plant Selection

In addition to meeting the above design criteria and calculations requirements, plant shall be selected to meet the following requirements and energy efficiency standards.

Designers shall calculate, document, and provide evidence to Imperial College London to demonstrate appropriate plant selections based on the calculated loads. The plant selections shall account for (but are not limited to):

- Diversity and load profiles, such as durations of part loads and full load;
- Resilience;
- Spare capacity and future expansion;
- Whole life cycle performance;
- Plant space, costs, and maintenance requirements (i.e., access for inspection, maintenance, and plant delivery / replacement); and
- Minimum performance for energy efficiency, noise, emissions, and other parameters depending on the specific plant.

Refer also to Section 2.1.4 System Selection.

2.1.3.2.1 Diversity and Load Profiles

The designer shall consult users about their usage profiles and make appropriate proposals on plant diversity as well as adopted load profiles to the Imperial College London Engineering, Energy and Environment Team for review. Where system serves multiple buildings, the designer shall provide and document the chosen diversity for each building / network.

Factors to consider in determining plant diversity and load profiles include but are not limited to:

- Building orientation;
- Type of building / usage profiles; and
- Occupancy patterns.

2.1.3.2.2 Resilience

Based on the user design brief and criticality of the user activities, the designer shall determine the level of plant resilience required to mitigate risks in loss of mechanical services. Resilience shall also be built in to facilitate maintenance and plant replacements. The proposed plant resilience shall be presented by the designer to Imperial College London for review, for example:

- Is the installation or part(s) of it to have N+1 resilience?
- If a particular item of plant fails, what system capacity remains?
    - How does the remaining system capacity correspond to the building's load profiles?
    - And for how long?

2.1.3.2.3 Whole Life Cycle Performance

Designers and contractors shall evaluate and document whole life cycle performance when selecting plant. Evaluation criteria include but are not limited to:

- Carbon – both embodied, operational, and end-of-life emissions; and
- Cost – both capital and operational, e.g., energy and maintenance costs;

This evaluation will drive decision such as whether to refurbishing existing plant or provide new ones, etc. Designers and contractors shall evaluate, document, and provide evidence to Imperial College London to demonstrate optimised whole life cycle performance in accordance with:

- CIBSE TM65 – Embodied carbon in building services, a calculation methodology;
- BSRIA BG 59/2014 – Life cycle assessment, an assessment of a building services system;
- BSRIA BG 67/2016 – Life cycle costing;
- Mayor of London's London Plan Guidance – Whole life cycle carbon assessments; and / or
- Other similar standards and guidance as agreed with Imperial College London.

2.1.3.2.4 Energy Efficiency / Performance

The systems and plant selections shall be designed and incorporated together to maximise energy efficiency / performance whilst meeting the building services requirements.

Examples include but are not limited to the following.

- For central plant selection, the designers and contractors shall incorporate free cooling (whether airside or waterside) unless demonstrated otherwise; and
- For new systems or extensive refurbishment of existing systems, the designers shall incorporate the following features for energy performance and the College's future net zero carbon objective unless demonstrated otherwise:
  - **Low temperature heating** – which enables use of low or zero carbon (LZC) heat sources. This involves **reducing** the low temperature hot water (LTHW) flow and return temperatures **from** 82°C / 71°C or 80°C / 60°C (i.e., those typically used for heating systems with fossil fuel as primary energy);
  - **High temperature cooling** – which enables more energy efficient cooling. This involves **raising** the chilled water (CHW) flow and return temperatures **from** 6°C / 12°C, used traditionally as design benchmark, and / or raising the air handling unit (AHU) supply air temperature appropriately; and
  - **On-site low or zero carbon (LZC) plant** – such as air source heat pumps (ASHPs), ground source heat pumps (GSHPs), solar thermal, etc. where applicable.

Energy efficiency criteria for specific mechanical services

See Sections 2.2.7 Minimum Energy Efficiency Standards and 2.3.3 Minimum Energy Efficiency Standards below.

2.1.3.3 Ductwork and Pipework Sizing

Ducts and pipes shall be sized to balance between cost and carbon (capital / embodied, operational, and whole life), space, noise, energy efficiency (such as specific fan power, etc.), and other functional requirements (such as maintenance access, ability to commission, etc.).

In addition to those already referred to in this section (Section 2.1.3 Design Calculations), designers and contractors shall refer to the following for required standards and examples on ductwork and pipework sizing:

- CIBSE Guide B2 – Ventilation and ductwork;
- CIBSE Guide C – Reference data; and
- BSRIA BG 9/2011 – Rules of thumb guidelines for building services.

Table 9 to Table 11 below summarise and consolidate these guidance as quick references for use in College premises (refer to the standards and guidance for details).

Table 9 – Maximum duct velocities for normal[1] operations

Room types	Noise rating (NR) level	Velocity (m/s)[2]			Maximum pressure drop per metre (Pa/m)[3]
		Main ducts / risers	Branches	Final connections	
Domestic spaces (bedrooms)	~25[4]	3.0	2.5	<2.0	1 (for velocities between 3m/s to 6m/s)
Performing arts theatres, music / concert halls and spaces	25	4.0	2.5	<2.0	
Lecture theatres, cinemas	30	4.0	3.5	<2.0	
Halls of residence (bedrooms)	~25[4]	5.0	4.5	2.5	
Cellular offices / write-up areas, libraries, and seminar rooms	35	6.0	5.5	3.0	
Open plan offices	40	7.5	6.0	3.5	8 (for velocities between 7.5m/s to 15m/s)
Shops, cafeterias	45	9.0	7.0	4.5	
Workshops	55	10.0	8.0	5.0	

Notes:

(1) Not applicable for emergency operations, such as:
  - Fire safety, e.g., smoke extract and make-up air, escape routes pressurisation, etc.;
  - Purging of hazardous gases, e.g., chlorine leaks if used in swimming pool disinfection plant, nuclear magnetic resonance (NMR) cryogenic gas quenching;
  - Etc.

(2) Source: CIBSE Guide B2 2016, Table 2.16.

(3) Source: CIBSE Guide C 2007, Table 4.11 and BSRIA BG 9/2011, Table 11.

(4) Approximate value. See corresponding entry in Table 3 – Internal design conditions for different room types for details.

Table 10 – Typical velocities and pressure drops through selected ventilation system components

Ventilation system components		Velocity (m/s)	Pressure drop (Pa)
Grilles or terminals[1]	Supply	1.5	-
	Return / exhaust	2	-
Louvres[2]	Intake	2.5 (through free area)	35 max
	Exhaust		60 max
Coil[3]	Heating	Up to 2 – 2.5	~30 – 50
	Cooling	Up to 2	~60 – 120
Filter	Panel	As duct / plant (e.g., AHU, etc.) cross section	40 max[4]
	Bag	As duct / plant (e.g., AHU, etc.) cross section and up to 2	50 max[4]
	HEPA[5]	1.3	-
Heat recovery devices		See manufacturer's data.	

Notes:

(1) Source: CIBSE Guide B2 2016, Table 2.19. and Section 2.3.5.7.
(2) Source: CIBSE Guide C 2007, Table 4.12.
(3) Based on CIBSE Guide B2 2016, Section 2.3.5.7 and CIBSE Guide C 2007, Table 4.12 with energy efficiency design measures applied.
(4) Based on initial installation / clean filter.
(5) High efficiency particulate air.

See also Section 2.2.4 Ventilation Ductwork, Accessories, and Insulation for ductwork requirements (e.g., Section 2.2.4.2 Sheet Metal Ductwork for sheet metal ductwork, etc.), and Section 2.2.7 Minimum Energy Efficiency Standards.

Table 11 – Typical water velocities for pipework within buildings[1]

Situation / diameter	Velocity (m/s)[2]	Maximum pressure drop per metre (Pa/m)[3]
Small bore	<1.0	250
15mm Ø to 50mm Ø	0.75 to ≤1.10	
>50mm Ø		

Notes:

(1) Refer to CIBSE CP01 – Heat networks code of practice for the UK and CIBSE CP01G – Heat networks design guide on pipework sizing for heat networks.
(2) Source: CIBSE Guide C 2007, Table 4.6 and BSRIA BG 9/2011, Table 5.
(3) Based on BSRIA BG 9/2011, Table 5 balancing between optimum life cycle energy consumption and installation costs.

See also Section 2.3.3 Minimum Energy Efficiency Standards.

2.1.3.4 Cold Water Storage

Domestic cold water storage capacity shall be based on guidance given in:

- Approved Document Part G – Sanitation, hot water safety, and water efficiency (ADG);
- CIBSE Guide G – Public health and plumbing engineering;
- IoP – Plumbing engineering services design guide, etc.

for the appropriate building type and occupancy density (for example, the BCO Guide for office, and so forth).

Designers shall review the proposed amount of cold water storage with Imperial College London Engineering, Energy and Environment Team for acceptance.

2.1.4 System Selection

Designers shall evaluate, document, and provide evidence to Imperial College London to demonstrate appropriate system selections based on project, building, and campus requirements from early design stages:

- RIBA Stage 1 Preparation and briefing – the designers shall investigate and advise on potential energy strategy options to comply with any energy-related planning conditions, etc.; and
- RIBA Stage 2 Concept design – the designers shall coordinate with rest of design team on potential mechanical schemes for the preferred solution selected in RIBA Stage 1, etc.

Designers shall continue the process accordingly in remaining RIBA project stages. Refer to BSRIA BG 6/2018 – Design framework for building services for further information.

Where an existing system is present, the designers shall ensure the maximum value is utilised out of the existing system before considering new systems. Redundant (i.e., existing systems no longer providing a useful function, <u>not</u> those for standby / resilience) systems or parts of systems shall be safely decommissioned and removed.

Where the provision of comfort cooling is required in accordance with the BTP, chilled water systems shall be the default option. It is not College policy to use DX based split or variable refrigerant volume cooling systems except where prior acceptance has been given via an Engineering Exception Report or when installed in ICT Communication Wiring Centre (CWC) rooms.

2.1.4.1 Criteria / Considerations for System Selection

Project, building, and campus requirements that designers shall consider include internal design conditions and tolerance, system performance, spatial requirements, and whole life cycle assessment.

2.1.4.1.1 Internal Design Conditions and Tolerances

The internal design conditions and tolerances for rooms in question shall be designed to, in hierarchical order, the user brief and as described in Section 2.1.2.2 Internal Design Conditions for Summer and Winter (Occupied Hours). These design requirements will determine the system choice(s) capable of achieving such conditions. Some examples of internal design conditions and tolerances to be considered for system selection include:

- Temperature and humidity, and whether close control of either or both is warranted;
- Air quality – specifically those required for particular research, such as BS EN ISO 14644 cleanroom classes, BS EN 12128 biological research laboratories containment levels, etc.;
- Ventilation rate;
- Room pressure and isolation regime(s); and
- Noise.

2.1.4.1.2 System Performance

Designers shall appraise the system choices against performance requirements to establish selection. System performance criteria include but are not limited to:

- Reliability (minimal maintenance / failure);
- Ease of maintenance;
- Energy efficiency;

- Control;
- Air distribution;
- Flexibility / adaptability for future, such as anticipated change of layouts and / or use;
- Environmental impacts (other than energy / carbon – see Section 2.1.4.1.4 Whole Life Cycle Assessment below), such as choice of refrigerant, emissions dispersal (e.g., combustion products, fume cupboards, or other laboratory substances), external noise levels, etc.; and
- Ease of commissioning.

These and other factors shall be evaluated against each project's requirements and situations, which influence their relative importance.

2.1.4.1.3 Spatial Requirements

As systems have different spatial requirements, designers shall evaluate them against physical constraints and the opportunity costs of the spaces. The following shall be compared between the system options:

- Plant area;
- Services distribution – both vertical and horizontal; and
- Space for the mechanical services in occupied area.

2.1.4.1.4 Whole Life Cycle Assessment

Designers shall appraise the system options from a whole life cycle perspective. These include both:

- Carbon emissions and energy – embodied, operational, and end-of-life; and
- Cost – capital and operational, in terms energy as well as maintenance.

2.1.5 Fire Safety

Mechanical systems related to fire safety shall be designed, installed, commissioned, and maintained in accordance with:

- Building Regulations Approved Document Part B Fire safety (volume 1) – Dwellings (ADB1);
- Building Regulations Approved Document Part B Fire safety (volume 2) – Buildings other than dwellings (ADB2);
- BS 9991 – Code of practice for fire safety in the design, management and use of residential buildings;
- BS 9999 – Code of practice for fire safety in the design, management and use of buildings;
- The project's, building's, and / or campus's fire strategy and insurance conditions; and
- Other relevant regulations, codes, and standards.

Mechanical systems related to fire safety must integrate with other building service systems. These mechanical systems can include (but are not limited to):

- Dampers, such as fire dampers (FDs), fire and smoke dampers (FSDs), motorised fire and smoke dampers (MFSDs), smoke control dampers (SCDs), etc.;
- Smoke control systems, such as smoke extract / clearance, staircase protection for escape and / or firefighting, etc.; and
- Others listed in Section 2.7.2 Fire Alarm Interfaces with Mechanical Plant.

2.1.6 Access and Maintenance

2.1.6.1 General Requirements

Designers and contractors shall design for access and maintenance within their works throughout all project stages, including but are not limited to:

- In early stages –
    - Feasibility studies in RIBA Stage 1 Preparation and briefing shall consider space and method for access and maintenance in spatial planning. Consideration of Soft Landings requirement shall also begin at this stage (see 2.7.6 Testing and Commissioning).
    - During options selection in RIBA Stage 1 and Stage 2 Concept design, access and maintenance requirements shall be

incorporated into the system selection, such as spatial requirements evaluation described in Section 2.1.4.1.3 Spatial Requirements, etc.;

- Starting from RIBA 3 Spatial co-ordination, the plant access, maintenance, and replacement principles shall be presented as part of the project deliverables to Imperial College London for review (typically at an engineering review meeting / ERM); and
- The deliverable(s) describing the plant access, maintenance, and replacement shall be developed further in conjunction as the design stages progress.
  - For example, at RIBA Stage 5 Manufacturing and construction, the plant access, maintenance, and replacement methods shall be developed in accordance with the particular manufacturer requirements.

2.1.6.2 Regulations, Codes, Standards, and Guidance

Designers and contractors shall refer to and comply with the following regulations, standards, and guidance:

- Construction (Design and Management) Regulations (CDM);
- The Lifting Operations and Lifting Equipment Regulations (LOLER);
- Work at Height Regulations 2005;
- HSE L153 – Managing health and safety in construction, Construction (Design and Management) Regulations;
- HSE L113 – Approved code of practice on safe use of lifting equipment;
- HSE INDG401– Brief guide to working at height;
- CIBSE Guide M – Maintenance engineering and management;
- BSRIA BG 6/2018 – Design framework for building services;
- BSRIA TN 10/92 – Space allowances for building services distribution systems, detail design stage;
- BS 8313 – Code of practice for accommodation of building services in ducts; and
- Any other relevant regulations, codes, standards, and industry guidance.

2.1.6.3 Project Specific and Client Maintenance Requirements

Safe and simple access shall be provided by the designers and contractors for all maintainable and adjustable / commissionable items. In order to produce the access and maintenance deliverable described in Section 2.1.6.1 General Requirements, designer and contractors shall:

- Engage and agree with Imperial College London regarding the criticality of those items. Designers and contractors shall include and present to Imperial College London –
    - Where applicable, the regulatory, code, and standard requirements that have been incorporated;
    - Proposed demarcation of maintenance responsibility between users and estates maintenance;
    - Recommended number and type of spare parts, and, if applicable, specialist tools; and
- This engagement with Imperial College London maintenance shall occur as early as possible, typically starting from RIBA 3 Spatial co-ordination.

2.2 Ventilation / HVAC Airside (Particular Requirements on)

2.2.1 Air Handling Units (AHUs)

2.2.1.1 General

Air handling units (AHUs) shall incorporate all the components (excluding controls) necessary to provide an efficient and effective source of air distribution, i.e., fans, filters, coils, heat recovery etc.

AHUs shall be sized to take into account all key factors including but not limited to: specific fan power, air volume, heating / cooling requirements, humidity control (where applicable), space availability and noise levels.

Units shall be selected to provide the required duty at optimum performance and efficiency rated to recognised and applicable standards, including but not limited to:

- Ecodesign for Energy-Related Products Regulations and related regulations – these reference the European Union (EU) Ecodesign Directives and Regulations;
- BS EN 13053 – Ventilation for buildings, air handling units rating and performance for units, components, and sections;
- BS EN 1886 – AHUs mechanical performance; and
- Eurovent certification.

AHUs shall include clean and dirty filter automatic sensing as well as fan speed adjustment.

Sufficient access shall be allowed in the AHU design for ease of inspection, cleaning, and maintenance in accordance with relevant regulations, codes, standards, and guidance, and to the Imperial College London maintenance team's satisfaction.

Refer to Section 2.2.7 Minimum Energy Efficiency Standards for energy performance requirements.

2.2.1.2 Construction

AHUs shall be constructed in accordance with BS EN 1886 – AHUs mechanical performance, with the following requirements on these criteria within BS EN 1886:

- Casing strength – Class D1;
- Casing air leakage – Class L2;
- Thermal transmittance – Class T2;
- Thermal bridging factor – Class TB2; and
- Fire protection – Option 1 Non-combustible materials.

The external surfaces of AHUs shall be finished in “Plastisol” type plastic coating or alternative of proven equivalent performance. All internal surfaces of AHUs are liable to be affected by moisture, i.e., cooling coils, humidifiers etc, shall be treated with an anti-corrosion finish.

Where units are to be located externally, these shall be fully weatherproofed and shall include raked tops for rain run-off.

See Table 10 – Typical velocities and pressure drops through selected ventilation system components for limits on face velocities and thus cross section area. See Table 15 – Minimum energy efficiency standards for ventilation / HVAC airside for specific fan power limits.

2.2.1.3 Fans

The fan section of AHUs shall normally contain a direct drive centrifugal fan, mounted such that vibration is not transmitted to the AHU frame and be rated to recognised and applicable standards, such as BS 6583 – Volumetric testing for rating of fan sections in AHUs, etc.

The fan section shall be designed to allow for easy removal of the fan and motor for maintenance / replacement.

Refer to Section 2.2.2 Fans (General) for fan selections and motors requirements.

2.2.1.4 Heating

Where heating is required, air handling units shall incorporate:

- Appropriate means of frost protection, such as heat recovery device (e.g., plate heat exchanger, thermal wheel, run-around coil, or mixing section) and / or frost coil;
- Main heater battery; and
- Where required, a re-heater coil.

The designer shall specify the arrangement of these elements based on achieving both the required functions and the most energy efficient operation.

Low temperature hot water (LTHW) shall be the preferred means to provide heating to AHUs. Steam heating shall be replaced with LTHW where possible (see Section 2.4 Steam for further details).

Direct electric heater batteries are carbon intensive and expensive to operate; therefore, their use shall be restricted to low-power application (for example, trimming control, etc.).

Electric heater batteries shall be thyristor modulated control type for good temperature stability. Where an electric heater battery is considered to be necessary, an Engineering Exception Report shall be submitted for acceptance.

2.2.1.4.1 Frost Protection

The frost protection element shall be sized and selected to heat the incoming air to prevent frost and moisture pick up, typically from -4°C to at least 6°C.

Lattice type capillary tube frost thermostat shall be installed downstream of the frost protection element.

Coiled frost protection elements shall be constructed of plain tubing without fins and be as near to the outside as possible to minimise condensation during cold weather. Access for cleaning shall be provided to both sides of the coil.

A frost protection control strategy shall be in place to protect AHUs from damage. The designer shall present to Imperial College London Engineering, Energy and Environment Team the AHU's frost protection strategy regardless of the type of frost protection element used. Where a frost coil is selected as the means of frost protection, refer to the BMS / Controls section in this BESPR for control strategy.

2.2.1.4.2 Heating Coils

Heating coils shall be constructed from solid drawn copper tube expanded into continuous plate type fins of either aluminium or copper.

2.2.1.5 Cooling Coils

Cooling coils shall be constructed from solid drawn copper tube expanded into continuous plate type copper fins.

Sealing devices shall be provided at the tops and bottoms of coils to minimise air by-pass and water carry over.

2.2.1.6 Heat Recovery

All bidirectional (with both supply and extract) AHUs shall have heat recovery to maximise energy efficiency per the Ecodesign for Energy-Related Products Regulations.

Designers and contractors shall evaluate, document, and provide evidence to Imperial College London to demonstrate appropriate plant system selections as per Sections 2.1.3.2 Plant Selection and 2.1.4 System Selection, including whether and which heat recovery system is appropriate.

Table 12 below lists the main types of heat recovery systems available and provides an indicative comparison of these technologies.

Table 12 – Main types of air-to-air heat recovery systems and their indicative comparison

Type	Heat recovery efficiency	Advantages		Disadvantages	
Crossflow plate heat exchanger	~73% to 80%	• High heat recovery efficiency	• Mechanically reliable	• Supply and extract ducts must be gathered at same location.	• Requires larger amount of space
Thermal wheel	~73% to 85%		• Requires less space • Can have moisture recovery		• Risk of recirculation of odour and pollutants
Run-around coil	~40% to 60%	-	• Zero recirculation of odour and pollutants • Supply and extract ducts can have different locations	-	• Requires additional pumps and controls, leading to more maintenance

Designers and contractors shall evaluate and provide evidence similar to the above to Imperial College London to demonstrate compliance.

All AHU heat recovery shall have summer bypass.

The AHU heat recovery shall be controlled via the College's building management system (BMS), rather than the AHU manufacturer's packaged controls. Refer to the BMS / Controls section for details.

2.2.1.7 Control of AHUs / Ventilation Using Carbon Dioxide (CO_2) Sensors

Where appropriate, AHUs shall be provided with CO_2 monitoring for demand-controlled ventilation to save energy.

Designers and contractors shall evaluate, document, and provide evidence to Imperial College London to demonstrate appropriate system selections as per Section 2.1.4 System Selection, including whether CO_2 based demand-controlled ventilation is appropriate.

Demand-controlled ventilation shall adjust supply air volumes / fresh air content of ventilation systems in response to the space CO_2 levels (and hence the occupancy levels) via a combination of:

- Space CO_2 sensors;
- Variable speed fans and / or modulating dampers; and
- Variable air volume (VAV) devices (see Section 2.2.3.2.1 Variable Air Volume (VAV) Devices).

The system shall operate to a set point of 750 parts per million (ppm) CO_2 in the serviced spaces.

2.2.1.8 Air Filtration

AHU air filter types and efficiencies shall be as required to meet the necessary design criteria. Primary and secondary air filtration shall conform to BS EN ISO 16890 – Air filters for general ventilation for filter performance.

Primary filtration shall be achieved by use of high performance disposable pleated panel filters. The primary panel filters shall be ISO Coarse 60%[27] according to BS EN ISO 16890.

Secondary filtration shall be achieved utilising high efficiency bag filters which have a large media surface area and therefore, low air resistance. The bag filters shall have minimum rating of the following and be held in corrosion proof frames:

- BS EN ISO 16890 ePM_1 ≥50%, $ePM_{2.5}$ ≥70%, and ePM_{10} ≥80%[28]; or

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27 This replaced G4 rated filters in the now superseded BS EN 779 – Particulate air filters for general ventilation, determination of filtration performance.

28 This replaced F7 rated filters in the now superseded BS EN 779.

- BS EN ISO 16890 ePM_1 ≥80%, $ePM_{2.5}$ ≥90%, and ePM_{10} ≥95% (preferred)[29].

Where plant space permits, the bag filter section of the air handling unit shall be sufficient length (normally 700mm min) to accommodate the high efficiency, high capacity filters.

All filters shall be Eurovent certified and tested to BS EN 1886 – AHUs mechanical performance for air leakage and performance.

2.2.1.9 Filter Differential Pressure Gauges

AHUs shall be provided with Magnehelic type differential pressure gauges on the filter sections of units of 1 m³/s air volume and above.

The Magnehelic gauges as manufactured by Dwyer Instruments shall be selected to provide an appropriate range with the differential pressure measuring in pascals.

Gauges shall be appropriately labelled indicating design filter clean and dirty settings. Inclined gauge type manometers shall not be used in the above application.

2.2.1.9.1 Typical Gauge Pressure Ranges

The Magnehelic gauges shall normally be selected with a pressure range of **0-500Pa**, which would be suitable for most panel and bag filters.

Typical pressure drops for filters with a face velocity of 2 m/s are listed below:

Table 13 – Typical pressure drops for filters

<table>
<tr><th colspan="2">Type</th><th>Initial pressure drop (Pa)</th><th>Average pressure drop (Pa)</th><th>Recommended final pressure drop (Pa)</th></tr>
<tr><td colspan="2">ISO Coarse 60% panel filter</td><td>40</td><td>120</td><td>200</td></tr>
<tr><td rowspan="2">Bag filters</td><td>ePM1 ≥50%, ePM2.5 ≥70%, and ePM10 ≥80%</td><td rowspan="2">50</td><td rowspan="2">175</td><td rowspan="2">300</td></tr>
<tr><td>ePM1 ≥80%, ePM2.5 ≥90%, and ePM10 ≥95%</td></tr>
<tr><td colspan="2">H13 HEPA filter[(1)]</td><td>250</td><td>375</td><td>500</td></tr>
</table>

Notes:

29 This replaced F9 rated filters in the now superseded BS EN 779.

(1) To BS EN 1822-1 – High efficiency air filters (EPA, HEPA and ULPA), classification, performance testing, and marking.

As seen above, where AHUs incorporate HEPA filters, the gauge range needs to cover a pressure range of **0-1.0kPa**.

2.2.1.10 Dampers

Dampers used in sections of AHU shall be of the multi-leaf type. Damper blades shall be constructed to ensure rigidity and prevent distortion and jamming in operation. The blades shall be securely fixed.

Manually and automatically operated dampers shall include a means for clearly indicating externally the position of damper blades.

Air leakage through dampers shall not exceed the following as tested with BS EN 1751 – Ventilation for buildings, air terminal devices, aerodynamic testing of damper and valves:

- Leakage through closed blade at least Class 2 (classes range from 0 to 4, with 0 being no control on leakage and higher class numbers meaning lower leakages); and
- Casing leakage at least Class B (classes range from A to C, with C having the least leakage).

2.2.1.11 Access Doors

AHUs shall be provided with hinged doors with air seals and viewing ports / glass, to facilitate inspection and access to upstream and downstream faces and internal parts of all sections of the plant.

Access doors shall be 300mm or 600mm wide, depending on the size of the AHU and sections to be accessed.

2.2.1.12 Viewing Ports and Internal Lighting

Viewing ports and internal lighting shall be provided in larger AHUs for inspection. Power to the AHU internal lighting shall be served from the local mechanical control panel from which the AHU is served. Viewing ports shall be positioned to allow replacement of lamps.

2.2.1.13 Attenuators

Attenuators shall be fitted as part of the AHU. These shall be sized to achieve the necessary sound level reduction as advised by the acoustic consultant / specialist.

2.2.1.14 Condensate Traps

AHU condensate traps shall be installed with sufficient trap height to prevent emptying of the water seal due to the fan pressure.

The following measures shall be adopted to ensure that the traps have a sufficient water seal:

- Ensure AHUs that are installed in plantrooms / roof plant areas are located on concrete / steel plinths to a minimum height of 100mm (exact height to be calculated / provided by manufacturer based on fan pressure drops); and
- Install a trap at the cooling coil condensate drain point of each AHU. The trap shall be constructed from copper pipe and fittings consisting of two tees and removable plugs for inspection, cleaning and, if necessary, priming.

The AHU condensate drain shall run to fall terminating at a drain point with a suitable trap / air gap via gravity.

2.2.1.15 Control and Monitoring Instruments

Refer to the BMS / Controls section for details.

2.2.2 Fans (General)

This section is applicable to all fans in mechanical systems, whether standalone or as part of another equipment, such as AHUs, mechanical ventilation units with heat recovery (MVHRs), etc.

2.2.2.1 Fan Selections

Fans shall be selected based on the system requirements, including but not limited to system flow and pressure required, acoustic performance, and optimum operating point on fan curves and fan efficiency.

2.2.2.2 Fan Motors

See Section 2.7.1 Motors and Inverters.

2.2.3 Terminal Units

Refer to Section 2.1.4 System Selection, which will determine selection of terminal units in principle. Terminal units shall incorporate all the components necessary to provide an efficient and effective source of air distribution and temperature control.

Installations of terminal units shall include adequate space and simple methods for maintenance access. These maintenance access shall be provided to the following (but are not limited to): fans, motors, filters, dampers, drain pans, pipework connections, valves, actuators, electrical and controls components, etc.

If required, such as an installation where certain components are within reach of users, physical protection shall be provided to the terminal unit and its associated elements.

Terminal units cooling capacity calculations shall account for both sensible and latent cooling loads. For fan coil units (FCUs) and terminal coolers, it is acceptable for these to have latent cooling capacity. For **chilled beams or other exposed cooling devices** (e.g., chilled ceiling, etc.), there shall be **no latent cooling** allowed for.

2.2.3.1 System Zoning

Designers shall evaluate, document, and provide evidence to Imperial College London to demonstrate appropriate terminal units zoning based on project and building requirements. These include but are not limited to:

- Perimeter vs internal zones;
- Occupancy patterns and activities; and
- Physical room layouts – a single terminal unit shall not serve more than one room.

Room sensors (such as temperature, CO_2, humidity, or a combination of depending on application) arrangement shall correspond to the system zoning. There shall be a minimum of one room sensor per zone.

Designers and contractors shall demonstrate and test on site that the placements of diffusers / terminal units do not generate thermal discomfort via draughts. Refer to limits on thermal comfort from CIBSE Guide A, BS EN ISO

7730 – Ergonomics of thermal environment[30], and other relevant regulations, standards, and guidance.

Where presence detection is available, it shall maximise the potential of linking to the BMS for terminal unit control in corresponding HVAC zone(s). Refer to the BMS / Controls section for details.

2.2.3.2 Variable and Constant Air Volume Devices

Where an all-air system has been determined to be appropriate, or is existing and being refurbished, variable air volume (VAV) devices are preferred due to energy efficiency benefits.

Some exceptions include but are not limited to:

- Where close space temperature and / or humidity control is required for an entire room, such as a laboratory with tight climatic requirements; or
- Where a high air change rate is required, such as an operating theatre.

The designer shall assess the room requirements to determine and demonstrate to Imperial College London whether a VAV or CAV system is more appropriate.

VAV and CAV devices shall be sized, selected, installed, and commissioned appropriately for the range of design conditions to ensure accurate control.

VAV and CAV devices shall be provided with a built-in flow measuring apparatus which feeds back to the building management system (BMS) for control and monitoring purposes. Where a mechanical CAV device is determined to be applicable for the situation, it shall have the following arrangements:

- The flow measuring device shall take the form of a fixed orifice plate with a differential pressure sensor across; and
- The calibrated differential pressure sensor shall feedback to the BMS for airflow volume monitoring.

[30] BS EN ISO 7730 – Ergonomics of the thermal environment (analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria).

VAV and CAV devices shall be installed in accordance with the manufacturer's instructions, including but not limited to specific inlet and outlet arrangements for reducing noise and improved control.

2.2.3.2.1 Variable Air Volume (VAV) Devices

VAV devices shall be, depending on the application, controlled by room CO_2, temperature, or differential pressure sensor(s). Refer to the BMS / Controls section for details.

Refer also to Section 2.2.1.7 Control of AHUs / Ventilation Using Carbon Dioxide (CO_2) Sensors for VAV devices used as CO_2 based demand-controlled ventilation.

2.2.3.2.2 Constant Air Volume (CAV) Devices

Where applicable, mechanical CAV device(s) may be used as a way to simplify control and maintenance. In this case, the mechanical CAV(s) shall be provided with remote flow monitoring function via the BMS. Refer to Section 2.2.3.2 Variable and Constant Air Volume Devices and the BMS / Controls section for details.

2.2.3.3 Terminal Reheaters and Coolers

The use of terminal reheaters and coolers shall be minimised for energy efficiency purposes. Where practicable, the zone conditions shall be controlled via variable air volume devices. Terminal reheaters and coolers shall be limited (and sized accordingly) for final trimming of supply air conditions.

Terminal reheaters and coolers shall be built, installed, and tested and commissioned to the following standards.

- BS 4857 – Testing and rating terminal reheat units for air distribution systems.

Where electric terminal reheaters have been determined as appropriate, these shall include thermal cut-out feature.

All other relevant requirements in Sections 2.2.3 Terminal Units and 2.2.3.4 Fan Coil Units (FCUs) shall apply to terminal reheaters and coolers, such as maintenance and access, drip trays, controls, presence detection link, etc.

2.2.3.4 Fan Coil Units (FCUs)

2.2.3.4.1 Introduction

Fan coil units (FCUs) shall be sized to take into account all key factors including specific fan power, air volume / static pressure available, heating / cooling requirements, space availability, and noise levels.

Units shall be selected to provide the required duty at optimum performance and efficiency rated to recognised and applicable standards, including but not limited to:

- Ecodesign for Energy-Related Products Regulations and related regulations – these reference the European Union (EU) Ecodesign Directives and Regulations;
- BS EN 1397 – Hydronic room fan coil units, test procedures for establishing the performance (standard rating condition);
- BS EN 16583 – Hydronic room fan coils units, determination of the sound power level; and
- Eurovent certification.

Where FCUs are installed within ceiling voids, the FCU return air path shall be ducted from a ceiling mounted return air grille and plenum box direct to the FCU return air plenum at the back of the FCU. This is done for better control, operation, and maintenance throughout the life of the FCU.

The outside air supply from the AHU shall be ducted to ceiling mounted plenum box(es) and diffuser(s) such that the outside air can be supplied into the rooms without the FCU fan running. See Figure 5 and Figure 6 below.

Depending on what is most appropriate for the application, the return air to the AHU may be via:

- Ceiling mounted return air grille(s) and bellmouths within the ceiling voids (where future flexibility is more important). See Figure 5 below; or
- Ducted ceiling return air grille(s) and plenum boxes. See Figure 6 below.

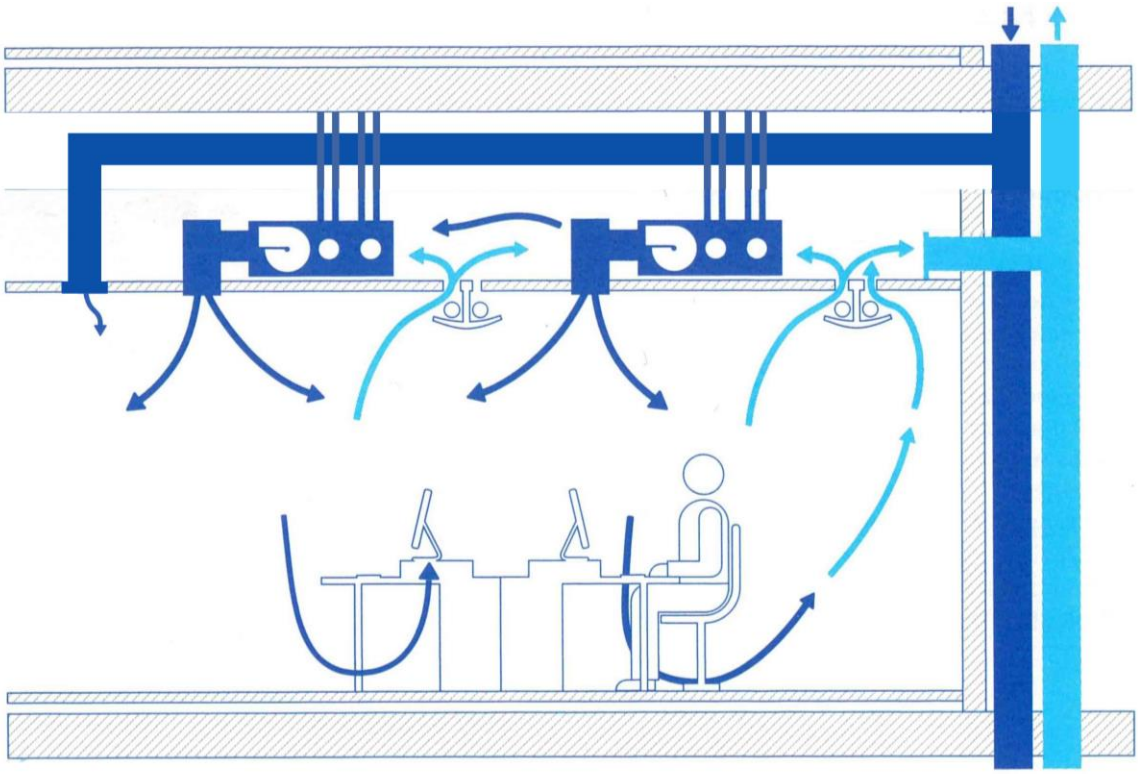

Figure 5 – Option 1 for FCU airside connections (outside air supply ducted to ceiling diffuser and plenum extract)

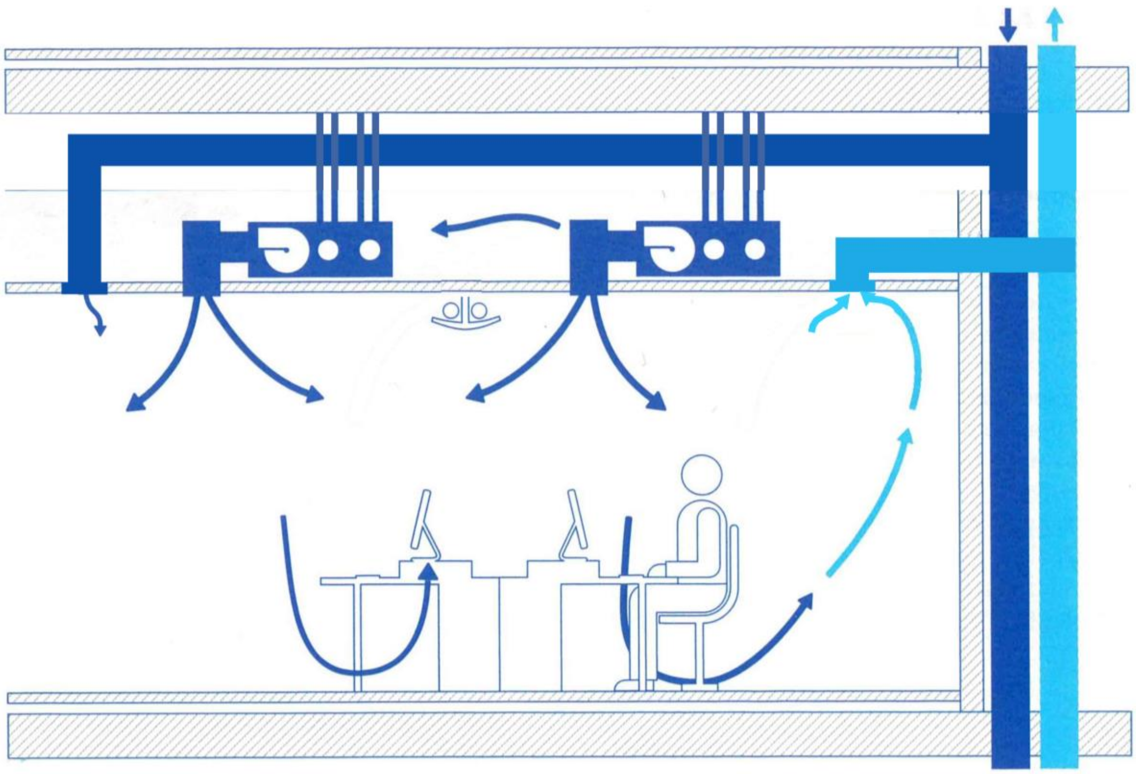

Figure 6 – Option 2 for FCU airside connections (outside air supply and extract both ducted to ceiling diffuser / grille)

See Section 2.2.7 Minimum Energy Efficiency Standards for minimum energy efficiency standards.

2.2.3.4.2 Wall or Floor Mounted FCUs

For wall or floor mounted FCUs, casings shall accommodate pipework connections, valves, controls, and other accessories such that these items are concealed and protected. An example of such installation is shown in Figure 7 below.

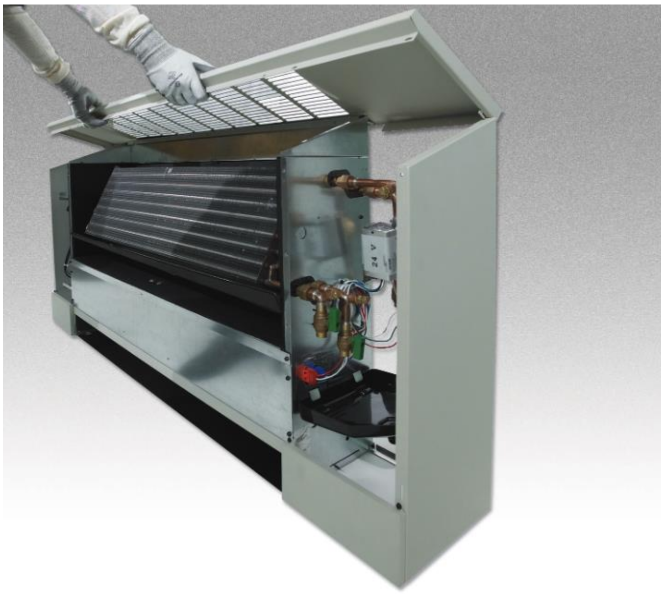

Figure 7 – Wall or floor mounted FCUs with casings that accommodate pipework connections, valves, controls, and other accessories

2.2.3.4.3 Fans

FCUs shall incorporate brushless electronically commuted (EC) motors and variable speed fans that are adjustable via BMS.

FCUs shall be selected to achieve the desired cooling / heating duty and desired noise rating on low to medium fan speed.

2.2.3.4.4 Filters

All fan coil units shall include an easily removable and replaceable air filter. Filters shall be rated ISO Coarse 50% according to BS EN ISO 16890 – Air filters for general ventilation.

2.2.3.4.5 Control

FCUs shall be provided with two-port control valves except at the end of the system.

BMS control of FCUs

FCUs shall be controlled / monitored via the BMS in accordance with the BMS / Controls section of this document.

The mechanical contractor shall liaise with the FCU manufacturer and the controls contractor to determine how the following controls components will be supplied alongside with the FCUs:

- FCU controller;
- Temperature sensors for supply and return air monitoring; and
- Others.

Typically, the FCU should be supplied to site with all controls components (except for the valves and actuators) as an assembly, ready for system integration by the various contractors.

Occupancy Control of FCUs In Cellular Areas

Where presence detection control of the lighting system has been incorporated, this shall also, via the BMS, apply a set-back to the dead-band of the FCU temperature control. Refer to the BMS / Controls section for details.

2.2.3.5 Chilled Beams

Chilled beams shall **<u>not</u>** be used in conjunction with openable windows or natural ventilation. Chilled beams shall be selected from a standard range by an approved supplier in the Imperial College London Approved Suppliers / Components List to ensure performance and ease of maintenance.

Chilled beams shall be tested, rated, and certified to the following.

- **For active chilled beams**: BS EN 15116 – Ventilation in buildings testing and rating of active chilled beams;
- **For passive chilled beams**: BS EN 14518 – Ventilation in buildings testing and rating of passive chilled beams.

The maximum cooling outputs for chilled beams are typically in the order of 100W/m² to 140W/m². Designers shall demonstrate, through calculations, that the selections made are appropriate for the applications. As part of these calculations, system psychrometric calculations shall be produced, validating the efficacy of the design.

Active chilled beams are typically installed with a ceiling to enable the Coanda effect for even room air distributions. Where active chilled beams are being proposed in an exposed soffit installation, the designers and contractors shall demonstrate and test on site that the installation does not generate thermal discomfort via draughts. Refer to Section 2.2.3.1 System Zoning for details.

Where other building services, such as lighting, sprinklers, etc., are integrated into the chilled beams, access and maintenance to the other building services shall be considered and be as simple as possible.

2.2.3.5.1 Installation

The floor facing panels in chilled beams shall be easily demountable to enable access and maintenance to the chilled beam coils. Where other building services are integrated into the chilled beams, it shall be possible to maintain those services individually without affecting others.

2.2.3.5.2 Control

Chilled beams shall be controlled via room temperature sensors installed in accordance with the system zoning (see Section 2.2.3 Terminal Units for requirements on terminal units zoning). A relative humidity or dew point temperature sensor shall be provided at the AHU to deliver feedback for the control strategy and operational monitoring.

A group of chilled beams in the same zone may be controlled via a single control valve and actuator to simplify control actions and maintenance. Appropriate number(s) of condensation sensor(s) shall be provided at the chilled beams for control and operational feedback purposes.

2.2.4 Ventilation Ductwork, Accessories, and Insulation

2.2.4.1 Introduction

All ventilation ductworks should be constructed in accordance with the industries standard specifications, issued by the Building Engineering Services Association (BESA) and appropriate to the purpose of the system.

Access provisions for cleaning and maintaining ductwork (such as ductwork access panels, easily demountable ceiling panels, unobstructed space in ceiling voids to maintainable components, etc.) shall be provided in accordance with BESA DW144 – Specification for sheet metal ductwork and corresponding standards.

Table 20 in BESA DW144 is excerpted below (in Figure 8) as a quick reference for requirements on access panels around ductwork components. Refer to the full BESA DW144 and other BESA ductwork standards for details.

Table 20 Location of Access Panels for Inspection/Servicing and/or Internal Cleanliness*			
In-line equipment	**Location**	**Party responsible for provision of suitable access panel**	
		Ductwork Contractor	**Specialist Cleaning Contractor**
Control Dampers	Both sides	Up-stream panel	Down-stream panel
Fire Dampers	Both sides	To suit damper maintenance	Opposite side
Heating/Cooling/Re-claim Coils	Both sides	Panel on both sides	-
Attenuators (rectangular)	Both sides	Up-stream panel	Down-stream panel
Attenuators (circular)	Both sides	Up-stream panel	Down-stream panel
Filter sections	Both sides	Up-stream panel	Down-stream panel
Air turning vanes	Both sides	Up-stream panel	Down-stream panel
Changes of direction	One side	-	One panel to suit
In-duct Fans/Devices	Both sides	Up-stream panel	Down-stream panel
Inlet/Exhaust Louvre	One side	One panel to suit	-
Intermediate cleaning panels		-	To suit frequency specified in TR/19 and DW/172

Figure 8 – Summary in BESA DW144 for ductwork access panels requirements

For ductwork straight runs and bends, refer to BS EN 12097 – Requirements for ductwork components to facilitate maintenance of ductwork systems. As a minimum, the ductwork shall be equipped with sufficient access panels in order to ensure that no part of the ductwork is located with more than:

- One dimensional change from an access panel;
- One change of direction of more than 45 ° from an access panel; or
- 7.5 meters of duct from an access panel.
- The top and bottom of vertical risers shall be provided with access panels.

Access for cleaning such that activities in BESA TR19 – Internal cleanliness of ventilation systems and BESA TR19 Grease – Fire risk management of grease accumulation within kitchen extract systems can be carried out.

2.2.4.2 Sheet Metal Ductwork

Where sheet metal ductwork is specified, this shall be to the requirements of BESA DW144.

Table 1 from BESA DW144 is excerpted below in Figure 9 to describe the pressure classes and air leakage limits for sheet metal ductwork.

Table 1 Ductwork Classification and Air Leakage Limits

Duct pressure class	Static pressure limit		Maximum air velocity	Air leakage limits litres per second per square metre of duct surface area
	Positive	Negative		
1	2	3	4	5
	Pa	Pa	m/s	
Low pressure – Class A	500	500	10	$0.027 \times p^{0.65}$
Medium pressure – Class B	1000	750	20	$0.009 \times p^{0.65}$
High pressure - Class C	2000	750	40	$0.003 \times p^{0.65}$
High pressure - Class D	2000	750	40	$0.001 \times p^{0.65}$

Where p is the differential, pressure in pascals.

Figure 9 – Ductwork pressure classes per DW144

Designers should limit the design external (i.e., external to the fans, AHUs, etc.) pressure drops of ductwork systems to less than or equal to 500Pa, in other words within the Class A ductwork limits.

Unless otherwise specified or required, the specification and installation of ductwork shall be in accordance with their working pressures and:

- Minimum Class B ductwork within plant rooms and risers; and
- Minimum Class A for other ductwork.

2.2.4.3 Plastic Ductwork

Where plastics ductwork is specified / required (e.g., for fume extract, etc.), including uPVC and polypropylene, this shall be to the requirements of BESA DW154 – Specification for plastics ductwork.

2.2.4.4 Kitchen Ventilation

Where ductwork is specified for kitchen ventilation systems, this shall be to the requirements of BESA DW172 – Specification for kitchen ventilation systems.

In particular, DW172 requires all interior surfaces of the ductwork to be accessible for cleaning and inspection purposes. Example provisions include but are not limited to:

- Access doors installed at 2m centres, unless a detailed cleaning specification / method states otherwise; and
- Drains shall be installed at the base of all risers.

Refer to Section 2.2.6 Kitchen and Catering Ventilation System for overall requirements on kitchen and catering ventilation system (for example, water-wash or water mist grease and odour treatment system are not permitted).

2.2.4.5 Ductwork Fire Protection

All ventilation ductwork systems shall be designed and installed to have the necessary fire protection measures in accordance with:

- The regulations, codes, standards, guides, and requirements stated in Section 2.1.5 Fire Safety above;
- BS EN 1366 – Fire resistance tests for service installations;
- Association of Specialist Fire Protection Blue Book - Fire resisting ductwork tested to BS EN 1366; and
- Other relevant regulations, codes, and standards.

In particular, smoke extract ductwork shall comply with BS EN 12101-7 – Smoke and heat control systems, smoke duct sections, and be tested to BS EN 1366-8 and 9.

Fire resisting ductwork shall be provided via an integrated system (where part of the fire protection is integral to the ductwork) that is offsite manufactured, tested, and certified for compliance to:

- The Construction Products Regulation and Construction Products (Amendment etc.) (EU Exit) Regulations (CPR); and
- Bear the CE / UK mark.

Systems that are applied on site to ductwork for fire protection, such as Promat Vicuclad, Firemaster FastWarp, etc., are <u>not</u> permitted.

2.2.4.6 Ductwork Thermal Insulation

See Section 2.7.4 Insulation and Finishes to Ductwork, Pipework.

2.2.4.7 Ductwork System Type and Materials

Unless otherwise justified and specified by the designer or applicable to the project's specific situation, ductwork system type and materials shall in accordance with Table 14 below.

Table 14 – Ductwork system type and materials general specification

System Type		Material
General supply air		Galvanised sheet steel to BESA DW144
General extract air		
Laboratory supply air		
Laboratory extract (general)		
Laboratory extract (fume extraction)		Plastics (uPVC / polypropylene) to BESA DW154
Local exhaust ventilation		Dependent on application
Kitchen ventilation		Galvanised sheet steel to BESA DW172
Fire resisting ductwork	Fire protected ductwork	Proprietary galvanised sheet steel system tested to BS EN 1366 and installed per manufacturer's instructions
	Smoke extract ductwork	Proprietary galvanised sheet steel system compliant with BS EN 12101-7, tested to BS EN 1366-8 and 9, and installed per manufacturer's instructions
Fire safety dampers[1]	Fire dampers (FDs)	**E** classification conforming to BS EN 15650, BS EN 1366-2, and BS EN 13501-3, and installed per manufacturer's instructions[2]
	Fire and smoke dampers (FSDs)	**ES** classification conforming to BS EN 15650, BS EN 1366-2, and BS EN 13501-3, and installed per manufacturer's instructions[2][3]
	Motorised fire and smoke dampers (MFSDs)	
	Smoke control dampers (SCDs)	Conforming to BS EN 1366-10 and BS EN 12101-8, and installed per manufacturer's instructions[4]

Notes:

(1) BS EN 15650 – Ventilation for buildings, fire dampers.
BS EN 1366-2 – Fire resistance tests for service installations, fire dampers.
BS EN 1366-10 – Fire resistance tests for service installations, smoke control dampers.
BS EN 12101-8 – Smoke and heat control systems, smoke control dampers
BS EN 13501-3 – Fire classification of construction products and building elements, fire resisting ducts and fire dampers.

(2) Minimum 60 minutes or to match the integrity rating of the fire resisting elements, whichever is higher.

(3) Where ducts pass through enclosures of protected escape routes, ES classified FSDs or MFSDs which is activated by a suitable fire detection system (i.e., method 4 as described in Building Regulations ADB1 and ADB2) are required.

(4) To match the required classification and performance criteria of the smoke control system and fire strategy, such as:
    - Single or multi compartment;
    - Integrity "E", insulation "I", and smoke leakage "S" classifications;
    - Suitability for vertical and / or horizontal installation, together with mounting in a duct or in a wall or both;
    - "500", "1000", or "1500" indicating suitability of use up to these negative pressures;
    - "AA" or "MA" indicating automatic activation or manual intervention;
    - Whether the element has been tested and fulfils requirements from fire inside or outside only or both;
    - Suitability for use in smoke control only, combined smoke and environmental control, or modulating use in combined smoke and environmental control system;
    - Whether it needs or has the "HOT 400/30" indication for additional high operational temperature requirements;
    - Etc.

    See BS EN 1366-10 and BS EN 12101-8 for details.

2.2.5 Toilet Ventilation System

2.2.5.1 Design Criteria

Per Table 3 – Internal design conditions for different room types in Section 2.1.2.2 Internal Design Conditions for Summer and Winter (Occupied Hours), toilets shall be provided with 10 air changes per hour (ach) of extract and 8 ach of supply / makeup air. Refer to Section 1 Design criteria for details.

The toilet ventilation systems shall be designed, installed, and tested & commissioned such that:

- Toilets are maintained at negative pressure with respect to surrounding accommodations; and
- The systems prevent recirculation on exhaust / extract air into the intake / supply (see also Section 2.1.2.1 External Design Conditions, Air).

2.2.5.2 Provisions

The designer shall propose compliant and practical solutions for the toilet ventilation system and present them to Imperial College London for review.

In general, the ventilation provisions shall enhance with increasing number of individual toilets, level of service required, privacy, and cost. The provisions can include but are not limited to the following (in hierarchy):

a) Natural ventilation;
b) Mechanical extract and natural make-up, with air transferred from outside;
c) Mechanical extract and natural make-up, with air transferred from other parts of the building;
d) Mechanical extract with automatic-switching duty / standby extract fans and mechanical make-up / supply; and
e) Mechanical extract with automatic-switching duty / standby extract fans and mechanical make-up / supply with crosstalk attenuators.

The designer shall be responsible for proposing and justifying to Imperial College London the most appropriate solution for the situation.

For toilets in new buildings, the provision shall be at least to option c above.

For refurbishment of toilets in existing buildings, the following shall be investigated and justified in order:

- Assessing and re-arranging existing ventilation assets (grilles, ducts, etc.) within the toilets. Validate and re-balance;
- Assess existing system capacity. Where appropriate, extend and / or upgrade existing toilet ventilation system and re-balance; and
- Provide new, standalone toilet ventilation system.

2.2.5.3 Control

Controls shall be provided to toilet ventilation system, appropriate for the application and size of the system.

As a minimum, the ability to turn the system on and off under control, whether through light switch, occupancy sensor, or building management system (BMS) shall be provided. This shall not be provided via any form of humidity sensing.

For options d) and e) in Section 2.2.5.2, the system shall be controlled by the College BMS.

Where BMS control is provided, the on / off and time scheduling functions shall be via BMS. Fault monitoring via BMS shall be provided.

2.2.6 Kitchen and Catering Ventilation System

Kitchen and catering ventilation is typically a fit-out package to be designed, installed, and tested and commissioned by a specialist catering design and build (D&B) contractor. The Imperial College London catering team is responsible for setting out the user brief (incorporating design, operation, and maintenance requirements) together with the estates operation team.

All applicable regulatory requirements, standards, and industry guidance for general ventilation shall be applied to kitchen ventilation systems.

Additional compliance requirements for kitchen ventilation systems can include but are not limited to the following.

- BESA DW172 – Specification for kitchen ventilation systems. For ductwork requirements, refer also to Section 2.2.4.4 Kitchen Ventilation for kitchen ventilation ductwork; and
- Any local authority requirements with respect to noise, odour, and discharge / flue locations.

Example requirements and specifications from BESA DW172 include the following:

1) Designers shall produce and provide to Imperial College London its design calculations, based on BESA 172, to demonstrate compliance.
2) Designers shall assess ventilation in adjoining areas in order to ensure effectiveness, air balance, and compliant airflow / pressure regime.
3) Drawings and / or models showing the following shall be produced and provided to Imperial College London to demonstrate compliance:
    - o Catering equipment / kitchen layout, canopy(s), ductwork, insulation, damper(s), fan(s), discharge arrangement, and make-up air provisions;
    - o Grease separation device(s), sound attenuator(s) (if required), fire suppression (if required), and appropriate interlocks (such as for cooking appliances, automatic fire alarm, ultraviolet / UV lamps, etc.);

        - Where sound attenuator(s) are required on the extract, they shall be compatible with grease laden air, e.g., Melinex lined attenuators to prevent grease impregnation into the acoustic media;
    - Maintenance access and proposed maintenance regime; and
    - Any other accessories to form a complete, fit-for-purpose system.

4) On damper(s):
    - Where volume control damper(s) (VCDs) are required, they shall be kept to a minimum and incorporate the following. For extract systems, the damper blades shall be fabricated from stainless steel. Their operating mechanism shall be outside the airstream and be capable of withstanding the higher air temperatures associated with kitchen extract systems.
    - In accordance with Building Regulations Approved Document Part B Fire safety (volume 2) – Buildings other than dwellings (ADB2) and BS 9999, **fire dampers (FDs) and fire and smoke dampers (FSDs)** shall **<u>not</u>** be used in kitchen extract system. This is because the likely build-up of grease within the duct can adversely affect dampers, and fire authorities may use the extract fan to clear smoke.
    - Fire resisting ductwork (see Sections 2.2.4.5 Ductwork Fire Protection and 2.2.4.7 Ductwork System Type and Materials) may be required, depending on the fire strategy requirements.
    - Back-draught dampers shall not be used.

5) Only centrifugal fans shall be used for kitchen extract systems. Where practicable, the motor shall be outside of the exhaust airstream to minimise maintenance. Otherwise, for example with small, domestic-like kitchen hoods, the motor shall be protected from grease and contamination.

6) Appropriate grease and odour treatment systems shall be provided. These may include any combination of stainless steel baffle grease filter, panel filter, high efficiency particulate air (HEPA) filter, activated carbon filter, ultraviolet (UV) lamps, and electrostatic precipitator (ESP). For ease of maintenance and water conservation, **water-wash and** continuous **water mist systems** are **<u>not</u>** permitted.

7) Fire risk assessment and fire services provisions shall be provided, such as:
   - o Design and operational fire risk assessment(s) of the kitchen extract shall be carried out. These shall be in accordance with Fire Protection Association RC44 – Recommendations for fire risk assessment of catering extract ventilation; and
   - o Where the fire risk assessment determines that fire suppression is needed, this shall be an Ansul fire suppression system integrated into the catering equipment. See the fire services section for details.

Designers and contractors of kitchen ventilation systems shall comply with the relevant (i.e., within which the kitchen / catering installation is in) local authority's requirements with respect to noise, odour, and discharge / flue locations. Designers and contractors shall refer to the following standards and guidance on this matter.

- Some local authorities publish its own guidance on the subject, for example the City of Westminster's Prevention of odour and fume nuisance from commercial kitchen exhaust systems; and
- EMAQ+ (Emission Monitoring, Air Quality & Contaminated Land) – Control of odour and noise from commercial kitchen exhaust systems; and
- Department for Environment, Food & Rural Affairs (DEFRA) – Guidance on the control of odour and noise from commercial kitchen exhaust systems.

The solution(s) proposed shall be to the satisfaction of the controlling local authority.

2.2.7 Minimum Energy Efficiency Standards

Table 15 – Minimum energy efficiency standards for ventilation / HVAC airside

System / component types			Minimum energy efficiency standards					
			New buildings[31]			Existing buildings (refurbishment or plant replacement)[31]		
			Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
Specific fan power (SFP)(W/l/s)[32]	Central balanced mechanical ventilation system	With heating and cooling	≤2.0	≤1.8	≤1.2 - 1.5	≤2.6	≤1.8	≤1.2 - 1.5
		With heating only	≤1.9			≤2.2		
		All other	≤1.5			≤2.0		
	Zonal ventilation system where fan is remote from zone, such as ceiling void or roof-mounted units	Supply	≤1.1	-	-	≤1.4	-	-
		Extract	≤0.5			≤0.5		
		Balanced supply and extract	≤2.3			≤2.3		
	Local ventilation system, such as window / wall / roof units	Supply or extract	≤0.3	≤0.3	≤0.2	≤0.4	≤0.3	≤0.2
		Balanced supply and extract	≤2.0	-	-	≤2.0	-	-
	Fan coil unit (rating weighted average)		≤0.4	≤0.3	≤0.2[33]	≤0.4	≤0.3	≤0.2[33]
	Kitchen extract, fan remote from zone with grease filter		≤1.0	-	-	≤1.0	-	-
Heat recovery device efficiency			≥73% (except run-around coils, per Ecodesign Regulations)	≥76% (sensible)	≥90%	≥73% (except run-around coils)	≥76% (sensible)	≥90%

31 **Baseline:** As required in **Building Regulations Approved Document Part L2 – Conservation of fuel and power, buildings other than dwellings (ADL2)**.

Recommended: As a minimum, per the **notional building** described in Department for Levelling Up, Housing and Communities (DLUHC) – National calculation methodology (NCM) modelling guide (for buildings other than dwellings in England) 2021. The **notional building** is a theoretical building to which the actual building's performance is compared. It is the same size and shape as the actual building, and has **standardised properties for fabric and building services** that are **better than** the **baseline limits in ADL2**.

Best practice: Net zero carbon targets. Current ones listed are as per **London Energy Transformation Initiative (LETI) standard.** See LETI – Climate emergency design guide, LETI – Design archetype 04 commercial offices, etc.

32 Specific fan power refers to the amount of power (in W) required to deliver each litres / second of ventilation air to each required space. A smaller SFP is more energy efficiency. See ADL2 Table 6.9 Maximum specific fan power (SFP) in air distribution systems in new and existing buildings for details.

33 Based on manufacturers' data, with manufacturers from the ICL Approved Suppliers / Components List.

System / component types		Minimum energy efficiency standards					
		New buildings[31]			Existing buildings (refurbishment or plant replacement)[31]		
		Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
Controls provision (Baseline requirements from ADL2 included for **information only**. Refer to the BMS / Controls section in this BESPR for Imperial College London requirements.)	All mechanical ventilation system	• Subdivided into **separate control zones** for building areas where any of the following are meaningfully different: solar exposure, pattern of use, and type of use; • For **each control zone**, **independent control** (from other control zones) for all of the following: timing, and, where appropriate, temperature, ventilation rate, and air recirculation rate; and • Central plant shall operate only when zone systems require it. Default condition shall be off.	Refer to the BMS / Controls section for details. See also Sections 2.2.3.1 System Zoning and 2.2.1.6 Heat Recovery.		As per new buildings	Refer to the BMS / Controls section for details. See also Sections 2.2.3.1 System Zoning and 2.2.1.6 Heat Recovery.	
	Central mechanical ventilation system	In addition to above for all mechanical ventilation systems: • Time control at room level; and • On / off time control at air handler level.					
	Local or zonal mechanical ventilation system	In addition to above for all mechanical ventilation systems: • On / off air flow control at room level.					
	Heat exchangers	• Defrost control to protect heat exchangers; and • Control ability to stop, modulate, or bypass heat recovery during periods where recovery is undesirable.					

Notes:

(1) For balanced supply and extract systems, the maximum SFP includes an allowance for heat recovery and return filter.

(2) Where any of the following components are included in the installation, the maximum SFP may be increased.

- High efficiency particulate air (HEPA) filter: add 1.0W/l/s;
- Humidifier / dehumidifier: add 0.1W/l/s;
- Active chilled beams: add 0.3W/l/s; and
- Transpired solar collector: add 0.3W/l/s.

2.2.8 Mechanically Actuated Windows or Vents

For the purpose of this document, mechanically actuated windows or vents refer to products used for natural ventilation, whether for normal or fire safety function.

2.2.8.1 For Normal Function

For normal function (such as air quality and / or temperature regulation), designers and contractors shall demonstrate compliance to the following sections before proposing the use of mechanically actuated windows or vents.

- Section 2.1.2.1 External Design Conditions for consideration on external design conditions with regards to natural ventilation;
- Section 2.1.2.2 Internal Design Conditions for Summer and Winter (Occupied Hours) on whether the required internal conditions can be achieved; and
- Section 2.1.4 System Selection on:
    - Whether natural ventilation is an appropriate solution for the spaces; and
    - If it is appropriate, whether this should be provided via manually operated or mechanically actuated windows and / or vents.

2.2.8.2 For Fire Safety Function

If mechanically actuated windows or vents are used for fire safety functions, designers and contractors shall ensure compliance with the building and / or project fire strategy.

2.2.8.3 Product Selection

Mechanically actuated windows or vents shall be fit-for-purpose and be selected based on the following, but are not limited to, criteria.

- The windows / vents and the actuators shall be an **integrated system** from a manufacturer with experience on providing natural ventilation systems;
- The **specific requirements of the project**, such as:

  - Whether they are required for **normal or fire safety function or both**;
  - **Characteristics of the windows or vents and actuators assembly**, e.g., chain or linear actuator, locking points, vent position, free area requirement / opening stroke, voltage and electrical power requirement, force (N), hinge type, speed, flex length and specification, durability, maintenance requirements, etc.;
- **Weather performance** – in other words, weather tightness when closed and opened (for actuated louvres);
- **Thermal / energy performance** such as insulation, heat recovery (for natural ventilation with heat recovery / NVHR products), etc.; and
- Designers and contractors shall refer to CIBSE Application Manual (AM) 10 – Natural ventilation in non-domestic buildings, BS EN 12101-2 – Smoke and heat control systems, natural smoke and heat exhaust ventilators, and other relevant regulations and standards.

2.2.8.4 Control

How mechanically actuated windows or vents are controlled shall depend on the system's primary function (i.e., whether for normal or fire safety function). Typical arrangements are described below. The designers and contractors shall demonstrate compliance to regulations and standards to Imperial College London and to the satisfaction of Building Control.

2.2.8.4.1 Primarily Normal Function

For a system where its primary function is normal use (such as air quality and / or temperature regulation), the system shall:

- Be controlled via the BMS, rather than the manufacturer's proprietary control system. Refer to the BMS / Controls section for details; and
- Fail safe in the event of a fire, in accordance with the building and / or project fire strategy.

Designers and contractors shall propose the control strategy, complete with corresponding calculations and evidence, as part of their works for acceptance by Imperial College London.

2.2.8.4.2 Primarily Fire Safety Function

For a system where its primary function is for fire safety (such as staircase smoke vent, etc.), the system shall be controlled by:

- A dedicated system compliant to relevant regulations and standards, such as those listed in Section 2.1.5 Fire Safety and others (e.g., BS 5839 – Fire detection and fire alarm systems for buildings, BS EN 12101-2, BS EN 12101-10 – Smoke and heat control systems, power supplies, etc.); and
- Where additional normal function(s) (such as to moderate temperatures in the staircase, etc.) are required, outputs from the BMS to the above system.

See also Section 2.7.2 Fire Alarm Interfaces with Mechanical Plant and the Fire and security section for details.

2.3 HVAC Waterside (Particular Requirements on)

2.3.1 Main Plants

Refer to Section 2.1.3.2 Plant Selection for design calculations and selection criteria for main plant, such as diversity and load profiles, resilience, capacity, life cycle performance, space, etc.

Main plants shall have remote control and monitoring capability via open protocol with the ability to integrate with the College's Trend BMS system. Typically, this shall be facilitated via a high-level interface with the BMS (rather than a number of volt-free contacts). Refer to the BMS / Controls section in this BESPR for details.

Designers and contractors shall comply and provide evidence to Imperial College London for demonstrating compliance with the following:

- CIBSE Guide A – Environmental design;
- BS EN 12828 – Heating systems in buildings, design for water based heating systems;
- BS EN 17671 – Heating systems and water based cooling systems in buildings, design for water based cooling systems. (*This standard is currently in draft for public comments*; *compliance is required when it is in official publication)*; and
- Any other relevant regulations, standards, and guidance.

See Section 2.3.3 Minimum Energy Efficiency Standards for energy performance requirements.

2.3.1.1 Heat Networks

New heat networks or upgrades to existing heat networks shall be designed, constructed, tested, and commissioned in accordance with:

- CIBSE CP01G – Heat networks design guide;
- CIBSE CP01 – Heat networks code of practice for the UK;
- Mayor of London – London heat network manual; and
- BS EN 13941 – Design and installation of thermal insulated bonded single and twin pipe systems for directly buried hot water networks.

Designers shall investigate government funding opportunities for these new or system upgrades with Imperial College London via the Heat Networks Investment Project (HNIP), Green Heat Network Fund (GHNF) Transition Scheme, Heat Network Efficiency Scheme (HNES), or successive / equivalent future government schemes – for which adherence to the above standards is a pre-requisite.

2.3.1.1.1 Heat Network Substations and Heat Interface Units (HIUs)

Introduction

End user connections onto heat networks shall be indirect via plate heat exchangers. The plate heat exchangers and their necessary accessories shall be factory-made, pre-insulated packaged systems (commonly referred to as heat network substations or heat substations). In cases where further hydraulic separation is required (for example in individual flats or student accommodation), packaged heat interface units (HIUs) shall be provided. These are provided for hydraulic separation, to demarcate maintenance responsibilities, and to minimise impacts should there be a leak.

Heat network substations and HIUs shall be from a manufacturer with experience on providing these products. A heat network substation shall consist of, but are not limited to, the following.

Table 16 – Typical heat network substation

Part of heat network substation	To be provided outside of the heat network substation
• One or more plate heat exchanger(s), depending on the application; and • Isolation, commissioning, control, monitoring, and cleaning provisions.	• Circulation pumps and accessories (e.g., headers, valves, etc.); • Domestic hot water generation and storage and accessories – see Section 2.5.3 Hot Water Services for details; • Pressurisation units; and • Controls for the above – refer to the BMS / Controls section for further details.

A HIU shall consist of, but are not limited to, the following.

Table 17 – Typical heat interface unit (HIU)

Part of HIU	To be provided outside of the HIU
• Two plate heat exchangers – one for space heating and the other for	• Refer to project specific requirements for metering and remote control provisions.

instantaneous domestic hot water service; • Space heating circulation pump; and • Isolation, commissioning, control, monitoring, and cleaning provisions.	

Heat meters

Provisions and requirements for heat meters shall be compliant to the project's, building's, and site's metering strategy. Refer to the metering section in this BESPR for details.

Where applicable within the specific metering strategy and requirements of the metering section in this BESPR, heat meters can be provided as part of the heat network substation / HIU.

Requirements

Heat network substations and HIUs shall comply with the following standards.

- BS EN 1148 – Water-to-water heat exchangers for district heating, test procedures for establishing the performance data;
- BESA – UK heat interface unit (HIU) test regime;
- BSRIA BTS 2/2015 – Test methods for heat interface units (HIUs);
- CIBSE guidance note – Domestic hot water temperatures from instantaneous heat interface units; and
- Other relevant regulations, standards, and guidance.

Designers and contractors shall comply with Section 2.1.3.2 Plant Selection to determine load diversity and sizing (including provisions for low temperature heating), resilience, spare capacity, etc. for their selections of heat network substations and HIUs.

Designers and contractors shall evaluate, document, and provide evidence to Imperial College London to demonstrate appropriate heat network substations and HIUs selection based on project, building, and campus requirements, such as the following.

- Existing heat network operating parameters;
- Building and / or project design requirements: for example, sizing parameters (e.g., flow and return temperature difference, etc.) of the heat emitters (e.g., radiators, fan coil units, AHU coils, etc.) and others;

- Energy efficiency: CIBSE CP01G – Heat networks design guide recommends that heat substations are sized such that their return approach temperatures (see Figure 10 below) are as small as possible, at less than or equal to 3°C;
    - As described in Section 2.3.1.1 Heat Networks, new heat networks shall comply with this requirement; and
    - Works on existing heat networks shall assess whether this is practical.

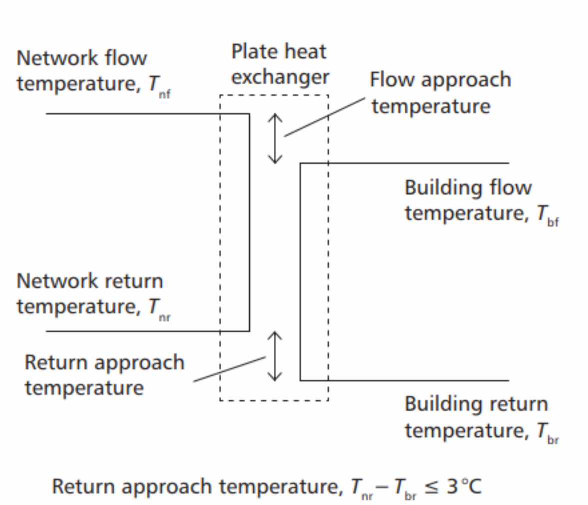

Figure 10 – Return approach temperature on plate heat exchangers (excerpted from CIBSE CP01G – Heat network design guide)

Refer to Section 2.3.3 Minimum Energy Efficiency Standards for minimum efficiency on plate heat exchangers.

Controls

Designers and contractors shall propose, provide evidence, and agree with Imperial College London engineering and maintenance teams the controls provisions for heat network substations and HIUs, including but are not limited to the following:

1) Description of operations;
2) General arrangement of sensors and mechanical control devices; and
3) Control system architecture, such as:
    - For new heat network substations on new heat networks –
        - Whether a supervisory control and data acquisition (SCADA) system will be used;

- If so, how does the SCADA interface with the building management system (BMS), e.g., what and how information are exchanged and displayed between the two systems;

- For new or refurbished / replaced heat network substations on existing heat networks, the same control system architecture per the existing heat networks shall normally be used.

Refer to the BMS / Controls section for further details.

Controls for heat interface units

Where heat interface units (HIUs) are provided for further hydraulic separations (for example in individual flats or student accommodation), the HIUs shall have integral controls as part of the package for regulating the space heating and domestic hot water services provided.

The HIU's controls shall be compatible with various room services and control strategy, e.g., radiators, underfloor heating and controls, programmable room thermostats, etc.

The HIUs shall also have the ability to integrate with the College's BMS system. As a minimum, these shall include common fault signals to the BMS.

Refer to the BMS / Controls section for further details.

2.3.1.2 Heat Source and Rejection

Designers shall appraise the various methods of heat source and rejection, and propose the most suitable method. Where there is waste heat (examples include but are not limited to equipment heat rejection, areas requiring constant cooling, etc.) designers shall review whether this is suitable for use in another process and can be recovered before rejection to the environment.

Heat source and rejection methods to the environment can include:

- Air based, such as via dry air coolers, air cooled chillers, air source heat pumps, etc.;
- Water based, such as via ground water (e.g., open loop ground source heat pump), surface water, etc.;
- Evaporative cooling, such as cooling towers, adiabatic cooling, etc.;
- Ground coupling, such as closed loop ground source heat pump, ground coupled seasonal energy storage, etc.; and

- Solar thermal / heating – see Section 2.5 Plumbing services.

Heat source and rejection devices shall conform to their corresponding regulations, codes, standards, and guidance, including but are not limited to the following.

Table 18 – Heat source and rejection regulations, codes, standards, and guidance

Heat source and rejection methods	Regulations, codes, standards, and industry guidance
Air based	• BS EN 1048 – Air cooled liquid coolers ('dry coolers') performance tests; and • See also Section 2.3.1.3 Heat Pumps and Chillers.
Water based	• Environment Agency's policies, such as Environment Agency – Approach to groundwater protection, Environment Agency – Environmental good practice guide for ground source heating and cooling, etc.; • CIBSE CP02 – Surface water source heat pumps code of practice for the UK and CIBSE CP02G – Guide to Surface water source heat pumps code of practice for the UK; • CIBSE CP03 – Open-loop groundwater source heat pumps code of practice for the UK and CIBSE CP03G – Guide Open-loop groundwater source heat pumps code of practice for the UK; • CIBSE TM45 – Groundwater cooling systems; and • See those listed for ground coupling below where the water is sourced from the ground.
Evaporative cooling	• The Notification of Cooling Towers and Evaporative Condensers Regulations 1992; • HSE HSG274 Part 1 – Legionnaires' disease: The control of legionella bacteria in evaporative cooling system; and • BS 4485 – Water cooling towers.
Ground coupling	• BS EN 15879-1 – Testing and rating of direct exchange ground coupled heat pumps(1); • CIBSE TM51 – Ground source heat pumps; and • Ground Source Heat Pump Association (GSHPA) standards, such as GSHPA – Closed-loop vertical borehole design, installation & materials standards, GSHPA – Thermal pile design, installation & materials standards, etc.
Solar thermal / heating	• BS 5918 – Code of practice for design and installation of solar heating systems for domestic hot water; • BS EN 12975 – Solar collector general requirements, and BS EN 12976 – Factory made thermal solar system and components; and • BESA (Heating and Ventilating Contractors' Association / HVCA) – Solar heating design and installation guide.

Heat source and rejection methods	Regulations, codes, standards, and industry guidance
All / miscellaneous	• Microgeneration Certification Scheme (MCS) standards (general standards and those for heat pumps, micro-CHP, and solar thermal).

Notes:

(1) BS EN 15879-1 - Testing and rating of direct exchange ground coupled heat pumps with electrically driven compressors for space heating and / or cooling, part 1: direct exchange-to-water heat pumps.

2.3.1.3 Heat Pumps and Chillers

Heat pumps and chillers shall conform to:

- Ecodesign for Energy-Related Products Regulations and related regulations – these reference the European Union (EU) Ecodesign Directives and Regulations;
- BS EN 378 – Refrigerating systems and heat pumps, safety and environmental requirements;
- BS EN 14511 – Air conditioners, chillers, and heat pumps[34];
- BS EN 16147 – Heat pumps for domestic hot water[35];
- BS EN 14825 – Air conditioners, chillers, and heat pumps: Testing and rating at part load and seasonal performance calculation[36];
- BS EN 12102 – Air conditioners, chillers, heat pumps, and dehumidifiers, sound power level[37];
- CIBSE AM16 – Heat pump installations for multi-unit residential buildings;
- CIBSE AM17 – Heat pump installations for large non-domestic buildings;
- BESA TR30 – Guide to good practice for heat pumps;
- Eurovent certification;

34 BS EN 14511 – Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors.

35 BS EN 16147 – Heat pumps with electrically driven compressors: Testing, performance rating and requirements for marking of domestic hot water units.

36 BS EN 14825 – Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling: Testing and rating at part load conditions and calculation of seasonal performance.

37 BS EN 12102 – Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers, with electrically driven compressors: Determination of sound power level.

- Microgeneration Certification Scheme (MCS) standards (general standards and those for heat pumps); and
- Any other relevant regulations, standards, and guidance.

Where a new heat pump or chiller is being installed, its design, selection, and installation shall comply with the relevant project external noise design criteria. Refer to Section 2.1.2 External and Internal Design Conditions for details.

Where a replacement heat pump or chiller is required, the acoustic performance of the replacement shall be equal or better than the existing unit. The designer / contractor / manufacturer shall provide Imperial College London with evidence on acoustic performance (e.g., test certificates, technical catalogues, etc.) for both the existing and replacement units to justify selection. The replacement unit shall incorporate features such as low noise electrically commutated (EC) fans, which will also bring energy efficient benefits.

Before selecting the replacement heat pump or chiller, the designer / contractor / manufacturer shall discuss with Imperial College London to investigate whether any noise complaints have been reported. Where present, the designer / contractor / manufacturer shall pay extra attention with the equipment selection and specify a quieter unit where possible.

2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant

As part of Imperial College London's Sustainability Strategy[38], the College has committed to become a carbon net-zero institution by 2040. As such:

- No new boiler, gas combined heat and power (CHP), and other fossil fuel fired / driven plant shall be installed in new buildings; and
- For central plant replacement and major refurbishments, designers and contractors shall produce, provide to, and agree with Imperial College London their feasibility and options evaluation for non-fossil fuel alternatives.
    - See Section 2.1.4 System Selection for evaluation criteria.

38 https://www.imperial.ac.uk/sustainable-imperial/

Where boilers and gas CHP plant are provided, they shall conform (but are not limited) to the following.

Table 19 – Gas boiler and CHP regulations, codes, standards, and guidance

Classification	Regulations, codes, standards, and guidance
Overall	• Gas Safety (Installation and Use) Regulations 1998; • HSE L56 – Approved code of practice for safety in the installation and use of gas systems and appliances; • BS EN 303 – Heating boilers; and • BS EN 15502 – Gas-fire central heating boilers.
≤70kW net input	• Building Regulations Approved Document Part J – Combustion appliances and fuel storage systems; • BS 6798 – Gas-fired boilers of rated input ≤70kW net(1); and • BS 5440 – Flueing and ventilation for gas appliances of rated input ≤70kW net(2).
70kw to 1.8MW net input (includes modular boilers with total input falling within this range)	• BS 6644 – Gas-fired hot water boilers of rated inputs between 70kW net and 1.8MW net(3); and • Institution of Gas Engineers and Managers (IGEM) Utilisation Procedures (UP) 10 (IGE/UP/10) – Installation of flued gas appliances in industrial and commercial premises.
CHP	• CIBSE AM12 – Combined heat and power for buildings; • BS EN 15316-4-4 – Energy performance of building-integrated CHP(4); • UK Government – Combined Heat and Power Quality Assurance (CHPQA) Programme guidance notes; and • Microgeneration Certification Scheme (MCS) standards (general standards and those for micro-CHP).

Notes:

(1) BS 6798 – Specification for selection, installation, inspection, commissioning, servicing, and maintenance of gas-fired boilers of rated input not exceeding 70 kW net.

(2) BS 5440 – Flueing and ventilation for gas appliances of rated input not exceeding 70kW net (1st, 2nd and 3rd family gases).

(3) BS 6644 – Specification for the installation and maintenance of gas-fired hot water boilers of rated inputs between 70kW (net) and 1.8MW (net) (2nd and 3rd family gases).

(4) BS EN 15316-4-4 – Energy performance of buildings, calculation of system energy requirements and efficiencies, building-integrated CHP.

2.3.1.5 Thermal Buffer Vessels and Stores

The terms ‘thermal store’ and ‘buffer vessel’ are sometimes incorrectly used interchangeably. Per CIBSE CP01G – Heat networks design guide, their definitions are as follows.

Table 20 – Thermal buffer vessel vs thermal store

Item	Definition
Thermal buffer vessel	Used to create a delay in heat transfer around the primary circuit, thereby enabling main plants to operate for a longer cycle.
Thermal store	Simply a store of thermal energy, such as heated / chilled water, etc. Typically, the thermal storage is generated either: • During a period of low demand for later use; or • For resilience to cover immediate plant failure. Where appropriate, this may enable optimum value for main plants due to: better match between system demands and plant sizes, simple way to provide essential plant resilience, etc.

Where thermal buffer vessels or thermal stores are proposed by designers and contractors, designers and contractors shall:

1) Refer to and provide evidence to Imperial College London Engineering, Energy and Environment Team that the plant selection criteria in Section 2.1.3.2 Plant Selection have been appropriately addressed;
2) These shall include consolidated load profiles, plant sizing, turndown ratios, and responses, and –
    - In the case of a thermal buffer vessel, the delay in heat transfer around the primary circuit created and comparison of plant cycles with or without the thermal buffer vessel;
    - In the case of a thermal store,
        - Amount of usable thermal energy stored (accounting for factors such as flow and return temperatures of heat transfer medium, thermal gradient within the store, etc.);
        - Duration of said storage, with draw-off as well as storage rates and profiles; and
        - Quantitative benefits realised, for example, amount of carbon emissions saved by being able to run low or zero carbon (LZC) technologies for longer, duration of resilience offered, etc.;
3) Evidence referred to in item 2) shall be presented in appropriate graphical formats.

Refer to Section 2.5.3.1 Domestic Hot Water Storage and Plate Heat Exchangers for requirements on domestic hot water storage tanks.

2.3.2 Circulation

2.3.2.1 Closed Loop Circuits

New closed loop circulation systems shall be variable flow delivered by variable speed pumps, with pump pressure control via remote static pressure sensor(s) wired to the same building management system (BMS) outstation as the pump inverters.

Systems shall be designed in accordance with (but are not limited to):

- CIBSE Knowledge Series (KS) 7 – Variable flow pipework systems;
- CIBSE KS7S – Variable flow pipework systems: valve solutions;
- BSRIA Application Guide (AG) 16/2002 – Variable-flow water systems design, installation, and commissioning guidance;
- CIBSE Commissioning Code W – Water distribution systems;
- CIBSE KS9 – Commissioning variable flow pipework systems; and
- BSRIA Building Guide (BG) 2/2010 – Commissioning water systems.

It is important that practical commissioning requirements are considered by the designer starting from RIBA Stage 2 Concept design through to final commissioning.

In other words, the designer, in conjunction with other team members, shall ensure that the system can be regulated and that there are appropriately located valves and flow measurement devices to enable the commissioning specialist to achieve this. Early discussions with the commissioning specialist will assist the designer to achieve this.

Systems shall be designed such that during refurbishment or future expansion, parts of the system can be modified without affecting the rest of the system.

See Section 2.3.3 Minimum Energy Efficiency Standards for energy performance requirements.

2.3.2.1.1 Pump Selections

Pumps shall be selected based on the system requirements, including but not limited to:

- System flow and pressure required;
- Optimum operating point on pump curves and efficiency;
- System characteristics under different loads and weather conditions;
- Resilience; and
- Spare capacity and future expansion.

Overall pump efficiencies shall be in accordance with the Ecodesign for Energy-Related Products Regulations. See Section 2.7.1 Motors and Inverters for pump motor efficiencies requirements.

2.3.2.1.2 Pump Installations

Pump sets shall be installed in accordance with:

- Project and building requirements;
- Manufacturer's instructions and recommendations; and
- Specific Imperial College London minimum requirements described here.

Designers and contractors shall adhere to requirements of the project and building regarding noise and vibration when selecting and installing pumps. In situations where nearby spaces are sensitive to noise and vibration, such as near recording studios, specialist laboratories (e.g., quantum mechanics, optics / photonics research, etc.), the design team shall engage an acoustic consultant and follow their advice.

Depending on these requirements and the pump selection, manufacturers will have corresponding instructions and recommendations for installation. Where a choice is available, preferred methods of pump support are (in descending order) pipe mounted, brackets, or via pump bases for ease of maintenance.

As a minimum, the following shall be provided for each pump for operational and commissioning purposes (from inlet to outlet):

- Inlet isolation valve;
- Strainer;
- Inlet pressure gauge;

- Binder test point;
- Pump (along with any transition, etc. as recommended by the manufacturer);
  - Where required, differential pressure sensor across the pump (together with quarter-turn ball isolation valves with handles to enable sensor replacement);
  - Refer to designer's description of operation and the BMS / Controls section for further details;
- Binder test point, orifice plate, and binder test point (preferably in one assembly);
- Outlet pressure gauge;
- Non-return valve (if required); and
- Outlet isolation valve.

Where duty / standby pumps are required as determined by the criteria described in Section 2.1.3.2.2 Resilience, an individual pump within the set shall be demountable for maintenance / repair / replacement without causing any downtime in system operations.

Duplex pump sets are **not** permitted for such duty / standby installations.

2.3.2.1.3 Control

The designer and contractor shall ensure that the correct / appropriate control valves are included in the specification, installation, and testing & commissioning of the systems.

From RIBA Stage 4 Technical design and depending on specific project arrangements, the project shall engage with a controls specialist. The controls specialist shall be responsible for final control valves selection, such as valve characteristics, valve authorities, kV values, actuators, and BMS integration. Refer to the BMS / Controls section for further details.

The control elements shall communicate with the BMS per described in the BMS / Controls section.

Where an existing system is being refurbished and / or extended, provisions for variable flow control shall be implemented as appropriate and practical. Example provisions include but are not limited to pump controls and various control valves, such as two-port control valves, differential pressure control valves (DPCVs), pressure independent control valves (PICVs), etc.

2.3.2.2 Pressurisation Units

Where mains pressure is adequate for the purpose, the Mikrofill pressurisation unit as supplied by Mikrofill Systems Ltd shall be used. This shall be used in conjunction with an adequately sized expansion vessel.

Where it is not possible to provide a Mikrofill unit, the pressurisation unit shall be selected from the standard range of packaged units provided by approved suppliers in the Imperial College London Approved Suppliers / Components List.

The selection of pressurisation units and associated pressure vessels shall be in accordance with BS 7074 – Application, selection, installation of expansion vessels and ancillary equipment for sealed water systems, and based on an appropriate assessment of the system water volumes and pressures. Once tested and commissioned, the system water volumes and pressures shall be marked using durable labels on the pressurisation units and pressure vessels for ease of operation & maintenance.

The cold fill pressure in the water system shall be equal to the static pressure + 0.5bar to 1.0bar maximum to suit the application.

2.3.2.2.1 Unit Specification

The specified pressurisation unit shall be complete with the following:

- Expansion vessel;
- Quick-fill connection;
- High / low system pressure switches; and
- Low pressure, high pressure, and common fault signals to BMS.

For pumped packaged units, the unit shall, in addition to the above, include the following:

- Duty / standby pumps with manual maintenance switch;
- Break tank; and
- Pump trip indication (indicated on the local control panel but not via the BMS).

Password protection shall be disabled in the unit's control features.

2.3.3 Minimum Energy Efficiency Standards

Table 21 – Minimum energy efficiency standards for HVAC waterside

System / component types			Minimum energy efficiency standards					
			New buildings[39]			Existing buildings (refurbishment or plant replacement)[39]		
			Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
Heat networks	Central heat source		See requirements for heat pumps below.			See requirements for natural gas boilers and combined heat and power (CHP) plant below.		See requirements for heat pumps below.
	Network performance (per kWh of delivered heat to buildings on the network)[40]		≤0.35kgCO_2 **OR** ≤1.45kWh of primary energy	≤0.23kgCO_2 **OR** ≤1.05kWh of primary energy[41]	To enable buildings on the network to achieve net zero carbon. (See also requirements for heat pumps below.)	Refurbishment or plant replacement on existing heat networks shall form part of a plan to improve network performance towards the following standards. Designers and contractors shall provide evidence to demonstrate compliance to this requirement.		
						≤0.35kgCO_2 **OR** ≤1.45kWh of primary energy	≤0.23kgCO_2 **OR** ≤1.05kWh of primary energy	To enable buildings on the network to achieve net zero carbon. (See also requirements for heat pumps below.)
Heat pumps (Seasonal coefficient of performance / SCoP)[42]	Electric for space heating (except air-to-air with output ≤12kW)		≥2.5	≥2.9	≥2.9 (LETI)	≥2.5	≥2.9	≥2.9 (LETI)
	Electric for domestic hot water		≥2.0			≥2.0		
Comfort cooling (Seasonal space cooling	Split and multi-split air conditioners	≤12kW	≥5.0	≥5.5[43]	≥5.5 (LETI)	≥5.0	≥5.5[43]	≥5.5 (LETI)
		>12kW	≥5.0			≥5.0		

39 **Baseline:** As required in **Building Regulations Approved Document Part L2 – Conservation of fuel and power, buildings other than dwellings (ADL2)**.

Recommended: As a minimum, per the **notional building** described in Department for Levelling Up, Housing and Communities (DLUHC) – National calculation methodology (NCM) modelling guide (for buildings other than dwellings in England) 2021. The **notional building** is a theoretical building to which the actual building's performance is compared. It is the same size and shape as the actual building, and has **standardised properties for fabric and building services** that are **better than** the **baseline limits in ADL2**.

Best practice: Net zero carbon targets. Current ones listed are as per **London Energy Transformation Initiative (LETI) standard.** See LETI – Climate emergency design guide, LETI – Design archetype 04 commercial offices, etc.

40 Calculations, in accordance with CIBSE CP01, CP01G and DLUHC – NCM modelling guide, shall be provided to ICL to demonstrate derivations of heat network performance – see Section 2.3.1.1 Heat Networks.

41 These correspond to a district heat network supplied by a gas-fired CHP with an electrical efficiency of 30% and a heat efficiency of 50%, supplying 80% of the heating load, with the remaining 20% assumed to be supplied by an electric heat pump with an efficiency of 264% (and a 15% uplift applied to the CO2 and primary energy content of heat to account for network heat losses).

42 Seasonal coefficient of performance (SCoP) and seasonal space cooling energy efficiency (SEER) as determined using BS EN 14825 – Air conditioners, chillers, and heat pumps: Testing and rating at part load and seasonal performance calculation, with average climate data, and in conjunction with European Union (EU) Ecodesign Commission Regulation No. 2016/2281.

43 From lines 51 and 47 in the NCM modelling guide, which describe a Seasonal System Energy Efficiency Ratio for cooling (SSEER) of 4.4 and 20% distribution losses, i.e., 4.4 / (100% - 20%) = 5.5.

System / component types			Minimum energy efficiency standards					
			New buildings[39]			Existing buildings (refurbishment or plant replacement)[39]		
			Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
energy efficiency / SEER)[42]	Variable refrigerant flow / volume (VRF / VRV) systems[44]		≥5.0			≥5.0		
	Water to water chillers	<400kW	≥5.0			≥5.0		
		400 - <1500kW	≥6.0		≥6.0	≥6.0		≥6.0
		≥1500kW	≥6.5		≥6.5	≥6.5		≥6.5
	Air cooled chillers	<400kW	≥4.0		≥5.5 (LETI)	≥4.0		≥5.5 (LETI)
		≥400kW	≥4.5			≥4.5		
High temperature (≥7°C flow) process cooling (SEPR)[45]	Water cooled chillers	<200kW	≥7.0		≥8.5	≥7.0		≥8.5
		200 - <400kW			≥12.5 (≥13.0 from ≥1000kW)			≥12.5 (≥13.0 from ≥1000kW)
		400 - <1500kW	≥8.0			≥8.0		
		≥1500kW	≥8.5		≥13.0	≥8.5		≥13.0
	Air cooled chillers	<200kW	≥5.0		≥6.5	≥5.0		≥6.5
		200 - <400kW			≥8.0			≥8.0
		≥400kW	≥5.5			≥5.5		
Natural gas boilers (Seasonal efficiency, gross calorific value)	Single boiler	≤400kW output	No new fossil fuel fired plant is to be used in new buildings, in order fulfil the College's goal to be a carbon net-zero institution by 2040. See Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant for further information.			≥91%	≥96% overall[46]	Fossil fuel fired plant is not to be used, in order fulfil the College's goal to be a carbon net-zero institution by 2040. See Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant for further information.
		>400kW - 2MW output				≥88%		
		>2MW output				≥84%		
	Multiple boilers					≥91% overall		
	Natural gas	Direct-fired				≥91%	≥93%[47]	

44 For VRV/VRF systems, SEER is for the full system including indoor units.

45 Seasonal energy performance ratio (SEPR) for process chillers as determined using BS EN 14825 – Air conditioners, chillers, and heat pumps: Testing and rating at part load and seasonal performance calculation, in conjunction with European Union (EU) Ecodesign Commission Regulation No. 2016/2281. Baseline and recommended minimum energy efficiency standards per Table 6 in EU Ecodesign Commission Regulation No. 2016/2281. Best practice reference per benchmarks in Table 30 of the same regulation.

46 From NCM modelling guide, Table 7 Space heating system SCoP and fuel type in the notional building (natural gas entry) and line 53 on heating system distribution losses. 86% Seasonal System Coefficient of Performance (SCoP) / (100% - 10% distribution losses) ≈ 96% boiler seasonal efficiency.

47 From NCM modelling guide, Table 8 Water heating seasonal generator efficiency and fuel type in the notional building for high HW demand activities.

System / component types			Minimum energy efficiency standards					
			New buildings[39]			Existing buildings (refurbishment or plant replacement)[39]		
			Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
Domestic hot water (DHW) systems		Indirect-fired						
	Electric (direct, point-of-use)[48] (See entry under heat pumps above for electric heat pumps for domestic hot water.)		100%					
	Domestic hot water storage vessels		See Table 4.7 in ADL2.[49]	-	-	See Table 4.7 in ADL2.[49]	-	-
Combined heat and power (CHP)	Gas-fired CHP		No new fossil fuel fired plant is to be used in new buildings, in order fulfil the College's goal to be a carbon net-zero institution by 2040. See Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant for further information.			Refurbishment or plant replacement of existing gas-fired CHP shall form part of a plan to decarbonise the system it serves. Designers and contractors shall provide evidence to demonstrate compliance to this requirement.		
						CHPQA index ≥105 and power efficiency ≥20% (see below for minimum controls provisions)[50]	Electrical efficiency ≥30% **and** heat efficiency ≥50%, supplying ≥80% of heat load (see below for minimum controls provisions)[50]	Fossil fuel fired plant is <u>not</u> to be used, in order fulfil the College's goal to be a carbon net-zero institution by 2040. See Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant for further information.
Circulation pumps	For all systems		Where pump motor is rated at >750W, variable speed and variable volume control shall be provided.			Per requirements for new buildings where: • New pump(s) and circuit(s) are installed; or • Existing circuit is already on variable volume control. For works on existing pump(s) and circuit(s) on constant volume control, designers and contractors shall assess life cycle performance, and provide evidence to Imperial College London, to evaluate effectiveness of conversion to variable volume control. Refurbishment or plant replacement on existing pump(s) and circuit(s) shall form part of a plan to improve performance towards the following standards. Designers and contractors shall provide evidence to demonstrate compliance to this requirement.		

48 Local, point-of-use electric water heaters / boilers (wall mounted, not instantaneous hot water tap). See ICL Approved Suppliers / Components List.

49 From ≤2.1kWh / 24h to ≤5.2kWh / 24h heat losses, depending on nominal volume of storage vessels, from 200l to 2000l.

50 CHP quality assurance (QA) index per Department for Business, Energy, and Industrial Strategy (BEIS) – CHPQA Standard. Only applicable where the decarbonisation and life cycle plan / evaluation concludes that it is still viable to refurbish or replacement the existing gas-fired CHP.

System / component types			Minimum energy efficiency standards					
			New buildings[39]			Existing buildings (refurbishment or plant replacement)[39]		
			Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
	Building level[51]	LTHW only	≤0.4W/m^2 of floor area	≤0.3W/m^2 of floor area		≤0.5W/m^2 of floor area	≤0.4W/m^2 of floor area	≤0.3W/m^2 of floor area
		LTHW and CHW	≤1.1W/m^2 of floor area	≤0.9W/m^2 of floor area		≤1.5W/m^2 (of floor area)	≤1.1W/m^2 of floor area	≤0.9W/m^2 of floor area
	Network level (district heating or cooling)		Pump energy to be optimised against other factors such as wasteful heat losses in order to achieve required minimum heat network energy efficiency performance stated above. Refer to CIBSE CP01 – Heat networks code of practice for the UK and CIBSE CP01G – Heat networks design guide.					
Controls provision	All space heating and comfort cooling systems		• Subdivided into **separate control zones** for building areas where any of the following are meaningfully different: solar exposure, pattern of use, and type of use; • For **each control zone, independent control** (from other control zones) for timing and temperature; • **Prevent simultaneous heating and cooling** if both are provided in same space[52]; • Central plant, including associated pumps, shall operate only when zone systems require it. Default condition shall be off; • Multiple units controlled to ensure combined plant operates in its most efficient modes, such as sequencing, part load controls, etc.; and	Refer to the BMS / Controls section for details. See also Section 2.2.3.1 System Zoning.		Refurbishment or plant replacement on existing systems(s) shall form part of a plan to improve performance towards the following standards. Designers and contractors shall provide evidence to demonstrate compliance to this requirement.		

51 From NCM modelling guide, Table 14 Pump power density for actual building (W/m^2). Figures for new and existing buildings correspond to the following entries / assumption:

Buildings type	**Baseline**	**Recommended**	**Best practice reference**
New buildings	Variable speed pumping with **differential pressure sensor in the system**	Variable speed pumping with **multiple pressure sensors in the system**	
Existing buildings (refurbishment or plant replacement)	Variable speed pumping with **differential pressure sensor across pump**	Variable speed pumping with **differential pressure sensor in the system**	Variable speed pumping with **multiple pressure sensors in the system**

52 **Unless** required to meet specific space functions (e.g., in laboratories, etc.) – such as close temperature and / or humidity control, minimum air change rate, and others.

System / component types		Minimum energy efficiency standards					
		New buildings[39]			Existing buildings (refurbishment or plant replacement)[39]		
		Baseline	Recommended	Best practice reference	Baseline	Recommended	Best practice reference
		• Thermostatic room controls[53] for each room.					
	All space heating systems	In addition to above for all systems: • Where appropriate and technically feasible, weather compensation.			As per new buildings	Refer to the BMS / Controls section for details. See also Section 2.2.3.1 System Zoning.	
	All comfort cooling systems	In addition to above for all systems: • Meet BS EN 15232[54] Class C as a minimum.					
	Boilers	In addition to above for all systems: • At output >100kW, optimum start / stop control with either night setback or frost protection outside occupied periods; and • At output >500kW, full modulating burner controls.					
	CHP	In addition to above for all systems: • Controls to ensure CHP operates as lead heat generator; • Meter for hours run, electricity generated, and fuel supplied.					
	Domestic hot water systems	See Clauses 6.26 to 6.32 in ADL2.					
	Heat networks	Refer to CIBSE CP01 and CP01G.	In addition to baseline requirements, refer to the BMS / Controls section for details.				

53 To be achieved via a most appropriate method, such as thermostatic radiator valves (TRVs), room sensors and controllers, etc., and is not referring specifically to TRVs. Refer to the BMS / Controls section for details.

54 BS EN 15232 and BS EN ISO 52120-1 – Energy performance of buildings, contribution of building automation, controls, and building management. Classes range from D to A, with A as the best. Class C corresponds to standard building automation and control (BAC).

2.3.4 Miscellaneous

2.3.4.1 Process Cooling

Designers and contractors shall determine the proposed solutions and installations for process cooling through the following:

1) Establish the equipment's cooling requirements;
2) Determine appropriate source of cooling; and
3) Based on 1) and 2) above, document, present, and propose corresponding and appropriate solution.

Designers and contractors shall produce and provide to Imperial College London their findings, calculations, and proposal to demonstrate compliance to relevant regulations, standards, codes of practice, industry guidance, and the above criteria.

2.3.4.1.1 Equipment Cooling Requirements

Designers and contractors shall liaise with users and equipment manufacturers to determine said equipment's cooling requirements, such as:

- Available or acceptable methods of cooling, by co-ordination with the building engineering services infrastructure available (e.g., air cooled, water cooled, etc.);
- Flow rates (minimum and maximum);
- Temperature (both inlet temperature range and temperature difference);
- Amount of heat to be rejected and its variations over time / usage, including which equipment are used together;
- If water cooled –
    - Whether the equipment has internal built-in plate heat exchanger and pump set for hydraulic separation;
    - Pressure range and drop across equipment;
    - Water quality, e.g., pH, total dissolved solids, filtering, etc.;
    - End connections required, e.g., size (metric / imperial), type of connections, location, user required frequency for disconnection and re-connection; and

- If applicable, tolerances on above criteria.

The above requirements can sometimes be found in the equipment's technical datasheets, which the users shall provide. These shall also be documented, agreed with users in writing, included in the project deliverables, and presented to Imperial College London engineering and maintenance teams for review.

2.3.4.1.2 Source of Cooling

Based on outputs from 2.3.4.1.1 Equipment Cooling Requirements, designers and contractors shall determine appropriate source of cooling for the equipment. The selection criteria include but are not limited to the following.

- Air cooled or water cooled, based on co-ordination with the existing or proposed building engineering services infrastructure; and
- The system selection criteria described in Section 2.1.4 System Selection.

Where an existing system is present, the designers shall ensure the maximum value is utilised out of the existing system before considering new systems. Existing process cooling systems in Imperial College London's buildings vary. Some examples include:

- Room cooling equipment such as dedicated extract fans, fan coil units (FCUs), or computer room air conditioning (CRAC) units;
- A central chilled water system providing both comfort and process cooling; and
- Dedicated systems for process cooling, which can be chilled water or condenser water.

Domestic water supply as a once-through cooling source is not permitted and shall be replaced if works are being executed.

2.3.4.1.3 Proposed Solution

The proposed solution shall be documented and presented to Imperial College London for review as a distinct project deliverable, which shall include:

- Items from Section 2.3.4.1 Process Cooling, 2.3.4.1.1 Equipment Cooling Requirements, and 2.3.4.1.2 Source of Cooling above;

- Schematics and drawings (and / or models);
- System specifications;
- Controls, such as method of control, description of operations, etc.;
- Testing and commissioning plan and provisions (see also Section 2.7.6 Testing and Commissioning); and
- Operation and maintenance manual, documenting demarcation and description of users' and Imperial College London maintenance team's responsibilities.
    - For water cooled systems, typically the demarcation lies at the plate heat exchanger(s) (PHEs) with the users responsible for all equipment downstream of the PHEs.

2.3.4.1.4 Particular Requirements

The minimum requirements on the project team's proposed solution (see above in Section 2.3.4.1.3 Proposed Solution) are as follows.

For water cooled systems:

- There shall be hydraulic separation between the laboratory users / process cooling system and the source of cooling via plate heat exchanger(s) (PHEs);
- Where practicable, locate the plate heat exchanger(s) and associated pump(s) & accessories outside of the laboratory areas for maintenance access;
- The following shall be provided on the secondary / laboratory side –
    - Pressurisation system with automatic fill function (see Section 2.3.2.2 Pressurisation Units);
    - Dosing pot (for biocide, corrosion inhibiters, etc.);
    - Automatic air vents;
    - Appropriate water treatment, which, depending on requirements determined per Section 2.3.4.1.1 Equipment Cooling Requirements, can be sidestream filtration, deioniser, pH stabilisation, reverse osmosis, etc. A water treatment specialist shall be engaged where required; and

  - Gauges, sensors, valves, controls, and other accessories to form a complete, fit-for-purpose system.

Materials requirements for water cooled systems:

- All components and materials on the secondary side shall suit the water quality requirements, e.g., stainless steel, non-ferrous metals, etc. to suit the water quality requirements determined per Section 2.3.4.1.1 Equipment Cooling Requirements;
- PHEs and process cooling circulation pumps shall be stainless steel;
- Secondary pipework shall be in Aquatherm Green Pipe type SDR7.4 fusion welded system, with stainless steel inserts where compression fittings are used. See also Section 2.7.3 Pipework and Ancillaries;
- All valves and fittings shall be of de-zincifiable brass or stainless steel; and;
- Where user equipment is to be frequently connected and disconnected thus requiring quick release connections, these shall be self-sealing quick release stainless steel valves.

2.3.4.2 Thermostatic Radiator Valves (TRVs)

TRVs shall comply to BS EN 215 – Thermostatic radiator valves requirements and test methods. The valve shall be brass construction per BS EN 215. Removal of the valve insert shall be achievable without draining the system.

Designers and installers shall liaise local Imperial College London maintenance team to determine and provide the appropriate TRVs in line with models stocked in local maintenance store.

2.3.4.2.1 Temperature Sensing Device

Depending on the application and maintenance requirement, the designer / installer shall provide one of the following methods of temperature sensing:

- Thermostatic valve with integral sensor;
- Thermostatic valve with integral temperature selector with remote sensor; or
- Thermostatic valve with the remote sensor incorporating the selector.

The designer shall provide proposal and justification for Imperial College London to review.

Removal of the sensor heads shall be achievable without draining the system. Depending on the application, tamper-proof sensor heads may be installed.

2.3.4.2.2 Radiator Lockshield (Return) Valves

Radiator lockshield (return) valves shall have a double regulating function with tamper-proof setting by use of a special tool to allow accurate balancing of the system.

Removal of the double regulating valve insert shall be achievable without draining the system.

2.4 Steam

The College is the process of phasing out steam systems in its buildings, with the South Kensington campus leading the way amongst all campuses. Any new autoclaves shall be electric with built-in steam generators, using instead a water connection to generate steam locally.

New projects in the South Kensington campus shall propose to decommission existing steam systems and convert the source of heat to LTHW systems, and, if applicable, the South Kensington campus heat network. See Section 2.1.4 System Selection for the decision process.

Where new LTHW infrastructure (such as plate heat exchangers / PHEs, pumps, LTHW pipework, accessories, etc.) are required to achieve this, designers shall investigate opportunities for allowing future / further conversion of existing steam provisions in the building into LTHW from the same infrastructure. As with all other parts of the design, designers shall document and present the investigation, rationale, and proposed decision to Imperial College London for review.

The same process described above for determining what to do the existing steam provisions is required for all projects.

2.4.1 New Branch Connections to Existing Steam Systems

Further to the above, no new steam systems shall be provided in the College's buildings.

Where new branch connections to existing steam systems are to be provided, these shall be made into the top of the existing steam mains to ensure that the steam is dry (see CIBSE TM58 – Design and operation of modern steam systems, Section 5.3 Design of steam headers and off-takes).

Site investigations, consultation with the Imperial College London maintenance team, review with the Imperial College London Engineering, Energy and Environment Team, and, if appropriate, site validations are required to confirm that there is sufficient capacity and appropriate existing system conditions for the new branch connection(s) proposed.

2.4.2 System Components for Use on Steams Mains

Extensions and modifications on existing steam systems and components used shall be compliant to the relevant regulations, standards, and guidance, including but are not limited to the following:

- HSE INDG436 – Safe management of industrial steam and hot water boilers;
- HSE HSG253 – Safe isolation of plant and equipment;
- CIBSE TM58 – Design and operation of modern steam systems;
- Combustion Engineering Association (CEA) BG01 – Guidance on safe operation of steam boilers; and
- Spirax Sarco – The steam and condensate loop book.

All system components shall be by Spirax Sarco except where Spirax Sarco does not manufacture them, such as boilers, pipes, etc. All system components shall be installed and commissioning in accordance with the manufacturer's instructions.

2.4.2.1 Isolation Valves for Use on Steam Mains

Isolation valves for use on steam mains shall be manufactured from cast steel and selected for the correct system pressures. Isolation valves manufactured from cast iron shall not be used on steam systems under any circumstances.

Double block and bleed (DBB) valves with locking mechanism, compliant to HSE HSG253, shall be used for steam system isolation (e.g., connections to device such as steam coils, humidifiers, boilers, etc., on branches, etc.).

2.4.2.2 Steam Meters

Refer to the metering section in this BESPR (for requirements on steam meters and the types to be used, etc.).

2.4.2.3 Steam Traps

Steam traps shall be provided appropriately, per the above regulations, standards, and per manufacturer's recommendations. As a minimum, every terminal device requires a proper steam trap.

Steam traps shall be carefully sized for the application and condensate load expected, because both under sizing and oversizing can cause serious problems. Under sizing can result in undesirable condensate backup and excessive cycling, which can lead to premature trap failure. Oversizing might appear to solve this problem and make selection much easier because fewer different sizes are required, but if the trap fails, excessive steam can be lost leading to an inefficient system.

Unless otherwise specified and appropriate, the following types of steam traps shall be used in the corresponding locations.

- With mains drainage points:
  - Thermodynamic type when externally mounted;
  - Float type when internally mounted; and
- With items of plant:
  - Float type when internally mounted.

2.4.2.4 Typical Installation Details

Refer to CIBSE TM58 and manufacturer's literatures for typical installation details. Automatic monitoring, such as automatic trap monitor, etc., is not normally required, unless requested specifically by the Imperial College London maintenance team. Designers and contractors shall consult and agree this with the Imperial College London maintenance team.

2.5 Plumbing services

2.5.1 System Design and Provisions

The design, provision, installation, and testing and commissioning (T&C) of cold and hot water services shall comply with the relevant regulations, standards, and guidance – including but are not limited to:

- The Water Supply (Water Fittings) Regulations 1999;
- Building Regulations Approved Document Part G – Sanitation, hot water safety and water efficiency;
- Relevant British Standards (BS), such as:
  - BS 8558 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings;
  - BS EN 12831-3 – Energy performance of buildings, methods for calculating design heat load, domestic hot water systems heat load;
  - BS EN 806 – Specifications for installations inside buildings conveying water for human consumption;
  - PD 855468 – Guide to flushing and disinfection of services supplying water for domestic use within buildings; and
  - BS 5918 – Code of practice for design and installation of solar heating systems for domestic hot water (where appliable);
- CIBSE Guide G – Public health and plumbing engineering;
- BSRIA BG 2/2006 – Design checks for public health engineering;
- Institute of Plumbing – plumbing engineering services design guide;
- Specifically for Legionnaires' disease:
  - Health & Safety Executive (HSE) L8 – Approved code of practice for control of legionella bacteria in water systems;
  - HSE HSG274 Part 2 – Legionnaires' disease: The control of legionella bacteria in hot and cold water systems;
  - HSE HSG282 – Control of legionella and other infectious agents in spa-pool systems;
  - CIBSE TM13 – Minimising the risk of Legionnaires' disease; and

- BS 8580-1 – Water quality: Code of practice on risk assessments for Legionella control.

The designer shall state the design criteria and provide calculations for demonstrating compliance to the above for Imperial College London Engineering, Energy and Environment Team. These design criteria include but are not limited to:

- Number of devices and their loading units;
- Diversified design flow rates and profiles (for profiles – where applicable, i.e., for large systems); and
- Type and conditions of fluids.

2.5.1.1 Central Systems

Where there is a requirement to provide new or additional cold and / or hot water services, extending and utilising the College's existing systems shall be the preferred route.

The designer will have to prove that it is not possible to extend existing systems (due to capacity, location, or any other reason) before proposing new systems. In this case, the designer shall consult the College Engineering, Energy and Environment Team for guidance with its proposed solution(s).

2.5.1.2 Minimising Risk of Legionnaires Disease

The design, provision, installation, and testing and commissioning (T&C) of domestic cold and hot water services shall comply the regulations, standards, and guidance. See Section 2.5.1 System Design and Provisions for these, and, for Legionella bacteria, the HSE L8, HSG274, and HSG282 in particular. Compliance includes but are not limited to the following provisions.

Cold and hot water systems should be designed and constructed so they:

- Take account of and comply with the Water Supply (Water Fittings) Regulations 1999;
- Aid safe operation (e.g., without dead-legs, or if this is not possible, limit the length of dead-legs, and disconnect or remove redundant or non-essential standby plant);
- Reduce stored cold water to the minimum needed to meet peak needs;

- Aid cleaning and disinfection (e.g., by providing suitable access points in the system; and
- Minimise heat gain / loss (e.g., cold, and hot water pipes and storage tanks shall be insulated).

Refer to Imperial College London – Control of Legionella bacteria in water systems estates operations policy and procedures (document owned and controlled by the Imperial College London maintenance team) for any other design and installation provisions to facilitate operational requirements.

2.5.1.3 Minimum Water Efficiency Standards

Table 22 – Minimum water efficiency standards for new buildings or refurbishment / replacement in existing buildings

System / component types		Minimum water efficiency standards(1)		
		Baseline	Recommended	Best practice reference
Water closet (WC)		≤6 / 4 litres dual flush **or** ≤4.5 litres single flush	≤3.75 litres	≤3 litres
Shower		≤10l/min	≤6l/min	≤3.5l/min
Bath		≤185 litres	≤140 litres	≤100 litres
Basin taps		≤6l/min	≤5l/min	≤3l/min
Sink taps		≤8l/min	≤6l/min	≤5l/min
Kitchen taps	Kitchenette	≤8l/min	≤6l/min	≤5l/min
	Restaurant (pre-rinse nozzles only)	≤9l/min	≤7.3l/min	≤6l/min
Urinal		≤6 litres/bowl/hour	≤1.5 litres/bowl/hour	0 litres/bowl/hour
Dishwasher	Domestic	≤1.25 litres/place setting **or** ≤13 litres/cycle	≤12 litres/cycle	≤10 litres/cycle
	Commercial	≤7 litres/rack	≤5 litres/rack	≤3 litres/rack
Washing machine	Domestic	≤8.17 litres/kg **or** ≤60 litres/use	≤40 litres/use	≤30 litres/use
	Commercial	≤12 litres/kg	≤7.5 litres/kg	≤4.5 litres/kg
Greywater and rainwater system (where proposed and as % of WC or urinal flushing demand met using		0%	≥25%	≥75%

System / component types	Minimum water efficiency standards(1)		
	Baseline	Recommended	Best practice reference
recycled non-potable water)			
Controls	Solenoid valve linked to occupancy sensor to shut off water supply to toilets when unoccupied		
Leak detection	Per maintenance requirements	Per maintenance and BREEAM requirements	

Notes:

(1) **Baseline:** As required in **Building Regulations Approved Document Part G – Sanitation, hot water safety, and water efficiency (ADG)** where applicable. Otherwise from Table 8.3 Water efficient consumption levels by component type in Building Research Establishment (BRE) – Building Research Establishment Environmental Assessment Method (BREEAM) UK new construction version 6.0 technical manual (SD5079), Level 1.

(2) **Recommended** and **best practice:** From Table 8.3 Water efficient consumption levels by component type in BRE – BREEAM UK new construction v6.0 technical manual. Recommended is per Level 3 and best practice reference is per Level 5.

2.5.2 Cold Water Services

2.5.2.1 Storage Tank

All break tanks and cold water storage tanks shall be constructed of glass fibre reinforced plastic (GRP). Where possible, single moulded units shall be provided. Where this is not possible, externally flanged sectional tanks shall be provided. Where internally flanged tanks are required because of space restraints, etc., these shall be subject to an Engineering Exception Report.

Cold water storage tanks shall be complete with all the necessary access hatches, access ladders, connections, etc. to enable maintenance.

The designer / contractor shall establish an access and maintenance strategy prior to installation of tanks in order to ensure safe access to tanks for inspection, maintenance, and cleaning.

2.5.2.2 Pumping Equipment

Cold water booster pumps shall be fully packaged, self-contained units comprising a number of main duty pump(s) and a standby pump with automatic change-over and variable speed pump control. The pump package shall enable one of the pumps to be removed for maintenance without affecting the system. The booster pumps and integral control panel shall be mounted on a fabricated steel base plate / frame.

The booster pump set shall provide fault indication and low pressure signal to the building management system (BMS). Password protection shall be disabled in the unit's control features.

2.5.3 Hot Water Services

The preferred method of generating domestic hot water is to provide a central system comprising of domestic hot water (DHW) storage tanks, plate heat exchangers (PHEs), circulation pumps (where applicable), expansion vessels, heat interface units (where applicable), controls, etc.

2.5.3.1 Domestic Hot Water Storage and Plate Heat Exchangers

Where centralised hot water generation is the appropriate method to provide DHW services, the hot water generator shall comprise of a package system of DHW storage tank(s) complete with electric immersion heater(s) as backup heat source, stand-alone plate heat exchanger(s), pump(s), expansion vessel(s), etc. on a skid.

Shell and tube type calorifiers shall <u>not</u> be used.

2.5.3.2 Secondary Circulation

Where a new domestic hot water system is to be provided from a centralised storage system, pumped secondary return pipework shall be incorporated.

The pumped secondary return legs shall be provided so as to prevent the risk of Legionella growth. Only a single pump is required for the secondary return loop.

2.5.3.3 Stand-alone Point-of-use Water Heaters (Basin and Sink Taps)

Where it is not possible to use a central system, local "point-of-use" type heaters shall be provided subject to acceptance.

Where this type of system is proposed, an Engineering Exception Report shall be submitted to the College Engineering, Energy and Environment Team for acceptance.

2.5.3.4 Water Boiling Points (for Hot Drinks)

Where water boiling points are required in kitchenette areas etc, the preferred arrangement shall be a wall mounted, electric water boiler.

The boiler shall be sized to suit the required usage and shall be provided with a suitable drip tray built into the worktop and connected to a drain.

2.5.3.5 Hot Water Safety

To prevent scalding, burns, as well as the growth of Legionella and other bacteria, the design, installation, testing and commissioning (T&C) of the hot water systems shall provide safe hot water temperatures in line with the following guidelines.

- HSE and NHS Estates – Safe hot water and surface temperatures;
- HSE L8 – Approved code of practice for control of legionella bacteria in water systems;
- HSE HSIS6 – Managing the risks from hot water and surfaces in health and social care;
- HTM 04-01 – Safe water in healthcare premises and supplements, such as HTM 04-01 Supplement D08 – Specification for thermostatic mixing valves (TMVs) (healthcare premises), etc.

Where vulnerable people (e.g., for accessible toilets, children, older people, health care settings, etc.) may use the systems, additional measures shall be provided to reduce the risks.

2.5.4 Cold and Hot Water Taps

The preferred type of cold and hot water taps for toilets other than accessible toilets are the Conti+ touchless sensor thermostatic mixing taps. All taps shall be complete with a flow limiting, aerating facility to reduce water consumption.

Spray type taps shall not be installed as they can create an aerosol effect increasing the risk of infection by Legionella bacteria.

Provide lever ball isolation valves at taps for isolation and maintenance.

2.5.5 Cold and Hot Water Services in Laboratories

It shall be assumed that all laboratories within the College are classified as high risk under Fluid Category 5 of the Water Supply (Water Fittings) Regulations 1999.

The preferred solution for back-flow prevention of water systems within laboratories shall be the provision of segregated water systems, i.e., laboratory (process) cold and hot water services shall be totally segregated from the domestic water services.

Where segregation of services is proven to be impossible, type DC (pipe interrupter with permanent atmospheric vent) Water Regulations Advisory Scheme (WRAS) approved pipe interrupters shall be installed subject to submission of an Engineering Exception Report.

Where type DC devices are installed following acceptance, these shall be subject to the following provisions:

- Type DC devices shall not be attached to any apparatus that would create a back pressure (including but not limited to glassware washers, jet wash, other devices with pumps, etc.); and
- Type DC devices shall not be installed on outlets in microbiological safety cabinets (MSCs). Outlets in MSCs shall be fed via Type AA, AB, or AD air gaps.

2.5.6 Specialist Gas Services

Specialist gas services may include vacuum, compressed air, medical gases, laboratory gases, etc.

The design, provision, installation, and testing and commissioning (T&C) of specialist gas services shall comply with the relevant regulations, standards, and guidance – including but are not limited to:

- Pressure Systems Safety Regulations (PSSR);
- Pressure Equipment (Safety) Regulations;
- Dangerous Substances and Explosive Atmospheres Regulations (DSEAR);
- HSE L122 – Approved code of practice for safety of pressure systems;
- Office for Product Safety & Standards – Statutory guidance for Pressure Equipment (Safety) Regulations;

- HSE L138 – Approved code of practice for dangerous substances and explosive atmospheres;
- Relevant industry standards, such as:
    - CIBSE Guide G – Public health and plumbing engineering;
    - Corresponding British Compressed Gases Association (BCGA) codes of practice (CP) and guidance notes (GN), for example –

Table 23 – Indicative list of industry standards for specialist gas services

Classification	BCGA CP and GN
Overall	• BCGA CP4 – Gas supply and distribution systems (excluding acetylene); • BCGA CP44 – Storage of gas cylinders; • BCGA CP18 – Safe storage, handling, and use of special gases; • BCGA GN41 – Separation distances in the gases industry • BCGA GN11 – Management of risk when using gases in enclosed workplaces; and • BCGA GN13 – DSEAR risk assessment guidance for compressed gases; and • BCGA CP34 – Application of the Pressure Equipment Regulations to customer sites.
Compressed gases	• BCGA CP33 – Bulk storage of gaseous hydrogen at users' premises; • BCGA CP6 – Safe distribution of acetylene in the pressure range 0-1.5 bar; and • BCGA CP7 – Safe use of oxy-fuel gas equipment (individual portable or mobile cylinder supply).
Liquid or cryogenic gases	• BCGA CP36 – Cryogenic liquid storage at users' premises; • BCGA CP26 – Bulk liquid carbon dioxide storage at users' premises; • BCGA CP46 – Storage of cryogenic flammable fluids; and • BCGA CP45 – Design and operation of biomedical cryogenic storage systems.
Medical or healthcare applications	• BS EN ISO 7396 – Medical gas pipeline systems; • HTM 02-01– Medical gas pipeline systems; • BCGA GN32 – Medical gases, good distribution practice; and • BCGA GN26 – Medical gases, selection and maintenance of seals used on high pressure cylinders.

- Imperial College London safety Codes of Practice and policies, such as:
    - Imperial College London – Code of Practice for safe handling, use and storage of compressed gases;
    - Imperial College London – Code of Practice for liquid nitrogen: storage, use and transportation within College premises;
    - Imperial College London – Cryogenic liquids policy, etc.

Designers and contractors shall document and present to Imperial College London proposed specialist gas services provisions for review and to demonstrate compliance. This may require specialist advice as appropriate for the project.

The Imperial College London safety, engineering, and maintenance teams shall be engaged from an early design stage (e.g., RIBA Stage 0 Strategic definition or Stage 1 Preparation and briefing) to completion, T&C, and handover for review and acceptance.

2.6 Drainage

2.6.1 Design Compliance and Calculations

The design, provision, installation, and testing and commissioning (T&C) of drainage services shall comply with the relevant regulations, standards, and guidance – including but are not limited to:

- Building Regulations Approved Document Part H – Drainage and waste disposal;
- CIBSE Guide G – Public health and plumbing Engineering;
- Institute of Plumbing – Plumbing engineering services design guide;
- BSRIA BG 2/2006 – Design checks for public health engineering;
- Relevant British Standards (BS), such as:
    - BS EN 12056 – Gravity drainage systems inside buildings;
    - BS EN 752 – Drain and sewer systems outside buildings;
    - BS 8515 – Rainwater harvesting system code of practice (where applicable); and
    - BS 8525 – Greywater systems code of practice (where appliable).

The designer shall state the design criteria (such as number of devices, discharge units, design rainfall intensity and return period, design flow rates, type and conditions of fluids / discharge, and others) and provide calculations to demonstrate compliance to the Imperial College London Engineering, Energy and Environment Team.

2.6.2 Design Principles

The designer shall evaluate sustainable drainage and demonstrate to the satisfaction of Imperial College London Engineering, Energy and Environment Team the proposal when designing drainage systems. Systems to be evaluated include but are not limited to sustainable urban drainage systems (SuDS), rainwater harvesting, and greywater recycling. These shall be in accordance with the following (but are not limited to):

- Mayor of London – London sustainable drainage action plan;
- Construction Industry Research and Information Association (CIRIA) – The SuDS manual; and

- The applicable sustainability assessment framework for the particular project, e.g., Building Research Establishment Environmental Assessment Method (BREEAM) or others.

All drainage systems (including condense drains from air handling units and terminal units, such as fan coil units, etc.) shall be designed as gravity systems.

Kitchen and catering drainage shall be provided with appropriate grease trap(s). Systems that rely only on chemical dosing for treating fats and grease is not permitted. Designers and contractors shall provide a proposed maintenance regime for Imperial College London acceptance.

Provide rodding eyes at every bends, other locations, etc. to facilitate maintenance access. These shall be located at accessible locations, fully coordinated with access panels, openings, doors, ceilings, room layout and fixtures, etc. (see Section 2.1.6 Access and Maintenance).

2.6.2.1 Pumped Drainage

To propose and install a pumped drainage system, the designers and contractors must seek Imperial College London maintenance and Engineering, Energy and Environment Teams' explicit acceptance and must demonstrate why a gravity system is not possible.

Acceptance shall only be considered following receipt of a full proposal, which includes details of the proposed pumped drainage installation, including schematics and drawings (and / or models), system specifications, packaged pumped drainage plant manufacturer and model, controls, etc.

Where a pumped drainage proposal has been accepted, this shall be achieved via the following for ease of maintenance:

- Integral, factory manufactured and assembled package pumped drainage plant, complete with pumps(s), collection tank, sensors, controls, alarms, etc., per BS EN 12050 – Wastewater lifting plants for buildings and sites;
  - Part 1: Lifting plants for wastewater containing faecal matter;
  - Part 2: Lifting plants for faecal-free wastewater;

- Part 3: Lifting plants for limited applications[55] – This is not normally expected within Imperial College London buildings. Where plant of this type is proposed, Imperial College London maintenance and Engineering, Energy and Environment Teams' explicit acceptance is required;
- Part 4: Non-return valves for faecal-free wastewater and wastewater containing faecal matter;

- This type of plant is sometimes known as drainage / sewage / wastewater lifting stations;
- Main pump body or bodies shall be located outside of (not submerged in) the collection tank to allow easy removal for replacement;
- Where applicable, duty and standby pumps shall be provided for resilience; and
- The plant shall provide fault / alarm indication to the building management system (BMS). Password protection, if present, shall be disabled in the unit's control features.

A site assembled system, such as that consisting of concrete sump pit(s) with separately installed drainage pumps and controls, is not permitted.

2.6.3 Cooling System Condensate Drainage

Cooling system condensate drainage shall be provided using copper tube to BS EN 1057 – Seamless round copper tubes for water and gas in sanitary and heating applications R250 (half hard) with appropriate drainage traps. Traps shall connect to the main drainage system at an appropriate point and must be compliant with HSE L8 – Approved code of practice for control of legionella bacteria in water systems.

To prevent traps for condensate drainage from drying out, the provisions shall be either:

- Group all condensate drains and provide a tundish complete with appropriate air gap and trap installed at the connection point to the main drainage system; or
- Provide dry or waterless trap (e.g., HepVo or equivalent).

55 Limited application means that the number of users is small, and the plant is located in the same room as the sanitary appliance(s) served by it.

If it is agreed to install condensate pumps, the approved arrangement shall include a collection vessel and pump controlled via a float switch. If installed on fan coil units (FCUs), the FCUs shall be arranged to shut down on condensate pump failure.

For condensate drip tray requirements, refer to Section 2.2.3.4 Fan Coil Units (FCUs).

Condensate pump health / fault status shall be included on the building management system (BMS) graphics.

2.6.4 Plant Room Drainage Points

Adequate floor drainage points shall be provided at low points within the plant room, i.e., with suitable fall towards the drain point. Drainage points are required for dealing with leaks, the prevention of flooding of adjacent areas, the drainage of condense from cooler batteries, overflows, and relief valves, and for draining down the system for maintenance.

The floor drains shall be connected to foul system with ventilated stacks.

If the provision of a floor drain point within a plant room is not a practical solution, an Engineering Exception Report shall be submitted with proposals for an alternative arrangement.

The following types of floor drainage points shall be installed in plant rooms to suit the application:

- Drainage gully with removable bell trap – This type of gully is an open grating cast iron type with a removable “bell” or “bucket” trap. This type of gully can be accessed from within the plant room to clear blockages by removing the grating and lifting out the bell trap for cleaning. For use where the gully is only accessible from above.
- Tundish inlet gullies – This type of gully can be used for the discharge from temperature and pressure relief valves from boilers and hot water storage vessels etc. This shall be done with great care to avoid spillage of water/steam into plant areas etc. It shall be noted that where this type of gully is used, a 25mm air gap shall be maintained between the top of any tundish inlet and the bottom of any pipe discharging over it. Discharge pipes shall never be submerged below the rim of the inlet.

All plant room gullies shall have metal bodies and gratings appropriate to the application.

2.6.5 Medical and Laboratory Drainage

Specialist medical and laboratory drainage may be required dependent on the specific user / client brief and requirements to handle biological, chemical, radioactive, or other medical and laboratory waste.

At the outset and throughout, designers and contractors shall establish, document, provide, present, and agree medical and laboratory drainage proposals (in written form) with the Imperial College London safety, engineering, and maintenance teams, following the same process described in Sections 2.6.1 Design Compliance and Calculations and 2.6.2 Design Principles and in accordance with the relevant regulations, standards, and guidance.

Medical and laboratory drainage proposals shall include (but are not limited to):

- User requirements, such as types, probable quantities, and potential hazards and risks of effluents that will be discharged, allowance required for future alterations and / or extensions, etc.;
- Applicable regulations, standards, and guidance and their requirements;
- Options evaluation and proposed method of treatment, such as –
    - Separate container and corresponding operational procedures for holding such wastes;
    - Appropriate system(s), e.g., separate stacks, limit horizontal runs (for ease of maintenance), etc.;
    - Appropriate components, e.g., filters on drains, anti-siphon, dilution, and / or glass traps, sterilisation equipment, effluents dilution and recovery, etc.;
- Available budget and acceptable levels of complexity;
- Engineering and maintenance requirements, such as –
    - Infrastructures and other system selection criteria as described in Section 2.1.4 System Selection; and
    - Maintenance access and other requirements as described in Section 2.1.6 Access and Maintenance, e.g., if there are horizontal runs on the floor below, which rooms are they in, etc.

Medical and laboratory drainage shall be provided using a proprietary system, such as Vulcathene. See also Section 2.7.3 Pipework and Ancillaries.

2.7 Common Elements

2.7.1 Motors and Inverters

In accordance with the Ecodesign for Energy-Related Products and Energy Information Regulations 2021 / (Amendment) Regulations 2021, motors and inverters shall be:

- Meet the minimum energy efficiencies set in the regulation[56]; and
- Be provided with inverters for control and energy efficiency purposes.

Motors shall be selected to operate at a frequency range of between 25Hz and 50Hz.

Inverters shall be separate from the motors for:

- Circulation pumps such as low temperature hot water, chilled water, condenser water, etc. (apart from very small pumps in applications like domestic hot water secondary circulation, solar thermal, etc.); and
- Fans for central plants such as AHUs, supply fans, extract fans, etc., unless the option is not available.

Apart for inverters for terminal units such as FCUs, etc., inverters shall be provided with a keypad for manual adjustments. Password protection shall be disabled on the inverters.

56 Ecodesign sets out minimum energy performance standards (MEPS) for motors by performance classifications known as IE levels, from IE1 to IE5 (per BS EN 60034-30-1). IE1 is the least energy efficiency and IE5 the most. The following table summarises regulatory requirements and timeline (source: WEG, a manufacturer).

Minimum Efficiency of Electric Motors and Variable Speed Drives

Regulation scope		Year and minimum efficiency requirements (2015 onwards)						
AC induction motors <= 1000 V		**2015**	**2017**	**2018 - 2020**	**2021**	**2022**	**2023**	**Onwards**
0.75-7.5 kW	3 phase, 2/4/6 pole	IE2	IE2+VSD/IE3	→	IE3	→	→	→
7.5-375 kW	3 phase, 2/4/6 pole	IE2+VSD/IE3	→	→	IE3	→	→	→
75-200 kW	3 phase, 2/4/6 pole						IE4	→
0.75kW-1000kW	3 phase 2,4,6,8 pole				IE3	→	→	→
0.75-1000 kW	ATEX/Brake all poles				IE3	→	→	→
0.12kW-1000kW	Ex eb all poles						IE2	→
0.12kW & above	1 phase all poles						IE2	→
0.12-0.75 kW	3 phase/brake all poles				IE2	→	→	→
Variable speed drives		**2016**	**2017**		**2021**	**2022**	**2023**	**Onwards**
0.12kW-1000kW				**2018 - 2020**	IE2	→	→	→

Inverters shall be integrated with the building management system (BMS) for control. Refer to the BMS / Controls section for details.

2.7.2 Fire Alarm Interfaces with Mechanical Plant

This section describes the requirements of and principles for the interfaces between mechanical plant and fire services systems. Refer also to the Fire Services section for details.

Designers and contractors shall propose and provide to Imperial College London the following to demonstrate compliance to regulations, standards, codes of practice, industry guidance, and the building / project specific requirements:

- **Fire strategy** for their works; and
    - Where works involve existing fire services systems and building, proposed fire strategy shall integrate with the existing building fire strategy appropriately. This includes plant refurbishment or replacement as the refurbished or replaced plant need to integrate with the building's existing fire strategy and fire services systems;
- **Fire alarm cause and effect**, where an automatic fire alarm (AFA) system is present.

Required deliverables for the above include but are not limited to:

- **Fire strategy drawings and report**; and
- **Fire alarm cause and effect matrix** – for mechanical plant interfaces, this provides a clear presentation of the logic involved.

Level of information and details for these deliverables shall be appropriate for the design stage and project / works, increasing and developing further as design stages progress and as project / works complexities rise.

Table 24 below provides some common mechanical plant interfaces with fire services systems and typical actions required upon detection of fire. These serve as references for designers and contractors to further develop during the course of their works.

Table 24 – Common mechanical plant interfaces with fire services systems

Category of plant	Specific plant	Example or notes	Action upon detection of fire[1]
Combustion plants and fuel delivery systems	Boilers and gas-fired combined heat and power (CHP) plant	-	Close inlet valve(s) or main shut-off valve(s) on natural gas / fuel delivery line(s)[2]. (For natural gas supply, this valve is sometimes referred to as the slam-shut valve).
	Fuel delivery systems	Natural gas supply for Bunsen burners, catering appliances, etc.	
		Diesel / petrol delivery system for generators, engine test laboratory, etc.	
Normal ventilation / HVAC air side plant	Ventilation plant (if powered via motor control centres / MCCs)	Air handling units (AHUs), fans, etc.	Hardwired to shut down via the MCCs.
	Ventilation plant (powered locally)	MVHRs, local extract fans, etc.	Building management system (BMS) to control hardwired contactor for power circuit to shut down. Refer to the BMS / Controls section for details.
	Terminal units	Fan coil units (applies for both water and refrigerant based), electric heater batteries, etc.	
	Mechanically actuated windows or hatches / vents	See Section 2.2.8 Mechanically Actuated Windows or Vents.	See Section 2.2.8.4 Control.
Specialist mechanical equipment	Fume cupboards (FCs) and microbiological safety cabinets (MSCs)	Refer to the Fire Services section for Firetrace automatic fire suppression system requirements and specifications.	Specific case risk assessment to be carried out to determine safe action for mechanical plant, as part of the fire and safety risk assessment[3].
	Local exhaust ventilation (LEV)	-	
	Medical and laboratory gases	See Section 2.5.6 Specialist Gas Services.	Specific case risk assessment to be carried out to determine safe action[4].
	Others	Chlorine system in swimming pool, etc.	Specific case risk assessment to be carried out to determine safe action.
Fire safety	Mechanical plant to maintain fire compartmentation	Fire dampers (FDs), fire and smoke dampers (FSDs), motorised fire and smoke dampers (MFSDs), etc.	Shut to maintain fire compartmentation[5].
	Mechanical plant to assist fire evacuation and / or firefighting	Natural smoke vents, mechanical smoke vent / extract (including smoke control dampers / SCDs), staircase / escape route smoke clearance or pressurisation, etc.	Activate based on logic agreed as part of the fire strategy[6].

Notes:

(1) Mechanical plant controlled via dedicated equipment (e.g., dedicated control panel and system, MCC, BMS controller, etc.), not the automatic fire alarm (AFA) system. Mechanical plant to just receive fire signal from the AFA based on the fire alarm cause & effect.

(2) Closing of valve(s) to be controlled via a dedicated gas detection panel and system, which shall be compliant to:
- BS EN 50402 – Requirements on functional safety of gas detection systems for combustible or toxic gases or of oxygen;
- BS EN 60079-29 – Requirements, selection, installation, use and maintenance of gas detection systems for flammable gases and oxygen; and
- Other relevant regulations, codes, standards, and guidance.

(3) Risk assessment shall, as a minimum, consider whether fire suppression is present, substances being handled and their quantities, operating procedures, etc. For instance, where Firetrace is present, continued running of the extract will remove the released fire suppressant and may prevent suppression of fire. In other cases, however, it may be safer to continue running the extract to safely disperse hazardous substances outside.

(4) Safe action to be controlled via dedicated medical and laboratory gas control panel and system, which shall be compliant to the relevant regulations, codes, standards, and guidance, such as those listed in Section 2.5.6 Specialist Gas Services. Risk assessment shall, as a minimum, consider the following:
   - Fire strategy; and
   - Operational risk assessment – to be conducted out by the designer / project team and presented to Imperial College London safety team.

   The medical and laboratory gas control system shall allow two-way communications with the automatic fire alarm (AFA) system, with the following minimum inputs and outputs:

Inputs from AFA to medical and laboratory gas control system	**Outputs from medical and laboratory gas control system to AFA**	
	To AFA	**To other systems**
Fire signal(s) based on the fire alarm cause & effect	• System fault; • Safety alarm; • Additional interfaces as determined by the risk assessment. o For example, where there is a building wide medical and laboratory gas control system, whether alarm outputs need to be separated by zones corresponding to the AFA zones.	• To be determined based on risk assessment with users and Imperial College London safety team. • Any such alarms / alerts need to be managed by users and not the Imperial College London maintenance team, due to the specific safety and operational knowledge required.

(5) If there are less than 10 no. of FDs, FSDs, and MFSDs on the project, these shall be hardwired to shut via the MCCs. See BMS / Controls section for details. For greater than 10 no. of FDs, FSDs, and MSFDs, dedicated intelligent, expandable, addressable, and editable proprietary control systems shall be provided – e.g., Actionair Actionpac LNS5 or similar.

(6) Dedicated intelligent, expandable, addressable, and editable proprietary control systems shall be provided. Control system shall be compliant to relevant regulations, codes, standards, and guidance including but are not limited to those relating to life safety and firefighting power supply, battery backup, fire rating of cables and devices, etc. as appropriate.

   Control system shall allow two-way communications with the automatic fire alarm (AFA) system, with the following minimum inputs and outputs:

Inputs from AFA to control system for smoke management	**Outputs from control system for smoke management to AFA**
• Fire signal(s) based on the fire alarm cause & effect, including which AFA zone is on fire; and • Depending on the fire strategy, firemen's override.	• Common fault; and • System activation.

2.7.3 Pipework and Ancillaries

2.7.3.1 Pipework Materials and Jointing Methods

This section sets out pipework components, materials, jointing methods, etc. that are to be used on Imperial College London installations.

Pipework system shall comply with to the relevant regulations, codes, standards, and guidance, such as:

- Building Regulations;
- The Construction Products Regulation and Construction Products (Amendment etc.) (EU Exit) Regulations (CPR);
- For water based heating and cooling systems, those referenced in Section 2.3 HVAC Waterside (Particular Requirements on);
- For plumbing services systems, those referenced in Section 2.5 Plumbing services;
- For specialist gas services, those referenced in Section 2.5.6 Specialist Gas Services;
- For drainage services, those referenced in Section 2.6 Drainage;
- Pipework system shall be chosen to ensure compatibility with:
    - Medium being carried and the environment the system is exposed to;
    - Existing pipework system in use, where works are extensions of existing systems – for instance new connections to existing piped services shall be of same material where possible;
    - Corrosion prevention and resistance – for instance, galvanic corrosion between dissimilar metal shall be prevented (e.g., when joining copper to carbon steel, use of a brass or gunmetal fitting is recommended per manufacturer's instructions); and
- Any other applicable regulations, codes, standards, and guidance.

Designers and contractors shall specify and provide pipework systems for services based on application (e.g., type of service, operating conditions, etc.), situation, and manufacturer's recommendations to form a complete, fit-for-purpose system.

Table 25 and Table 26 below provide common pipework materials requirements for Imperial College London. These are not meant to be exhaustive and cover general applications. Designers and contractors are responsible for specifying and providing the correct type of materials for the applications.

Durapipe ABS pipe systems shall **not** be used.

Table 25 – Common pipework materials requirements

Piped service			Pipework material / specification								
			Steel (BS EN 10255)[1]	Steel (BS EN 10255), galvanised to BS EN ISO 1461[2] or BS EN 10240[3]	Copper		Polypropylene random copolymer (PP-R)[7]		Stainless steel[10]	Cast iron (BS EN 877)[11]	Ductile iron (BS EN 598)[12]
					BS 1306[4] and EN 1057[5]	BS EN 13348[6]	Aquatherm[8]	Vulcathene[9]			
Heating	Steam		X								
	Medium temperature hot water (MTHW) and high temperature hot water (HTHW)		X								
	Low temperature hot water (LTHW)		X				X				
Cooling	Chilled water (CHW)		X		X		X				
	Processed cooling						X[13]				
	Condenser water		X	X	X		X				
	Refrigeration				X						
Plumbing	Domestic cold water (DCW) and domestic hot water (DHW)				X		X				
	Specialist water services (e.g., deionised water, purified water using reverse osmosis, etc.)						X				
	Natural gas[14]		X		X						
	Compressed air			X							
	Laboratory gases and vacuum					X[15]			X[15]		
	Medical gases and vacuum					X[15]					
Drainage	Rainwater[16]									X	
	Wastewater	Gravity[16]								X	
		Pumped									X
	Condensate				X[17]						
	Medical and laboratory drainage							X			

Notes:

(1) BS EN 10255 – Non-alloy steel tubes suitable for welding and threading.
(2) BS EN ISO 1461 – Hot dip galvanized coatings on fabricated iron and steel articles.
(3) BS EN 10240 – Hot dip galvanized coatings applied in automatic plants for steel tubes
(4) BS 1306 – Copper and copper alloy pressure piping systems.
(5) BS EN 1057 – Seamless round copper tubes for water and gas in sanitary and heating applications.
(6) BS EN 13348 – Copper and copper alloys, seamless, round copper tubes for medical gases or vacuum.
(7) BS EN ISO 15874 – Polypropylene (PP) piping systems for hot and cold water installations, and / or BS EN ISO 21003 – Multilayer plastic piping systems for hot and cold water installations inside buildings.
(8) Aquatherm Green Pipe SDR7.4 or equivalent.
(9) See also Section 2.6.5 Medical and Laboratory Drainage.
(10) Per requirements in BCGA CP4 – Gas supply and distribution systems (excluding acetylene).

(11) BS EN 877 – Cast iron pipe systems and their components for evacuation of water from works, characteristics, and test methods.
(12) BS EN 598 – Ductile iron pipes, fittings, accessories, and their joints for sewerage applications, requirements, and test methods.
(13) See also Section 2.3.4.1 Process Cooling.
(14) Natural gas pipes shall be compliant to Institution of Gas Engineers and Managers (IGEM) Utilisation Procedures (UP) 2 (IGEM/UP/2) – Installation of pipework on industrial and commercial presmises.
(15) See also Section 2.5.6 Specialist Gas Services. For medical gasses and vacuum, see also HTM 02-01– Medical gas pipeline systems, and use BS EN 13348 R250 (half hard) for sizes up to 54mm, R220 (annealed) for larger sizes.
(16) Gravity rainwater, wastewater, and associated vent systems can also be provided in high density polyethylene (HDPE), unplasticized polyvinyl chloride (uPVC), or stainless steel as appropriate for the application. Where applied, these shall be in accordance with:

Materials		**British standards**
HDPE	Aboveground	BS EN 1519-1 – Polyethylene piping systems for soil and waste discharge within buildings
	Underground	BS EN 12666-1 – Polyethylene piping systems for non-pressure underground drainage and sewerage
uPVC		BS 4514 – Unplasticized PVC soil and venting pipes, fittings, and accessories BS 1329-1 – uPVC plastic piping systems for soil and waste discharge withing buildings
Stainless steel		BS EN 1124 – Stainless steel pipes and fittings with spigot and socket for wastewater systems

(17) See also Sections 2.4 Steam and 2.6.3 Cooling System Condensate Drainage.

Table 26 – Pipework, fittings, and accessories requirements for directly buried district heat network pipes

System[(1)]	Component assemblies	British standards
Single pipe	Pipe	BS EN 253[(2)]
	Fitting	BS EN 448[(3)]
	Valve	BS EN 488[(4)]
Twin pipe	Pipe	BS EN 15698-1[(5)]
	Fitting	BS EN 15698-2[(6)]
	Valve	

Notes:
(1) Directly buried district heat network pipes shall be designed and installed to BS EN 13941 – Design and installation of thermal insulated bonded single and twin pipe systems for directly buried hot water networks. See also Section 2.3.1.1 Heat Networks.
(2) BS EN 253 – District heating pipes, bonded single pipe systems for directly buried hot water networks, factory made assembly of steel pipe, polyurethane thermal insulation, and polyethylene casing.
(3) BS EN 448 – District heating pipes, bonded single pipe systems for directly buried hot water networks, factory made assemblies of steel fitting, polyurethane thermal insulation, and polyethylene casing.
(4) BS EN 488 – District heating pipes, bonded single pipe systems for directly buried hot water networks, factory made assemblies of steel fitting, polyurethane thermal insulation, and polyethylene casing.
(5) BS EN 15698-1 – District heating pipes, bonded twin pipe systems for directly buried hot water networks, factory made twin pipe assembly of steel pipes, polyurethane thermal insulation, and one polyethylene casing.
(6) BS EN 15698-2 – District heating pipes, bonded twin pipe systems for directly buried hot water networks, factory made twin pipe assembly of fitting and valve, polyurethane thermal insulation, and one polyethylene casing.

Pipe jointing methods shall be appropriate for the service type and system operating conditions. All joints shall be accessible, with sufficient access for jointing and maintenance tools, such as manufacturer recommended tools for torquing, soldering, brazing, pressing, compression, welding, coupling, etc.

All pipework and jointing systems shall be designed and provided in accordance with manufacturer's recommendations. Where proprietary systems (e.g., Victaulic, Aquatherm, Vulcathene, Pegler Yorkshire Xpress press fittings, etc.) are used, training must be provided to the Imperial College London maintenance team.

Table 27 below provides common pipe jointing methods requirements for Imperial College London. These are not meant to be exhaustive and cover general applications. Designers and contractors are responsible for specifying and providing the correct pipe jointing methods for the applications.

Table 27 – Common pipe jointing methods

Pipe material		Size	Locations / applications	Jointing method
Steel (BS EN 10255)[1] and galvanised steel (BS EN ISO 1461 or BS EN 10240)		15 - 50	All	Screwed
		>65	All	Flanged
Copper	BS 1306 and BS EN 1057	All	Normal / typical	Soldered with capillary fittings to BS EN 1254-1[2]
			Where low contamination is required[3]	Brazed with capillary fittings to BS EN 1254-1
		≤54	Normal / typical	Press fittings to BS EN 1254-7[4]
		10 - 22	Terminal devices, such as radiators and taps, or where other methods are <u>not</u> practical / possible, e.g., connecting to a water tank ball float valve.	Compression fittings to BS EN 1254-2[5]
	BS EN 13348	All	Medical gases and vacuum.	Brazed with capillary fittings to BS EN 1254-1[6]
Polypropylene random copolymer (PP-R)	Aquatherm	All sizes	-	Fusion weld to manufacturer's recommendations
	Vulcathene			
Stainless steel		All	Laboratory gases and vacuum	Welded to BS EN ISO 15609 and 3834[7]
Cast iron (BS EN 877)		All	Gravity drainage	With joints that are part of the same manufactured system, certified to BS EN 877
Ductile iron (BS EN 598)			Pumped drainage	With joints that are part of the same manufactured system, certified to BS EN 598

Notes:

(1) Grooved and shouldered couplings certified to BS EN 10311 – Joints for steel tubes and fittings connections for conveyance of water and other aqueous liquids, such as Victaulic or equivalent, can also be used if the application is suitable.

(2) BS EN 1254-1 – Copper and copper alloys plumbing fittings, capillary fittings for soldering or brazing to copper tubes.

(3) Such as for laboratory grade services, as some older silver solder systems may transfer particulate matter onto the joint and piping system.

(4) Pegler Yorkshire Xpress, Conex B-press, or equivalent. BS EN 1254-7 – Copper and copper alloys plumbing fittings, press fittings for use with metallic tubes. **Press fittings shall <u>not</u> be used on steam / condensate return systems.**

(5) BS EN 1254-2 – Copper and copper alloys plumbing fittings, compression fittings for use with copper tubes.

(6) See also Section 2.5.6 Specialist Gas Services and HTM 02-01– Medical gas pipeline systems.

(7) BS EN ISO 15609 – Specification and qualification of welding procedures for metallic materials.
BS EN ISO 3834 – Quality requirements for fusion welding of metallic materials.
For small pipe sizes and end connections (≤25mm), mechanical joints such as press or compression fittings may be used as long as they were designed for the intended gas service and operating conditions. See also Section 2.5.6 Specialist Gas Services and BCGA CP4 – Gas supply and distribution systems (excluding acetylene).

2.7.3.2 Isolation and Commissioning Valves

2.7.3.2.1 Isolation Valves

Isolation valves shall be installed to ensure isolation of the service(s) for maintenance and modifications.

Isolation valves shall be provided in accordance with the relevant projects' drawings and specifications. As a minimum, the College requires isolation valves at the following locations (unless otherwise agreed):

- At branch connections from distribution mains to allow isolation of all sub-circuits;
- At the base of all rising services and the top of all dropping services;
- Points of connection to all items of apparatus and equipment, such as:
    - Main plants – including but not limited to boilers, plate heat exchangers, chillers, calorifiers, pumps, etc.;
    - Terminal equipment – including but not limited to heating and cooling coils, radiators / trench heaters, fan heaters, fan coil units, chilled beams, etc.;
    - In short, isolation valves shall be provided such that all items on the system can be isolated for maintenance and / or exchange without detriment to the services; and
- Before every automatic air vent.

Table 28 lists some general Imperial College London requirements on isolation valves.

Table 28 – Isolation valves general requirements

Service	Nominal size (mm)	Type	Body	Connection	Minimum PN rating[1]	Additional requirements
MTHW LTHW CHW Natural gas	15 - 50	Ball	Bronze / dezincification resistant brass (DZR)	Screwed	16	Lever operated
	65 - 150	Butterfly	Ductile iron	Flanged		Fully lugged lever operated
	200+	Butterfly	Ductile iron	Flanged		Fully lugged gear operated
DCW & DHW	15 - 50	Ball	Bronze / DZR	Compression		Lever operated
DCW	65 - 150	Butterfly	Aquatherm[2]	Fusion weld		Fully lugged lever operated
DHW	65 - 150	Butterfly	Bronze / DZR	Flanged		

Notes:

(1) Nominal pressure (PN) rating. This is a general minimum rating; specific ratings for particular systems are dependent on their design maximum working pressures.

(2) Where Aquatherm pipes are specified for the DCW system.

See Section 2.4.2.1 Isolation Valves for Use on Steam Mains for isolation valve requirements for steam services.

2.7.3.2.2 Commissioning Valves

Commissioning sets and regulation valves shall be provided on all hydraulic systems as a means of measuring and balancing flow rates to the design values.

Commissioning valves shall be provided in the following locations:

- All pipework branches (except covered by the following sub-bullets), in accordance with CIBSE Commissioning Codes;
    - Provide differential pressure control valves (DPCVs) on branch connections to facilitate future system modification and expansion;
    - Alternatively, pressure independent control valves (PICVs) can be used;
    - The choice between DPCVs and PICVs shall be determined and proposed by designers and contractors, and agreed with Imperial College London on a project-by-project basis;
- Points of connection to all items of apparatus and equipment, such as:
    - Main plants – including but not limited to boilers, plate heat exchangers, chillers, calorifiers, pumps, etc.;
    - Terminal equipment – including but not limited to heating and cooling coils, radiators / trench heaters, fan heaters, fan coil units, chilled beams, etc.;
    - In short, commissioning valves shall be provided such that all items on the system can be balanced in accordance to CIBSE Commissioning Codes;

Commissioning stations and regulating valves must be provided with a means of indicating and locking the valve in the set / commissioned position.

All measuring stations shall be installed in clear, unobstructed pipework with a minimum of ten pipe diameters upstream and five diameters downstream, or in accordance with manufacturer's instructions – in order to obtain consistent and accurate readings.

Valves shall be selected as appropriate for the applications to ensure correct measurement and regulation. Correct valve selections shall be in accordance with, including but not limited to: flow rates, pressure drops, connection sizes, etc.

Table 29 lists some general Imperial College London requirements on commissioning stations and regulating valves.

Table 29 – Commissioning stations and regulating valves general requirements

Service	Valve type	Nominal size (mm)	Requirements
MTHW LTHW CHW Condenser water	Double regulating valves and commissioning stations	15 - 50	Bronze body, screw connection
		65 - 300	Cast iron / steel body, flanged / fully lugged butterfly type

2.7.3.3 Venting of Air in Pipework

The design and installation of pipework systems shall prevent air trapped inside. Ways to achieve this can include (in hierarchy):

- Minimise changes in elevation in pipework installation;
- Ensure air vent points are provided at the high points of the system, whether they are local high points or system high points; and
- Refer to Sections 2.7.3.3.1 Manual Air Vents and 2.7.3.3.2 Automatic Air Vents for provision at those air vent points.

2.7.3.3.1 Manual Air Vents

Where practicable, manual air vents shall be used to discharge air from heating, chilled water and condenser water closed pipework systems.

Manual air vents shall consist of air bottle, isolation valve, discharge pipe and air cock.

Discharge pipes shall be terminated in a convenient location which shall normally be determined on site with the Imperial College London maintenance team. Labels must be provided to indicate which system the discharge pipes are for.

2.7.3.3.2 Automatic Air Vents

Where it is not practical to install air bottles, automatic air vents shall be installed. These shall be Flamco Flexvent type automatic air vents or equal, subject to the satisfaction of the Imperial College London maintenance team.

Automatic air vents shall have 15mm inlet and be installed with means of isolation utilising a lever ball isolation valve.

Where automatic air vents are to be installed, the following requirements shall apply:

- Automatic air vents shall not be installed in areas where a release of water could cause damage to equipment; and
- Automatic air vents shall not be installed in concealed areas where leaks can go on undetected for long periods.

2.7.4 Insulation and Finishes to Ductwork, Pipework, Associated Equipment, and Accessories

Insulation can be applied to ductwork, pipework, and associated equipment due to thermal and acoustic requirements. This section covers the particular requirements with regards to thermal insulation.

Designers and contractors shall design, install, test, and commission mechanical provisions as so to eliminate noise at source via appropriate plant selection, attenuation, pipes, and ducts sizing, etc., rather than applying acoustic insulation to ductwork and pipework.

2.7.4.1 General Requirements

Thermal insulation can be required for ductwork, pipework, and associated equipment for building services for different and multiple purposes, such as:

- Energy efficiency – to save energy and reduce carbon emissions by minimising unintended heat losses and gains;
- Frost protection – to protect pipes from freezing / frost damages;
- Condensation control – to protect against surface condensation forming on cold / chilled building services, which can otherwise lead to water damages;
- Health and safety – for example, to protect:
    - Personnel against exposure to hot or cold surfaces;

    - Against Legionella and other bacteria growth in domestic cold water (DCW) services by guarding against excessive heat gain on DCW tanks and pipes, etc.; and
- Fire resistance – for instance, where the thermal insulation is part of the fire resisting ductwork system to offer the "I" (insulation) rating required. (Refer to Section 2.2.4.5 Ductwork Fire Protection for requirements on fire resisting ductwork).

Designers and contractors shall specify and provide thermal insulation to services based on application (e.g., type of service, operating conditions, etc.), situation, and manufacturer's recommendations to form a complete, fit-for-purpose system.

As a minimum, insulation shall be applied to the following services:

Table 30 – Indicative list of services requiring thermal insulation

System type	Services		Functions of required thermal insulation
Heating	Steam		Energy efficiency, health and safety
	Medium temperature hot water (MTHW)		
	Low temperature hot water (LTHW)		
Cooling	Chilled water (CHW)		Energy efficiency, condensation control
	Refrigeration		
Ventilation	Supply air	Cold air	
		Warm air	Energy efficiency
	Extract / return and exhaust air (where there is heat recovery)		
	Intake air		Condensation control (where applicable, i.e., where condensation risks exist)
Domestic water services	Domestic cold water (DCW)		Frost protection, condensation control, health and safety
	Domestic hot water (DHW)		Energy efficiency, health and safety
Others	Condensate		Condensation control
	Meters, valves, fittings, and accessories (see also Section 2.7.4.5 Meters, Valves, Fittings, and Accessories)		Energy efficiency, health and safety

System type	Services	Functions of required thermal insulation
	Other equipment, such as: • Heat exchangers, domestic hot water storage tanks, thermal buffer vessels and stores, etc.; and • See also Section 2.7.4.6 Other Equipment.	Where applicable – frost protection, condensation control

2.7.4.2 Regulations, Codes, Standards, and Guidance

Insulation shall comply with to the relevant regulations, codes, standards, and guidance, including but are not limited to the following:

- The Construction Products Regulation and Construction Products (Amendment etc.) (EU Exit) Regulations (CPR);
- Building Regulations Approved Documents Part L1 & L2 – Conservation of fuel and power (ADL1 & ADL2);
- Building Regulations Approved Documents Part B1 & B2 – Fire safety (ADB1 & ADB2) – such as for fire and smoke resistance and performance of insulating materials, etc.;
- BS 5422 – Specifying thermal insulating materials for pipes, tanks, vessels, ductwork, and equipment operating from -40°C to +700°C;
- BS 5970 – Code of practice for thermal insulation of pipework, ductwork, associated equipment and other industrial installations from -100°C to +870°C;
- The British Standards listed in Table 31 below for product conformance; and
- Thermal Insulation Manufacturers and Suppliers Association (TIMSA) – Guide for achieving compliance with Part L of the Building Regulations.

Table 31 – British standards for insulation products compliance requirements

Product	British Standards		Example product
	Fire resistance (BS EN 13501-1 [(1)] Class)	Product performance	
Mineral wool	A1 or A2-s1, d0 [(2)]	BS EN 14303 [(4)]	Rockwool or similar
Flexible elastomeric foam	B-s1, d0 [(3)]	BS EN 14304 [(5)]	Closed cell flexible nitrile rubber such as Armaflex Ultima or similar

Phenolic foam		BS EN 14314[6]	Kingspan Kooltherm or similar
Cellular glass	A1	BS EN 14305[7]	Foamglas or similar
Calcium silicate		BS EN 14306[8]	-

Notes:

(1) BS EN 13501-1 – Fire classification of construction products and building elements, classification using data from reaction to fire tests. This standard has replaced the national classifications (e.g., Class 0, 1, etc.) previously used in older versions of ADB1 and ADB2.

(2) Classes A1 is the highest class of fire resistance available. Class A2-s1, d0 means, broadly speaking, non-combustible, low smoke, and no flaming droplets.

(3) Class B1-s1, d0 means, broadly speaking, low flammability, low smoke, and no flaming droplets.

(4) BS EN 14303 – Specification of factory made mineral wool insulation products for building services applications.

(5) BS EN 14304 – Specification of factory made flexible elastomeric foam insulation products for building services applications.

(6) BS EN 14314 – Specification of factory made phenolic foam insulation products for building services applications.

(7) BS EN 14305 – Specification of factory made cellular glass insulation products for building services applications.

(8) BS EN 14306 – Specification of factory made calcium silicate insulation products for building services applications.

2.7.4.3 General Materials and Workmanship

All insulation shall have a smooth, homogeneous symmetrical appearance, the finished surface running true in line with the services layout. All rigid sections shall be concentric and be accurately matched for thickness. Irregular or badly finished surfaces, steps or undulations in surfaces shall not be accepted.

Insulation shall fit tight to the various surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered, or shaped as necessary. Where insulation is applied to vessels or equipment, it shall be neatly cut around name or test pressure plates, inspection covers, etc.

All thermostat pockets, unions, test points, etc. shall be left exposed with insulation tapered neatly at either side or around the perimeter.

All ferrous pipework shall be painted with two coats of “red-oxide” paint prior to applying insulation.

Systems must pass pressure testing before insulation are applied. This shall be demonstrated via sign-off by the project's site supervisor[57] of evidence such as test certificates, witnessing, etc. Refer to Section 2.7.6.2.1 Pressure Testing for pressure testing requirements.

2.7.4.3.1 Vapour Barriers

Where vapour barriers are required for insulation, their integrity shall be thoroughly checked and maintained. Any damage to vapour barriers shall be repaired immediately to manufacturer's recommendations.

Any special finishes to insulated pipework or ductwork shall be applied without compromising the integrity of the vapour barrier.

2.7.4.3.2 Pipe Ends

At the ends of insulated pipework or where any breaks occur in straight runs, e.g., between isolation valves, etc., these shall be fitted with end caps onto neatly cut insulation.

2.7.4.4 Choice Of Materials, Properties, and Thicknesses

Insulation choice of materials, properties, and thicknesses shall be in accordance with:

- Regulations, codes, standards, and guidance described in Section 2.7.4.1 General Requirements above;
- Manufacturer's recommendations; and
- Requirements described in Table 32 and Table 33 below.

57 The project site supervisor role is usually assigned to a ICL appointed consultant or the ICL quality assurance and technical compliance manager, rather than to the ICL engineering and maintenance teams. The project manager is responsible for appropriate appointment of the project site supervisor.

Table 32 – Table of insulation materials and associated finishes

Service	Location	Insulation(1)			Finish(2)			
		Mineral wool	Phenolic foam(3)	Closed cell nitrile rubber	Aluminium foil	Self-finish	Hammered aluminium cladding(4)	VentureClad(5)
LTHW & CHW Condenser water DHW & DCW	Internal concealed	X	X		X			
	Internal exposed to view	X	X		X			
	Plant rooms and tunnels	X	X				X	
	External	X	X					X
MTHW Steam Condensate	Internal concealed	X			X			
	Internal exposed to view	X			X			
	Plant rooms and tunnels	X					X	
	External	X						X
Buried district heat network pipes		Pre-insulated to BS EN 253(6) and 15698-1(7) and associated, corresponding standards for fittings, valves, joints, etc. See Table 26 – Pipework, fittings, and accessories requirements for directly buried district heat network pipes for details.						
Refrigeration pipes	Internal concealed			X		X		
	Internal exposed to view			X		X		
	Plant rooms and tunnels			X		X		
	External			X		X(8)		
Ductwork	Internal concealed	X	X		X			
	Internal exposed to view	X	X		X			
	Plant rooms and tunnels	X	X				X	
	External	X	X					X

Notes:

(1) Insulation shall be one of the following:

Material	Product specification

Phenolic foam	• Pre-formed rigid sections and slabs pipework and ductwork respectively, with factory applied foil face where used internally; and
	• **Not** allowed on:
	  ○ Services with high surface temperatures, e.g., steam, MTHW, etc.; **nor**
	  ○ **Copper / brass pipes, fittings, and accessories** due to risks of formicary corrosion. See BSRIA Topic Guide (TG) 18/2019 – Copper corrosion.

Mineral wool	• Pre-formed rigid sections and slabs for pipework and ductwork respectively, with factory applied foil face where used internally.

Nitirile rubber	• Closed cell flexible nitrile rubber such as Armaflex Ultima or similar.

See Table 31 for fire resistance and product performance requirements.

(2) Finishes shall provide the following protection functions as applicable: vapour barrier, mechanical protection, weather protection (e.g., rain, ultraviolet / UV, etc.), etc. Finishes together with the insulation shall achieve the fire resistance requirements as described in Table 31.

(3) **Not to be applied on copper / brass**, even with passivating silicate solution impregnated into the phenolic foam at foam manufacturing stage.

(4) Hammer-clad type purpose made aluminium cladding for services.

(5) 3M VentureClad 1577CW self-adhesive jacketing system (or equivalent) in silver or black, to be applied throughout and including bends.

(6) BS EN 253 – District heating pipes, bonded single pipe systems for directly buried hot water networks, factory made assembly of steel pipe, polyurethane thermal insulation, and polyethylene casing.

(7) BS EN 15698-1 – District heating pipes, bonded twin pipe systems for directly buried hot water networks, factory made twin pipe assembly of steel pipes, polyurethane thermal insulation, and one polyethylene casing.

(8) Where these are applied to external pipework, they shall be finished with Armaflex Tuffcoat or Arma-Chek Silver for mechanical and UV protection.

Thermal insulation materials shall have a thermal conductivity no greater than 0.04W/mK. Where phenolic foam insulation is specified, thickness is to be minimum of 15mm.

Table 33 below provides general minimum thermal insulation thickness requirements derived primarily from energy efficiency functions. Designers and contractors shall specify insulation thicknesses in accordance with all requirements noted above and per manufacturer's recommendations.

Table 33 – General minimum thermal insulation thickness requirements

Nominal pipe diameter (mm)	Low temperature hot water (LTHW)	Medium temperature hot water (MTHW)	Steam	Chilled water (CHW)	Condensate	Domestic hot water (DHW)	Domestic cold water (DCW)[2]	Heating duct	Cooling or dual-purpose duct
	Minimum thermal insulation thickness (mm)[1]								
≤10	30	30	40	25	30	35	30	-	-
≤15	35	35	40	25	30	35	30	-	-
≤25	40	50	50	25	30	40	30	-	-
≤32	45	50	50	30	35	40	35	-	-
≤40	45	55	60	30	40	40	40	-	-
≤80	50	65	70	50	50	45	50	-	-
≤100	55	65	80	50	50	45	50	-	-
≤150	55	70	85	50	55	45	55	-	-
≤200	55	75	90	50	60	45	60	-	-
>200	55	75	95	50	75	50	75	-	-
Flat surfaces (e.g., ducts, etc.)	-	-	-	-	-	-	-	35	60

Notes:

(1) Minimum insulation thickness requirements based on:

- Thermal conductivity of insulation at 0.04m/K;
- Low emissivity (0.05) faced insulation; and
- The following respective conditions:

Service	Average temperature of service	Ambient conditions	Source of reference for insulation thicknesses
LTHW	≤95°C	15°C	Table 4.4 in Building Regulations Approved Document Part L2 – Conservation of fuel and power, buildings other than dwellings (ADL2) and Section 6.2.2, low temperature heating service in TIMSA – Guide for achieving compliance with Part L of the Building Regulations (TIMSA guide).
MTHW	≤120°C	15°C	Section 6.2.2, medium temperature heating service in TIMSA guide.
Steam	Approximately ≤184°C (saturated steam at 10bar gauge pressure)	15°C	Section 6.2.2, high temperature heating service in TIMSA guide.
CHW	10°C	25°C	Section 6.2.3, water temperature of 10°C in TIMSA guide.
Condensate	5°C	25°C / 80% RH	Section 7.2, low emissivity table in TIMSA guide.
DHW	60°C	15°C	Table 4.5 in ADL2 and Section 6.2.1 in TIMSA guide.
DCW	5°C	25°C / 80% RH	Section 7.2, low emissivity table in TIMSA guide.
Heating duct	35°C horizontal duct	15°C	Table 4.6 in ADL2 and Section 6.2.4 in TIMSA guide.
Cooling or dual-purpose duct	13°C horizontal duct	25°C	Table 4.6 in ADL2 and Section 6.2.5 in TIMSA guide.

(2) For condensation control. Refer to TIMSA guide for thicknesses required for frost protection in applicable locations.

2.7.4.5 Meters, Valves, Fittings, and Accessories

Meters, valves, fittings, and accessories shall be covered with insulated jackets. The jackets shall be secured with strings and / or Velcro fasteners for easy removal.

2.7.4.6 Other Equipment

Equipment, such as heat exchangers, domestic hot water storage tanks, thermal buffer vessels and stores, etc., shall be provided with:

- Factory applied thermal insulation to comply with requirements noted above; and
- Appropriate finish to offer vapour barrier, mechanical protection, weather protection, etc.

Access panels / covers, removable insulation modules, or other similar methods shall be built-in with the factory applied thermal insulation and finish to enable maintenance access. Removable items, such as valves, gauges, inspection panels / covers, small plate heat exchangers (e.g., those as part of the domestic hot water generator as described in Section 2.5.3.1 Domestic Hot Water Storage and Plate Heat Exchangers, etc.), and others, shall be provided with insulated jackets similar to those in Section 2.7.4.5 Meters, Valves, Fittings, and Accessories.

2.7.5 Plant Identification

2.7.5.1 Asset Management Process

Designers and contractors shall comply the College asset management process, which can be found here (https://www.imperial.ac.uk/estates-facilities/buildings/procedures/assets/), and shall engage with Imperial College London maintenance and customer service centre (CSC) beginning at RIBA Stage 2 Concept design.

2.7.5.2 Plant Identification Requirements

In accordance with the asset management process described in Section 2.7.5.1 above, all new plant and equipment shall be adequately labelled providing the correct identification information.

All major items of plant and equipment shall be provided with Traffolyte type description labels with black characters on a white background. The labels shall be attached to plant using self-tapping screws or with adhesive.

Where plant has two parts, i.e., split type direct expansion air conditioning, then both ends of the system shall be labelled. Each label shall reference the location of the other part of the system.

2.7.5.3 Asset Tags

Asset codes and asset database management, for example addition, removal, or amendment, shall be in accordance with the asset management process described in Section 2.7.5.1 above.

The asset tag shall be a Traffolyte type label with white characters on a green background and shall be attached to the plant / equipment using screws, adhesive, or short chain as appropriate depending on the type of equipment.

2.7.5.4 Plant and Equipment to be Labelled

The type of plant and equipment items to be provided with Traffolyte type identification labels and asset tags are listed below (this list is not exhaustive).

Table 34 – Indicative list of HVAC waterside plant and equipment to be physically labelled

Categories	Items
Common to heating and cooling	Thermal buffer vessels and thermal storage tanks (including domestic hot water storage tanks)
	Control and commissioning valves
	Direct expansion systems(1)
	Heat exchangers(2)
	Heat pumps
	Pressurisation units
	Pumps
	Terminal units(3)
	Water treatment units(4)
Cooling	Heat rejection plant(5)
Heating	Boilers
	Combined heat and power (CHP) plant

Notes:

(1) Split systems, variable refrigerant flow (VRV), etc.
(2) Of various fluids / media and types
(3) Variable and constant air volume devices, terminal reheaters and coolers, FCUs, chilled beams, etc.
(4) Side stream filtration, automatic water quality control like deionisers, etc.
(5) Dry air coolers, evaporative coolers / cooling towers, chillers, etc.

Table 35 – Indicative list of airside plant and equipment to be physically labelled

Categories	Items
Main plant	Air handling units (AHUs)
	Fans[(1)]
Accessories	Attenuators
	Fire safety related and motorised dampers[(2)]
Terminal units	Chilled beams
	Fan coil units
	Terminal reheaters and coolers
	Variable and constant air volume devices[(3)]
User equipment	Fume cupboards
	Microbiological safety cabinets

Notes:

(1) The functions of the fans shall be stated on the labels, using the following formats. Where fans have dual functions, the format is [normal function / alternate function], e.g., EF01 / SEF01. This applies to AHUs as well.

Fan types	Abbreviations
Extract fan	EF – normal extract fan, FEF – fume extract fan, KEF – kitchen extract fan, SEF – smoke extract fan, TEF – toilet extract fan, etc.
Supply fan	MAF – make-up air fan (for smoke extract fans, etc.), SF – normal supply air fan, SPF - staircase pressurisation fan, etc.

(2) Such as fire dampers (FDs), motorised fire dampers (MFDs), motorised fire and smoke dampers (MFSDs), smoke control dampers (SCDs), motorised control dampers (MDs), etc.
(3) Such as variable air volume (VAV) box, constant air volume (CAV) box, etc.

Table 36 – Indicative list of plumbing and drainage plant and equipment to be physically labelled

Categories	Items
Common to plumbing and drainage	Pumps[(1)]
Plumbing	Buffer or pressure vessels
	Calorifiers

	Tanks(2)
Drainage	Grease traps

Notes:

(1) The functions of the pumps shall be stated on the labels, using the following formats:

Service	Abbreviations
Plumbing	DCWP – domestic cold water pump, DHWP – domestic hot water pump, PWP – process water pump, etc.
Drainage	***Pumped drainage only permitted if demonstrated not possible via gravity*** CP - condensate pump, FWP – foul water pump, RWP - Rainwater pump, etc.

(2) Such as potable water tank, CAT 5 break tank, laboratory water supply tank, etc.

Where items of equipment are concealed in ceiling voids, such as FCUs, etc., labels shall be located on the underside of units so that they are easily visible when ceiling tiles or access panels are removed. Additional labels shall also be added to the underside of ceiling grid, where acceptable, to indicate the equipment's location inside the voids.

2.7.5.5 Ductwork, Pipework, and Accessories

All services, irrespective of whether insulated or not, shall be provided with colour coded identification indicating service, size, and direction of flow.

Service identifiers shall be included at junctions, at both sides of each valve / damper and wall penetration, and at any other place where identification is necessary. The service identifiers shall be readily visible in every section or compartment (e.g., between floor joist sections, etc.). Where services are concealed, service identifiers shall be located at regular intervals of not more than 0.5m.

Where services identifiers are applied to external pipework and / or ductwork, the system shall incorporate ultraviolet (UV) protection.

Ductwork shall be identified in accordance with industry standards. Refer to Building Engineering Services Association (BESA) DW144 – Specification for sheet metal ductwork, 1st edition, Appendix B, and corresponding standards.

Pipework shall be identified in accordance with BS 1710 – Specification for identification of pipelines and services, with painting, adhesive colour bands or labels, or applied during manufacture, whichever most appropriate for the application.

All pipeline valves, commissioning sets, etc. shall be labelled with disc type Traffolyte labels using an appropriate numbering system. The valve labels shall correspond to the as-built system schematic (complete with valves chart), which shall be laminated or framed, and located in the associated plant room.

2.7.5.6 Required Level of Labelling Information

Plant description labels shall provide the appropriate information to enable quick identification.

The required level of information is shown below:

- Asset description, i.e., **CHILLER, BOILER No 1**, etc.;
- Description of where the plant serves, e.g., **LEVEL 2 NORTH ZONE, ROOMS 240 – 250**, etc.; and
- Function of the plant, e.g., **PRIMARY CHW**, **SECONDARY VT or CT LTHW**, **POTABLE WATER SUPPLY**, **CAT 5 WATER SUPPLY**, etc.

2.7.6 Testing and Commissioning

The CIBSE Commissioning Codes define testing and commissioning (T&C) as:

- "The advancement of an installation from the state of static completion to full working order to specified requirements. It includes the setting to work of an installation, the recording of set values and performance for future reference, and the regulation of the system."

For installed systems to work as intended, they need to be checked and set up to produce the design outputs. This is achieved through T&C, and the values obtained will demonstrate the capacities delivered (e.g., amount of ventilation, heating, cooling, etc.) to the various spaces are compliant.

To make certain systems are correctly commissioned and set to work, adequate time must be allowed in the construction programme, per the designers' and contractors' commissioning plans (see Section 2.7.6.3 Commissioning Plan).

Project managers, designers, and contractors shall comply with the following to ensure successful completion of T&C activities:

- Relevant regulations, such as the Building Regulations Approved Documents Part L1 & L2 – Conservation of fuel and power;
- British and industry standards, such as CIBSE Commissioning Codes, etc.;
- Requirements in this section of the BESPR; and
- Any other relevant regulations, standards, and guidance.

2.7.6.1 Soft Landings

The decision on whether and the extent of which to adopt Soft Landings (as in the BSRIA Soft Landings per BSRIA BG 54/2018 – Soft Landings framework or Government Soft Landings frameworks per UK BIM Framework – Government Soft Landings) for the project shall be investigated and evaluated:

- From early design stages (e.g., RIBA Stage 0 Strategic definition or Stage 1 Preparation and briefing); and
- In conjunction with whether and which sustainability appraisal framework to implement (e.g., BREEAM, etc.)

Soft Landings
Soft Landings is designed to help project teams **focus** more on the **client's needs throughout the project**, **smooth transition into use**, and **address issues often found post-occupancy** (see also Section 2.7.6.5 Building Performance Evaluation / BPEs). It is designed to prevent tensions and frustrations during initial occupancy, which can leave residual (and possibly persisting) problems. Soft Landings can be used for new construction, refurbishment, and alteration, and can be adopted for all projects irrespective of their types and sizes. Soft Landings ensures **operational performance driven targets and outcomes** are part of the project **success criteria** at **each stage as the project evolves**. It requires the design and construction teams to remain involved beyond practical completion (e.g., on longer-term monitoring, review, POE, feedback, etc.). This requirement has benefits for all parties as it: • Helps client ultimately get what they asked for;

Soft Landings

- Shows designers and contractors how their solutions work in practice; and
- Provides a valuable route to capture lessons learned for future projects.

In short, by introducing **Soft Landings** to a construction project, the **focus** is on **delivering an outcome** that will **align with requirements, improve operational readiness,** and **provide best performance in use and asset value**. Above all, **Soft Landings is a way to deliver better buildings**.

Soft Landings is complementary to existing processes, highlighting existing activities which can be used to ensure that the College's success criteria are kept in focus and achieved.

At its core, Soft Landings is a greater collaboration of designers and contractors with Imperial College London's project, engineering, maintenance, and operational teams and end users from design, construction, and before, during and after handover of building works.

The principles of Soft Landings are enabled through six Phases of activities running throughout the project and into operation.

Soft Landings
Refer to BSRIA BG 54/2018 – Soft Landings framework and the related series of guidance[58], and UK BIM Framework – Government Soft Landings for details.

2.7.6.2 Pre-commissioning Activities

Before commissioning for mechanical systems begin, a range of pre-commissioning activities shall be carried out:

- Check installation against drawings (and / or models) and records;
- Pressure testing; and
- Flushing / cleaning.

The contractor and commissioning engineer shall check that the mechanical system installations are per the RIBA Stage 5 Manufacturing and construction design, or, in the case of re-commissioning of existing systems, the as-built records. Any differences shall be recorded, with associated drawings (and / or models) and documents updated accordingly.

2.7.6.2.1 Pressure Testing

The systems shall be pressure tested in accordance with the following (but are not limited to):

- For ductwork, BESA DW144 – Specification for sheet metal ductwork, BESA DW143 – Guide to good practice for ductwork air leakage test, and other corresponding BESA standards;
- For pipework (other than drainage systems), BESA TR6 – Guide to good practice for site pressure testing of pipework; and
- For drainage systems,
  - Building Regulations Approved Document Part H – Drainage and waste disposal,
  - BS EN 12056 – Gravity drainage systems inside buildings,

58 BSRIA BG 38/2018 – Soft Landings core principles, BG 45/2014 – How to procure Soft Landings, BG 74/2019 – Success criteria for Soft Landings projects, BG 76/2019 – Soft Landings and design for performance, BG 77/2019 – Soft Landings case studies 2019, BG 81/2022 – Soft Landings for fit-outs, and others.

- BS EN 752 – Drain and sewer systems outside buildings, and
- BS EN 1610 – Construction and testing of drains and sewers.

Table 2: Test procedures applicable to different system types

System Type	Test	Comments
Hot and cold water supply pipes in buildings, LPHW, MPHW, HPHW heating systems, steam systems, chilled water systems and condenser water systems.	Hydraulic pressure test with water as described in Section 5.0	Pneumatic leak test first when there is a risk of damage to surroundings.
Cold water supply mains	Hydraulic pressure test with water to requirements of local water supply provider.	Main considerations described in Section 4.26
Sprinkler water systems	Pneumatic leak test followed by hydraulic pressure test as described in Section 6.0.	In accordance with LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845
Condense and Overflow Systems	As per Section 5.0	Testing in accordance with BS EN 12056-2: 2000
Thermal liquids pipelines and fuel oil mains.	Hydraulic pressure test as described in Section 5.0 using water or the thermal liquid as the test medium.	Need to implement precautions regarding water borne bacteria for diesel fuel oil, biofuels and organic solar thermal heat transfer fluids.
Natural gas	Pneumatic leak test followed by pneumatic pressure test as described in Section 7.0	In accordance with IGEM: UP1 and UP1A BS EN 1775
Compressed air	Pneumatic leak test followed by pneumatic pressure test as described in Section 7.0	Hydraulic pressure testing may be an option if pipework can be dried straight afterwards using hot air. See BCGA publications

Figure 11 - Excerpt from BESA TR6 on test procedures applicable to different pipework systems

2.7.6.2.2 Flushing / Cleaning

Ductwork cleanliness shall be maintained to the designer's specified levels in accordance with BESA TR19 – Internal cleanliness of ventilation systems, for example (in terms of):

- Dust accumulation levels / cleanliness quality class;
- Protection, delivery, and installation (PDI) level;
- Microbiological contamination, etc.

Flushing and cleaning of pipework systems prior to commissioning shall be in accordance with the following (but are not limited to):

- For heating and cooling systems, BSRIA BG 29/2021 – Pre-commissioning cleaning of pipework systems;
- For domestic cold and hot water systems (refer also to Section 2.5 Plumbing services above);
  - PD 855468 – Guide to flushing and disinfection of services supplying water for domestic use within buildings;
  - BS 8558 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings; and
  - BS 8554 – Code of practice for sampling and monitoring of hot and cold water services in buildings; and
- For specialist gas services systems (refer also to Section 2.5.6 Specialist Gas Services above);
  - British Compressed Gases Association (BCGA) Code of Practice (CP): BCGA CP4 – Gas supply and distribution systems (excluding acetylene); and
  - HTM 02-01– Medical gas pipeline systems.

2.7.6.3 Commissioning Plan

The designers and contractors shall prepare a project commissioning plan in accordance with:

- BSRIA BG 11/2010 – Commissioning job book;
- CIBSE Commissioning Code M – Commissioning management; and
- BSRIA BG 8/2009 – Model commissioning plan.

The commissioning plan shall comprise of the following stages / activities:

- Preparation;
- Design;
- Pre-construction;
- Construction;
- Commissioning of engineering services;

- Pre-handover;
- Initial occupation; and
- Post-occupancy aftercare.

For each project, designers and contractors shall consider the project's scale and complexities, and propose an appropriate commissioning plan for implementation. The designers and contractors shall:

- Propose and agree with Imperial College London the relevant deliverables and requirements at each of the commissioning stage above; and
- Demonstrate compliance via documented evidence, which shall be provided to Imperial College London.

2.7.6.4 Testing and Commissioning Requirements

Mechanical systems shall be tested and commissioned in accordance with:

- Building Regulations Approved Documents Part L1 & L2 – Conservation of fuel and power (ADL1 & ADL2);
- The design specifications; and
- The following (and any other relevant) regulations, codes, standards, and guidance for the corresponding elements (see sub-sections below).

All commissioned values, such as valve and damper settings, flow rates, etc., shall be recorded both on the handover information (e.g., operations and maintenance manual / OMM, record drawings and / or models, etc.) and the physical devices.

2.7.6.4.1 Ventilation

- Building Regulations Approved Documents Part F1 & F2 (ADF1 & ADF2) – Ventilation;
- CIBSE Commissioning Code A – Air distribution system;
- BSRIA BG 49/2015 – Commissioning air systems;
- BSRIA BG 46/2022 – Guide to measuring air flow rates for domestic ventilation systems;
- Other relevant documents appropriate for the project. For instance,

- On **gas combustion plant** ≤70kW and between 70kW to 1.8MW, and CHP plant, see Section 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant above.
- For **fume cupboards (FCs)**, Imperial College London - Code of practice (CoP) for selection, installation, use, maintenance and decommissioning of fume cupboards (FCs) and BS EN 14175 – Fume cupboards;
- For **microbiological safety cabinets (MSCs)**, Imperial College London - Code of practice (CoP) for selection, use and maintenance of microbiological safety cabinets (MSCs), BS 5726 – Recommendations and guidance on information exchange, siting, and use of microbiological safety cabinets (MSCs), and BS EN 12469 – Performance criteria for microbiological safety cabinets (MSCs);
- For **healthcare premises**, corresponding NHS or DoH guides, standards, and requirements such as HTM 03-01 – Specialised ventilation for healthcare premises;
- Others such as BSRIA BG 47/2013 – Designing and constructing for Airtightness, BSRIA BTS 3/2018 – Air Permeability testing of isolation facilities, BSRIA BG 65/2016 – Floor plenum airtightness;
- Etc.

2.7.6.4.2 Heating and Cooling

Overall

- CIBSE Commissioning Code R – Refrigerating systems;
- CIBSE Commissioning Code W – Water distribution systems;
- BSRIA BG 2/2010 – Commissioning water systems; and
- Refer also to Section 2.3.1 Main Plants for corresponding sub-section(s).

Heating

- See Section 2.3.1 Main Plants for corresponding sub-section(s), for example on Section 2.3.1.1 Heat Networks, 2.3.1.3 Heat Pumps and Chillers, 2.3.1.4 Boilers and Combined Heat and Power (CHP) Plant, etc.; and
- CIBSE Commissioning Code B – Boilers.

Cooling

- See Section 2.3.1 Main Plants for corresponding sub-section(s), for example on Section 2.3.1.2 Heat Source and Rejection, 2.3.1.3 Heat Pumps and Chillers, etc.

2.7.6.4.3 Plumbing and Drainage

Plumbing services

- The Water Supply (Water Fittings) Regulations 1999;
- Building Regulations Approved Document Part G – Sanitation, hot water safety and water efficiency;
- BS 8558 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings;
- BS EN 806 – Specifications for installations inside buildings conveying water for human consumption;
- PD 855468 – Guide to flushing and disinfection of services supplying water for domestic use within buildings;
- BS 8554 – Code of practice for sampling and monitoring of hot and cold water services in buildings;
- BS 5918 – Code of practice for design and installation of solar heating systems for domestic hot water (where appliable);
- CIBSE Guide G – Public health and plumbing engineering; and
- See also Sections 2.5.1 System Design and Provisions to 2.5.5 Cold and Hot Water Services in Laboratories above.

Drainage services

- Building Regulations Approved Document Part H – Drainage and waste disposal;
- BS EN 12056 – Gravity drainage systems inside buildings;
- BS EN 752 – Drain and sewer systems outside buildings;
- BS EN 1610 – Construction and testing of drains and sewers
- BS 8515 – Rainwater harvesting system code of practice (where applicable);
- BS 8525 – Greywater systems code of practice (where appliable);

- CIBSE Guide G – Public health and plumbing Engineering; and
- See also Sections 2.6 Drainageabove.

2.7.6.4.4 Specialist Gas Services

See Section 2.5.6 Specialist Gas Services.

2.7.6.5 Building Performance Evaluation

Building performance evaluation (BPE) is the process of assessing how a building performs, and can be carried out on both new and existing buildings. The scope of BPE will vary depending on the depth of the evaluation undertaken and is influenced by the building or project size, complexity, construction stage, time, access, and budget constraints.

A range of metrics can be evaluated, such as building fabric, building services and operating strategies, energy use, handover and commissioning processes, occupant satisfaction and comfort conditions, specialist standards like BS EN 12128 biological research laboratories containment levels, Medicines and Healthcare products Regulatory Agency (MHRA) GxP (e.g., good laboratory practice, etc.) criteria, etc.

The outcomes from BPE have the potential to:

- Reduce running costs and operational carbon emissions;
- Maximise asset investment by ensuring optimum performance;
- Optimise occupants' satisfaction and perceived productivity; and
- Provide feedback to inform future developments.

BPEs shall be carried out in accordance with the following and other relevant industry guidance.

Table 37 – Industry guidance for building performance evaluations

Types of building	Industry guidance
Non-domestic buildings	BSRIA BG 63/2015 – Building performance evaluation in non-domestic buildings
Domestic buildings	BSRIA BG 64/2016 – Building performance evaluation in domestic buildings
Specialist spaces	See Table 3 – Internal design conditions for different room types and discuss with Imperial College London team.

Where there are new buildings or extensive refurbishments, BPEs shall be incorporated as part of the deliverables. Extent of BPEs for the project shall be evaluated and agreed with Imperial College London:

- From early design stages (e.g., RIBA Stage 1 Preparation and briefing or Stage 2 Concept design); and
- In conjunction with discussions on Soft Landings and sustainability appraisal framework adoption. See Section 2.7.6 Testing and Commissioning.
    - Where Soft Landings is adopted, BPEs will be part of the Soft Landings requirements.

Criteria for determining extent of BPEs can include:

- Size and type of building and / or project;
- Age of the building (e.g., when building was initially built and commissioned, when was its last major refurbishment, when was the last check / re-commissioning exercise);
- Energy use and operating cost of the project area –
    - Against benchmarks, such as those in Table 38 below;
    - As a proportion of total annual energy use in Imperial College London;
- Levels and complexities of building services present;
- User satisfaction, such as number and nature of maintenance tickets, user reports (see also Section 2.7.6.5.1 Post-occupancy Evaluation (POE) below), and maintenance team's observations.

Table 38 – Examples of energy use benchmarks in the industry

Item	Benchmark	Weblink	Notes
1	CIBSE Guide F - Energy efficiency in buildings	-	-
2	CIBSE's online Energy Benchmarking Dashboard	https://www.cibse.org/knowledge-research/knowledge-resources/knowledge-toolbox/energy-benchmarking-tool	Consolidates and summarises benchmarks from CIBSE Guide F, energy performance certificates (EPCs), display energy certificates (DECs), etc.
3	RIBA's and CIBSE's CarbonBuzz platform	https://www.carbonbuzz.org/	Reported actual (rather than design) energy data, shared by industry.
4	Sector specific tools, such as International Institute for Sustainable Laboratories (I2SL) / Labs21's Laboratory Benchmarking Tool, etc.	https://lbt.i2sl.org/	One of the best sources currently available for laboratories sector. Data are focused on buildings in USA.
5	Association for Environment Conscious Building (AECB)'s Low Energy Building Database	https://www.lowenergybuildings.org.uk/	Focusses on Passivhaus or AECB standard certified buildings.
6	Mayor of London – Energy assessment guidance, Table 4 Energy use intensity and space heating demand values	-	Provides target energy use intensity (EUI) and space heating demand as kWh/m²/year for residential, school, office, hotel, and others. Targets are for buildings aiming to achieve net zero operational carbon.
7	Greater London Authority (GLA)'s London Building Stock Model	https://maps.london.gov.uk/lbsm-map/	Colour coded map of London's building stock by EPCs and DECs data.
8	Department for Levelling Up, Housing and Communities (DLUHC)'s open data on energy performance certificates (EPCs) and display energy certificates (DECs)	https://epc.opendatacommunities.org/	Full dataset for all UK buildings. Selected summaries of these data have been included in the CIBSE Energy Benchmarking Dashboard mentioned in item 2 in this table.

2.7.6.5.1 Post-occupancy Evaluation (POE)

A particular type of BPE that can be conducted is known as post-occupancy evaluation (POE), which constitutes activities of the BPE process once the building is occupied and in use, focusing on operational performance and building occupants.

There are a number of ways to carry out POEs, such as:

- Indoor environment monitoring, e.g., CO_2, temperature, etc.; and
- Where applicable, in a more structured way covering occupant satisfaction (e.g., survey questionnaires, interview, workshops, etc.), indoor environmental quality (IEQ), and operational performance.
  - This is ideally done at a minimum of one year after building occupation to cover at least one seasonal cycle;
  - There are a number of industry standard methods to carry this out, such as The Usable Buildings Trust's BUS Methodology, Building Research Establishment (BRE)'s Design Quality Method (DQM), method defined in the International WELL Building Institute (IWBI)'s WELL Building Standard, British Council for Offices (BCO)'s guide to POE, etc.; and
  - Consult the Imperial College London estates Engineering, Energy and Environment Team for further information and guidance.

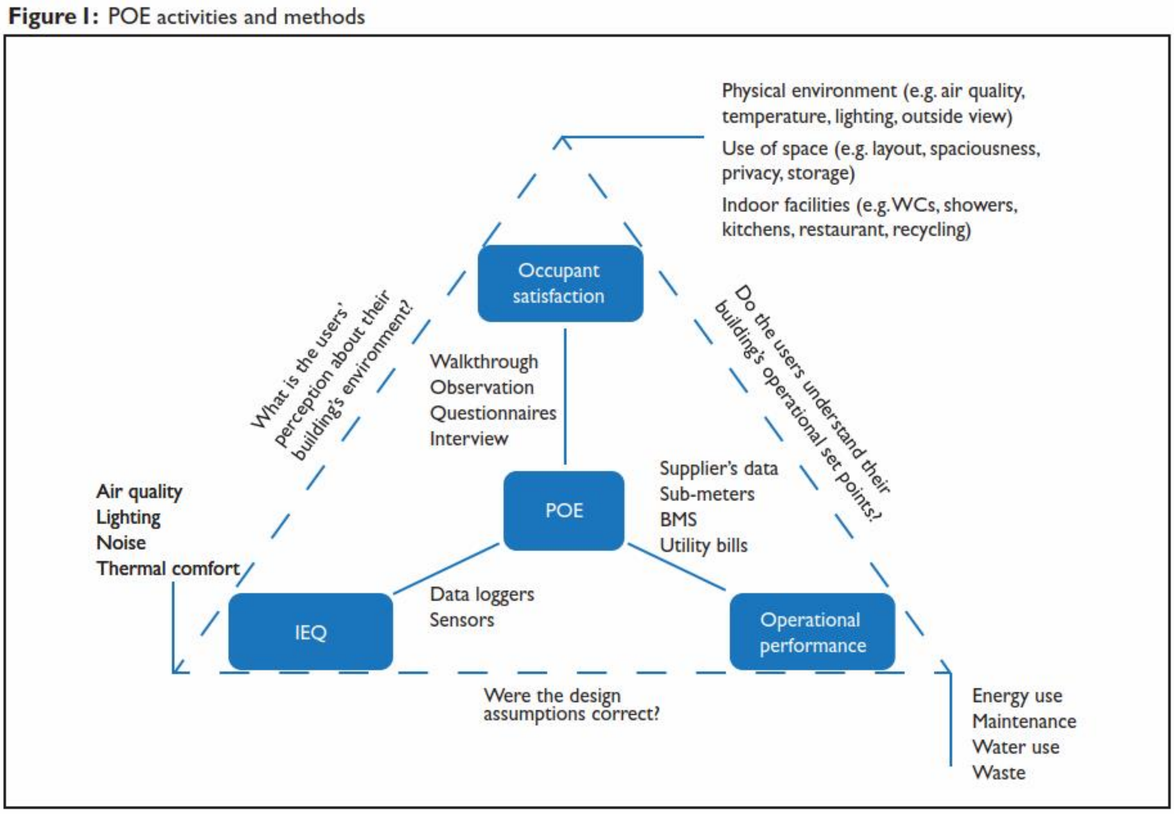

Figure 12 – A more structured way to carry out POEs, where applicable (Source: BSRIA BG 63/2015)

2.7.6.6 Seasonal Commissioning

Seasonal commissioning is the performance evaluation of a project or building and its engineering services under full load conditions during peak heating and cooling seasons, as well as part-load conditions in spring and autumn.

Seasonal commissioning recognises that:

- Some aspects of the systems need to be commissioned when external temperatures and indoor occupancy patterns are close to peak design conditions; and
- Systems are typically designed to operate correctly at full load conditions, and the plant and equipment is selected accordingly. However, for the majority of the time, most systems are operating at part load, and it is important to establish that they operate correctly at these conditions.

Refer to BSRIA BG 44/2013 – Seasonal commissioning for further information.

Seasonal commissioning can improve the project's or building's performance in the following manners (via system tuning during different seasons and loads):

- Ensures design brief and client's / occupant's requirements are met;
- Reduces running costs and operational carbon emissions;
- Maximises asset investment by ensuring optimum performance;
- Optimises occupants' satisfaction and perceived productivity; and
- Provides feedback to inform future developments.

The decision on whether to adopt seasonal commissioning for the project shall be investigated and evaluated from early stages, similar to or in conjunction with that for 2.7.6.1 Soft Landings and 2.7.6.5 Building Performance Evaluation.

Criteria for evaluating whether seasonal commissioning is warranted are similar to those described for determining the extent of a BPE in Section 2.7.6.5 Building Performance Evaluation, such as the project's or building's size and type, age, energy use and operating cost, levels and complexities of building services, etc.

Where Soft Landings is adopted for the project, BPEs will be part of the Soft Landings requirements. Through the process of determining the extent of BPEs for project, this will govern whether seasonal commissioning is to be adopted.

Where seasonal commissioning is adopted, this shall be carried out in accordance with BSRIA BG 44/2013 – Seasonal commissioning.

2.7.6.7 Continuous Commissioning

Continuous commissioning is the checking, adjustment and fine tuning of equipment, services, and systems to ensure they are kept working at optimum performance throughout their lives.

This is necessary for one or more of the following reasons:

- Statutory compliance, for example with fume cupboards safety, etc.;
- As part of planned and preventative maintenance because system performance may deteriorate over time;
- For providing evidence on established service level agreements;

- Evolving performance requirements of a building, for example, as a result of increasing or decreasing occupant density, changing occupancy patterns, system addition, deletion or reconfiguration; and
- Others.

In addition to some of the benefits already described in Section 2.7.6.6 Seasonal Commissioning (such as costs and carbon reductions, asset value maximisation, and ongoing occupants' satisfaction), continuous commissioning can:

- Reduce maintenance cost in long run; and
- Reduce barriers to refurbishment of spaces and buildings when the needs arise.

Continuous commissioning activities are carried out throughout the life of the building and not just for the period immediately after the construction as is the case with seasonal commissioning.

The extent of a continuous commissioning exercise shall be determined using the same criteria described in Section 2.7.6.5 Building Performance Evaluation, such as the project's or building's size and type, age, energy use and operating cost, levels and complexities of building services, etc.

Where a building performance evaluation (BPE) was completed, it will be a useful reference point.

As a minimum, a continuous commissioning exercise shall:

- Identity original record drawings and / or models as well as the systems' design and initially commissioned performance values;
- Provide updated drawings and / or models as well as current equipment and / or system performance information based on the above; and
- Where applicable, provide recommendations on resetting the systems to original values.

2.7.6.7.1 Continuous Commissioning Information at Projects Handover

Continuous commissioning recommendations shall be provided to Imperial College London engineering and maintenance teams at projects handover as part of the handover information (e.g., operations and maintenance manual / OMM, record drawings and / or models, etc.).

The recommendations shall enable activities described in 2.7.6.7 Continuous Commissioning to be carried out, and, as a minimum, shall include:

- The intervals at which each sub-system is to be re-commissioned, such as –
    - Annual testing for fume cupboard ventilation;
    - General ventilation to be re-commissioned every x years;
    - Etc.

3 Automatic Fire Alarm Systems

3.1 General

The aim of this section is to provide specific guidance on fire safety in the design of new installations and alterations/amendments to existing fire system for all Imperial College London premises. While not intended to cover every possible scenario, the standards and principles it advocates recognise that fire safety in Imperial College London premises is dependent on the interaction between physical fire precautions, dependency of the College building occupants, fire hazards, and the availability of sufficient and appropriately trained personnel to safely evacuate staff and students in a fire emergency.

This guidance is applicable to all Imperial College London Premises.

System design, installation, commissioning and maintenance must be carried out in accordance with current BS5839 Pt1 guidance, Building Regulations and Imperial College Particular Requirements set out in the following information.

3.2 Fire Alarm - Levels of automatic detection

BS 5839 Part 1 defines levels of automatic detection for "the protection of life" using categories L1, L2, L3, L4 & L5.

The following category is to be applied to all academic buildings with the approval of the Fire Safety Office. **Category L4.**

The following category is to be applied to all residential buildings with the approval of the Fire Safety Office. **Category L2.**

Notes

Prior to commencing the design of a fire alarm installation, the design concept shall be agreed with the College Fire Safety Office. This may lead to the application of an enhanced level of protection "designed to satisfy a specific fire safety objective" which exceeds the requirements and/or application of an L4 category for academic buildings or L2 category for residential building. A Fire Risk Assessment must also be submitted to ensure effective fire protection is provided.

The Fire Safety Office and Fire and Security Engineer (on behalf of the Head of Engineering, Energy and Environment) is to be consulted regarding the signalling required for all new control and indicating equipment.

Fire Alarm System contractors are to be LPS1014 certified.

3.3 Control and Indicating Equipment (CIE)

CIE to be EN54-2 Certified.

Analogue Addressable Panels shall be selected from the **Advanced MxPro 5** range, with the capacity to connect a minimum of four loop cards.

Device protocol Apollo **'XP95'**.

A diagrammatic representation of the premises (zone plan) is required at specific CIE locations. For clarification please contact the College Fire and Security Engineer.

CIE repeater panel type is to be agreed with the Fire Safety Office and Fire and Security Engineer.

CIE system networks are to be **fault tolerant**.

CIE nodes are to be deployed following a **distributed network** principle.

All CIE nodes must have their own display card connected.

CIE nodes must have a lockable Perspex (Lexan) door preventing unauthorised access to the panel keypad, the keys for each lockable cover are to be uniquely suite and will be managed by the College Fire Safety Office.

3.4 Conventional Systems

The specifications of a conventional fire alarm system must be approved by the Imperial College London Fire and Security Engineer.

For clarification please contact the College Fire and Security Engineer.

3.5 Fire System Cabling

Designing in flexibility should be paramount when considering fire cable infrastructure, College building's change over time in a dynamic way, and the ability to keep segments of a buildings fire system operational from areas under construction is key to building operations. Where practical, the systems design should include a loop configuration that allows easy isolation of segments of a building from the rest of the system during future refurbishment projects.

- A Landlord/Tennant principle should be followed;
- Cables to be specified to meet the application e.g., standard/enhanced;
- Terminals to have similar fire resistance to the cable;
- Fire cabling to be segregated from other service cabling and provided dedicated containment; and
- Fire cabling to be colour coded red.

For guidance please contact the College Fire and Security Engineer.

3.6 Power Supply Unit (PSU)

Power supplies to be EN54-4 certified.

Integrated CIE PSU and battery chargers are to be selected from the Advanced product range. Valve regulated lead acid batteries are to be selected from the Power Sonic/Yuasa product range, labels should be fixed to all batteries indicating their date of installation. The capacity of the battery should be sufficient to maintain the system in normal operation for a minimum of 24hours, after which sufficient capacity should remain to operate the system in full fire condition for a minimum of 30 min.

In specific applications the ability to maintain the system in normal operation may be increased or decreased, when this is a design consideration, notification and approval from the Fire Safety Office will be required.

In circumstances when PSUs are deployed in a separate enclosure to the fire system CIE, this enclosure is to be mounted adjacent the CIE position and must include a remote battery temperature sensor.

3.7 Devices for use in Analogue Addressable Systems

3.7.1 Point Type Detectors

Point detectors must be EN54 certified and suited for environmental conditions they will be deployed into.

3.7.1.1 Heat Detectors

Heat detectors to be chosen from the Apollo Soteria range.

3.7.1.2 Optical Smoke Detectors

Smoke detectors are to be chosen from the Apollo Soteria range.

3.7.1.3 Multi-sensor Detectors

Multi-sensor detectors to be chosen from the Apollo Soteria range.

3.7.1.4 Flame Detectors

Type to be agreed with the Imperial College London Fire and Security Engineer.

3.7.1.5 Carbon Monoxide Detectors

Type to be agreed with the Imperial College London Fire and Security Engineer.

3.7.1.6 Remote Indicators

Remote indicators will be required for ceiling void detectors at all times and must be chosen from the Apollo Fire range of devices.

Notes

Fire signal filtering will be applied to fire activations from automatic point detectors for the control of false alarms and unwanted fire signals, to achieve this, automatic point detectors will be put on “silent sounders.”

There will be a set delay on the activation of system sounders to allow for alarm verification before a full audible evacuation is signalled.

An activation of a second point detector (coincidence detection) or manual call point will result in the in delay timer being overridden.

For guidance please contact the College Fire and Security Engineer.

Point detection must not to be installed in locations that prevent ongoing maintenance for weekly or periodic testing, an alternative method of detection should be deployed in this scenario.

For clarification please contact the College Fire and Security Engineer.

All devices (including remote indicators) are to be labelled as follows, Node** Loop** Device*** e.g. 1.02.004.

3.7.2 Manual Call Points (MCP)

Manual Call Points to be BS EN 54-11 certified.

Manual call points shall be Type A and selected from the Apollo XP 95 range complete with clear plastic cover.

Notes

In certain applications an additional method of protection against the unwanted activation of a MCP may be required e.g. MCP sited adjacent a door to the open air. In this instance the clear plastic cover is to be replaced by a locally powered alarm cover with internal sounder.

Locally powered alarm covers must be selected from the STI Stopper range**.**

For guidance please contact the College Fire and Security Engineer.

3.7.3 Input/Output Units (I/O)

Input/Output devices to be BS EN 54-18 certified.

Intelligent Input/Output units are to be selected from the Apollo XP 95 range.

3.7.4 Beam Detectors

Beam detectors to be BS EN 54-12 Certified.

Beam detectors shall be selected from the Apollo Fire range of devices.

3.7.5 Aspirating Fire Detection

Aspirating systems to be BS EN 54-20 certified.

Aspirating systems shall be selected from the Xtralis range.

System sensing category **Type C** (normal sensitivity).

Prior to commencing the design of an aspirating system installation, the design concept shall be agreed with the College Fire Safety Office. This may lead to the application of an enhanced level of sensitivity, designed to satisfy a specific fire safety objective.

Fault and Fire condition shall be signalled to the building fire alarm system.

3.7.6 Duct Smoke Detectors

Duct smoke detectors are to be selected from the Apollo Fire Intelligent range combined with Apollo Soteria range of point detectors.

3.7.7 Short Circuit Isolators

Short circuit isolators to be BS EN 54-17 certified.

Short circuit isolators to be chosen from the Apollo Fire range of devices.

3.8 Signalling

3.8.1 Sounders

Sounders are to be BS EN 54-3 certified.

Sounders shall be selected from the Apollo addressable fire range of devices.

Sound synchronisation is mandatory.

3.8.2 Visual Alarm Devices (VAD)

VAD's are to be BS EN 54-23 certified.

VAD's shall be selected from the Apollo XP95 range. Lens colour to be agreed with the College Fire Safety Office.

Wall mounted VADs are preferred.

Synchronisation is mandatory.

3.8.3 GSM Alarm Communicator

The use of an GSM Alarm Communicator is to be approved by the College Fire Safety Office.

Type agreed with the College Fire and Security Engineer.

3.8.4 Vibrating Pillows

Type to be agreed with the College Fire and Security Engineer.

3.8.5 Wireless Safety Paging System

Wireless Radio Paging Systems must be BS EN 54-25 certified.

The deployment of WASOL (DeafWatch) system is mandatory in all Imperial College London Buildings.

Wasol (DeafWatch) system should be included in all building fire design strategies.

Design to include.:

- System Hardware;
- Installation;
- Interface into the building fire alarm system, fire and fault;
- Local power (dedicated non-switched fused spur); and
- Commissioning and validation by the WASOL specialist engineer.

Pager numbers and system messages to be agreed with the College Fire Safety Office.

Note

DeafWatch pagers are managed and distributed by the College Fire Safety Office.

3.9 Magnetic Door Retainers

Magnetic door retainers shall be selected from the Vimpex 24V range with a minimum of 500N holding force.

3.10 Plant Override Test Switch

Mechanical operation for plant override is to be approved by the College Fire Safety Office.

Type and configuration to be agreed with the College Fire and Security Engineer.

3.11 Fire Alarm/Access Control Interface

All doors with electronic locking systems shall include a provision to allow the door to automatically open in the event of a fire alarm or other emergency situation.

This requirement brings together two areas of responsibility, the access control system contractor and fire alarm system contractor

For guidance, the demarcation between these parties shall be as follows:

- Fire alarm system contractor – Install the fire intelligent I/O unit at an agreed location, connected to the output of this module a suitable length of fire rated cable shall be provided, with the contact terminations and healthy condition status marked.
- Access control system contractor – shall supply and install the door locking element, green override break glass unit (BGU) and all other physical access control associated equipment including Power Supply Unit (PSU). The Access Control specialist will route the supplied fire cable from the fire intelligent I/O unit - using suitable containment/fixings - into their control panel, and complete final termination.

Note

In situations where to meet a specific design objective, the interfacing of access controlled doors into a buildings fire system is **not** required, this design objective must be agreed with the College Fire Safety Office and Security Office.

3.12 DRAX AMX1 Alarm Management Display & Control GUI (AMX)

The status of the fire alarm systems deployed across the College's estate are monitored using the DRAX AMX1 Alarm Management Display and Control, Graphical User Interface (GUI).

The AMX software will need to provide a visual representation of the building's layout (floor by floor) with the locations of all installed fire devices mapped. This is a mandatory requirement.

At each administration location a dedicated workstation for this purpose is to be deployed and optimised for use with the DRAX AMX1 Alarm Monitoring Software.

The primary DRAX interface device is SMaRTWatch.

For guidance on connection options, hardware deployment and licencing requirements please contact the College Fire and Security Engineer.

To allow Imperial College London Information and Communication Technology (ICT) to register the SMaRTWatch device, the following information must be submitted to the Imperial College London Fire and Security Engineer.

Information to be formatted and sent as a Microsoft Excel table:

- Location of Panel e.g., campus, building, level, room;
- Type of device;
- MAC Address of the Device;
- Serial Number of the Device; and
- Network Socket Number.

Notes

Seven (7) working days' notice is required.

Data network devices are not to be connected to the College LAN until network registration has been confirmed.

3.12.1 Record Drawings

From an operational, project and maintenance perspective, it is essential to be able to access an up-to-date drawing for any part of the College's fire alarm network. To achieve this, it is necessary to maintain a 'master set' of controlled copies that are updated whenever a change is made to the building systems.

The College's 'master set' of drawings are held on the DRAX AMX software Workstations.

Only the College's appointed incumbent maintenance provider may amend the master set of record information. Therefore, the contractor appointed to undertake either a new installation, full upgrade, or alteration/amendment to the existing system, is required to employ the College's incumbent maintenance provider to record any changes to the information held on the AMX System.

Updating of the master set of record drawings is a project cost and will be deemed to be included in the installing contractor's tendered price.

For all other campus's, fire alarm record documentation is to be addressed as part of the requirements for O&M Manuals as set out in the College Project Procedures. In all cases, where existing drawings are required, these will be provided by the Fire Safety Office.

3.13 Log Book

All amendments/alterations to existing installations shall be entered as appropriate into a College buildings Fire Log Book.

Log books are to be kept adjacent to each building primary fire alarm panel, enclosed within an approved (Red) enclosure with an identical copy submitted to the Fire Safety Office.

Where a Log Book is not available, one shall be provided by the installing contractor and issued to the College Fire Safety Office; all relevant information shall be entered as appropriate.

The following details are required within the Log Book.

- The name of the responsible person; Premises Management;
- Brief details of maintenance arrangements;
- Dates and times of all fire alarm signals (regardless of whether the signal has resulted from the operation of a test, fire drill or genuine fire) must be recorded. In addition, the device type and location;
- Causes, circumstances surrounding, and category of all false alarms;
- Dates, times and types of all tests;
- Dates, times and types of all faults/defects;
- Dates and types of all maintenance (e.g. periodic testing or non-routine attention); and
- Variations.

Where work is carried out to the Fire Alarm System the contractor will record all required information (as above), it is the responsibility of the Project Manager or Works Initiator to ensure that this is carried out.

3.14 Temporary Fire Detection

Temporary fire detection must be agreed with the College Fire Safety Office and Fire and Security Engineer.

Notes

A standalone wired or wireless system with the appropriate detection type, interfaced into the buildings fire alarm system, may be considered.

Temporary modification of building's fire alarm system with the appropriate direction type, may also be considered. In this scenario the buildings fire system CIE and College's centralised AMX alarm monitoring software are to be updated to clearly reflect the changes made.

The Project Manager or Works Initiator has the responsibility to co-ordinate all works associated with providing a temporary fire alarm system.

All configuration and programming changes required to achieve the above shall be undertaken by the College's incumbent maintenance provider. The cost of this shall be included the projects scope of works information.

3.15 Fire Alarm/BEMS Interface

For guidance please refer to Section 6.4.7 Fire Alarm Interlock.

3.16 Fire Suppression in Fume Cupboards and other similar Enclosures

Where a fire detection system is to be connected to a fire extinguishing system to monitor the status of the extinguishing media it is important that the requirements of the two systems are specified in a manner that satisfies the integrity and performance requirements of the two systems.

Where Fire Suppression is specified following a Fume Cupboard Risk Assessment (using the FCS1 form) the system must be configured as per the following guidelines.

- FIRETRACE Ltd is a preferred supplier;
- System type to be Indirect, Low Pressure for Dry Powder, High Pressure for CO2;
- Extinguishant type to be identified in consideration of the chemicals, materials and processes involved within the Fume Cupboard Risk Assessment. The specification is to be signed off by the College's Safety Department and Fire Safety Office. Typically (Dry Powder for Class A, B & C) or (CO2 for Class B and Electrical);
- FIRETRACE diffuser type to match specified Extinguishant type;
- FIRETRACE to be interfaced into the Main Building Fire alarm via an intelligent I/O unit with the following status signals included;

- FT0124/1 3.5bar rising - Discharge Confirmation pressure switch (interpreted as fire condition).
- FT0124 5 bar falling - Monitoring Pressure switch (interpreted as fault condition) *and therefore a maintenance inspection of the FIRETRACE Cylinder is required.*

Regardless of the 'Risk Assessment' and subsequent proposed 'Fume Cupboard Use' at the time of its inception, the MINIMUM default position should be that the internal infrastructure for a 'FIRETRACE System' should always be installed into the Fume Cupboard, as it is highly likely that in time, the Fume Cupboard 'use' could change. In addition fire interface requirements via fire system intelligent I/O units should also be provided at this stage.

The following elements of these guidelines are only required if dictated by the College Operational Safety Department and Fire Safety Office via the 'Fume Cupboard Risk Assessment':

- The FIRETRACE system shall include provision for an interface to shut off electrical supplies and/or fuel supplies, either via direct connections locally to these systems, or remotely via 'exported' signals from the Fire Alarm system using intelligent I/O unit(s) and export relay units, following the status signal, this is to be carried out using third party equipment by way of a set of change over contacts.

The interface signalling from the Firetrace system (fire and fault) into a buildings fire alarm system and subsequent fire cause and effect schedule, must be agreed with the College's Fire Safety Office. This must include signalling through to the centralised AMX monitor and control GUI.

For clarification please contact the College Fire and Security Engineer.

Note

*FIRETRACE Normally Open (*NO)/*Normally Closed* (NC) Pressure switches are rated 5 Amps @ 240 volts AC.

3.17 Fire/Smoke Damper Control in General Ventilation Systems - Not Applicable to Fume Extracts or Categorised Areas.

The Imperial College London (Imperial College London) preferred method for the management and monitoring of Fire Smoke Dampers is via a fully monitored addressable system complying with current standards, interfaced into the Building Management System and Automatic Fire Detection Systems.

The notes below identify the particular requirements.

- Action Air is a preferred supplier;
- Fire Smoke Dampers are to be 24V;
- Dedicated local power supply unit for each damper;
- Dedicated Fire Alarm I/O unit for each damper; and
- Dedicated BMS monitoring of each Individual damper Open/Closed blade positions.

Where practical the above should be controlled by a fully monitored intelligent damper control system.

In circumstances where a fully monitored intelligent damper control system is not viable an alternative method of control, that meets the criteria laid out in the information above may be acceptable with the approval of the College Fire Safety Office and the Fire and Security Engineer.

There are a number of roles and responsibilities in the successful implementation of the above criteria, for clarity they are noted below.

- 240V AC power to be provided at each 24V Power Supply Unit (PSU) location in the form of neon indicated, non-switched fused spur – Appointed Electrical Contractor;
- Fire Alarm Interface – Appointed Fire Alarm Contractor;
- 24V Power Supply Unit (PSU) – Appointed BMS Contractor; and
- Interconnecting cables from PSU, Damper control Interface and BMS – Appointed BMS Contractor.

Notes

Fire Alarm output interfaces should **not** be included in weekly fire alarm testing and provision should be provided to allow them to be isolated accordingly.

3.18 Smoke Control Systems

Smoke control systems shall be selected from the Colt international range.

For guidance please contact the College Fire and Security Engineer.

3.19 Smoke and Fire Curtains

Type to be agreed with the College Fire and Security Engineer.

3.20 Connection and Commissioning

The following procedure applies to the connection of all additions and/or amendments to the College's fire alarm and fire detection systems.

The management and maintenance of the College's fire detection and alarm systems is the responsibility of Estates Operations maintenance dept.

Prior to undertaking any works to extend or amend a College building fire alarm system, the proposals shall be submitted for approval, to the College's Head of Maintenance, Fire Safety Office, and Fire and Security Engineer.

Only the College's appointed maintenance provider may make connections to the existing fire detection and alarm network, or any part thereof. Therefore, the contractor appointed to undertake the installation of any extension and/or amendment to the existing system, is required to employ the College's appointed maintenance provider to complete the final connections onto the College's building fire alarm system, this is to ensure that the whole system performs correctly on completion. The connection and commissioning works undertaken by the College's appointed maintenance contractor is a project cost and will be deemed to be included in the installing contractor's tendered price. The Colleges incumbent contractor must therefore issue the Commissioning Certificates in accordance with the current edition of BS 5839 on completion.

To initiate the connection and commissioning works described above, the installation contractor shall submit Form EP.03 [59](Fire and Security Alterations) in accordance with the instructions set out on the form.

3.20.1 Process for Undertaking Alterations and Additions to an Existing System

To align with the Colleges Building Engineering Services Particular Requirements (BESPR) document for the design, installation and commissioning of devices onto existing building fire alarm systems, there are a

[59] This form will be packaged in a folder along with this BESPR document. For any enquiries please contact the Engineering, Energy and Environment Team.

number of actions that need to be observed, this section outlines the specific roles and responsibilities associated with these actions.

3.20.1.1 Design

<u>Prior to any physical or operational change of a domain within a College building, the proposal must be review by a competent fire professional, and the submission of a fire design made to the College Fire Safety Office and Fire and Security Engineer for review. Once complete, this will be presented to the appropriate person leading the change.</u>

3.20.1.2 Validation of Existing Infrastructure

Prior to the commencement of works a validation of the existing system is to be undertaken by the Colleges incumbent maintenance contractor, this is to be initiated by raising a request via the estates customer services centre, Seven (7) working days prior to the date of validation, the request is to be actioned by either the Project Manager (PM) if project related, or Works Initiator (WI) if not project related.

The purpose of this validation is to.

- Establish if there is adequate capacity on the existing system to allow connection of any proposed additional devices;
- Marking design drawings with device addresses and pinpoint location of interface into the existing loop/panel (see note 1);
- Identify device/loop isolations where required, to allow proposed additions/alterations to take place;
- Establish temporary detection requirements during the works programme (see note 2)); and
- Allow the incumbent contractor to assess the works and submit a quotation to the PM/WI, to fulfil all the incumbent actions set out in this document.

Notes

1) To enable validation to take place, the College's incumbent contractor will need to be supplied with the following - where applicable – by the PM/WI:
    - o Copy of the building's Fire Strategy;

- Specification of proposed devices;
- Schematic drawings of the proposed alterations/additions; and
- Design drawings.

2) Safe Isolation of the existing system devices to be undertaken by the Colleges incumbent fire alarm system contractor.

3.20.1.3 Project Preliminaries

Coordinated by the Project Manager or Works Initiator

The College's incumbent contractor must undertake:

- Fire system device isolations within the project domain;
- Temporary detection within the project domain, when utilising the existing building fire system infrastructure. This methodology requires prior approval from the College Fire Safety Office;
- System interfacing between a standalone fire alarm system - within a projects domain - and a building fire alarm system. In this scenario, any impact on the existing buildings fire system cause and effect schedule, must be agreed with the College Fire Safety Office; and
- Mark on the design drawing the address of each proposed fire device and the precise location of interface for new cabling into the existing fire system cabling.

3.20.1.4 Installation

Undertaking and completion of the installation element of the works.

It will be the installation contractor's responsibility to install the systems as per the design drawings/scope of works, and on completion submit the documentation below to the PM/WI.

- Insulation test (@500V DC) of new cabling and record results;
- Installation certificate. *Installation contractor's declaration that the installation element of the work complies with the recommendations set out in the code, specific to installation; and*
- As fitted drawings including device addressing in PDF and DWG format (Device's addressed set to the schedule submitted by the incumbent contractor).

3.20.1.5 Commissioning

This work is to be coordinated by the Project Manager or Works Initiator.

The responsibility for commissioning the additions/alterations onto the existing building fire alarm system will be the Colleges incumbent maintenance contractor, where applicable the College incumbent maintenance contractor will.

- Validate the as fitted drawings;
- Complete cable connections into existing system;
- Commission the new devices onto the system;
- Update the centralised DRAX AMX system GUI;
- Validate 100% the additional devices;
- Update the Cause and Effect configuration;
- Updated Cause and Effect Schedule;
- Updated Node/Node's battery calculations;
- Update Node/Node's loop calculations; and
- Updated NFC file (entire system).

For guidance please contact the College Fire and Security Engineer.

3.20.1.6 Certification

The College incumbent maintenance contractor will submit system certification to the Project Manager/Works Initiator, this will include where applicable.

- Commissioning certificate. Commissioning contractor's declaration that the commissioning element of the work complies with the recommendations detailed in the code, specific to commissioning.
- Inspection and servicing certificate. Incumbent maintenance contractor's declaration that periodic inspection and servicing is undertaken in line with the recommendations detailed in the code, specific to system maintenance.
- Modifications Certificate. Incumbent maintenance contractor's declaration that modifications to an existing system are undertaken in line with the recommendations detailed in the code, specific to system modifications.

3.20.1.7 Handover and Acceptance

This work is to be coordinated by the Project Manager or Works Initiator.

Final acceptance will follow witnessing by the Colleges Fire Safety Office/Fire and Security Engineer.

- Test criteria must be agreed with the College Fire Safety Office;
- Acceptance certificate. College Fire Safety Office;
- Design Certificate. *System designer's declaration that the system has been designed in line with the recommendations detailed in the code, specific to system design; and*
- Verification certificate. *Issued when verification of design, commissioning and installation is undertaken by an independent source (the extent of independent verification will need to be agreed with the Project Manager/Works Initiator before the work is undertaken).*

3.20.1.8 SUMMARY CHECKLIST

I – RIBA STAGE 1:

☐ Design intent agreed with Fire Safety Office and Fire and Security Engineer.

II – RIBA STAGE 2/3/4:

☐ Validation of the system undertaken by incumbent contractor Information to be provided:

- ☐ Design drawings;
- ☐ Updated Fire Strategy (if one existing prior to the project);
- ☐ Schematics for proposed alterations;
- ☐ Spec for proposed devices;
- ☐ Consider added cost for potential upgrade in capacity if required;

☐ Temporary detection to be used during construction agreed with Fire Safety Office and Fire and Security Engineer.

III – RIBA STAGE 5 (Pre-construction):

☐ Request for isolation to incumbent contractor (7 working days' notice). The following documents will be submitted with the request:

- ☐ Marked up drawing with devices to be isolated clearly identified;
- ☐ Temporary detection in place (if using existing system, request to be issued for incumbent contractor to undertake the work);
- ☐ Incumbent contractor to mark up in a drawing where the new cabling needs to stop for them to connect to the existing fire panel; and
- ☐ Incumbent contractor to provide drawing with addresses to be used for all devices to installer contractor.

IV – RIBA STAGE 5 (Installation and Commissioning)

☐ Request for commissioning and witnessing (2 visits) to be issued to incumbent contractor with 7 working days' notice. Information to be provided with the request:

- ☐ Insulation test of new cabling (@500V DC);

☐ Installation certificate to BS5839-1;

☐ As built drawings both in PDF and DWG, in addition with devices addresses, sound pressure levels and cable routing;

☐ Updated cause and effect schedule;

☐ Commissioning, the incumbent contractor to undertake works as per the requirements set out in the BESPR;

☐ Following the commissioning of the system, the incumbent contractor will issue:

☐ Commissioning certificate;

☐ Verification certificate (if applicable;)

☐ Inspection and servicing certificate (if applicable;) and

☐ Modification's certificate (if applicable.)

V – RIBA WITNESSING and HANDOVER

Witnessing to be arranged:

☐ Witnessing conducted by incumbent contractor;

☐ Immediately after the commissioning;

☐ Full building system test required if amendments have been made to the buildings cause and affect schedule. (Coordinated through the Fire Safety Office and Building Manager;)

☐ Building Manager to notify all building users of the planned fire test; and

☐ Witnessing undertaken by a project appointed, accredited, competent third party.

Outputs:

☐ Acceptance certificate signed by the Fire Safety Office; and

☐ Design certificate issued by the system Designer.

4 Security Systems

4.1 Security Access Control System (SACS)

4.1.1 General

<u>Electronic Security Access Control Systems are to be designed and installed to Current BS EN Standards and industry best practice guidelines.</u>

Software Platform: LENEL•S2 Onguard (Contact the Imperial College London Fire and Security Engineer for current version), centralised single server, system topology.

ID Card Proximity Contact Protocol standard ISO/IEC 14443A-3 (13.56MHz) Mifare Classic1k 4Byte or 7Byte UID.

4.1.2 Methods of Door Access Control

4.1.2.1 Primary Online Access Control

High/Medium security doors requiring an audit trail and full door status monitoring via LENEL•S2 Onguard administration software e.g., Perimeter, corridor, bike store, plant rooms, laundry room doors and Red/Amber categorised areas.

- Proximity Reader Type

LENEL•S2 BlueDiamond Multi-Technology Reader LNL-R10320-05TB, Imperial College London custom format.

  - Reader RED and GREEN LED Indicators to be configured as follows; Continuous RED in standby mode changing to continuous GREEN on a valid read.
  - All Readers are to be labelled with the appropriate ASSET CODE supplied by the College ID Card Office (black text on white background).

- 2) Proximity and PIN Reader Type

LENEL•S2 BlueDiamond Multi-Technology Reader LNL-R10325-05TB Imperial College London custom format.

- Reader RED and GREEN LED Indicators to be configured as follows; Continuous RED changing to continuous GREEN on a valid read and/or PIN entry.
- All Readers are to be labelled with the appropriate ASSET CODE supplied by the College ID Card Office (black text on white background).

Notes

A LENEL•S2 Onguard reader licence is to be supplied for each reader added to the College's SACS.

Perimeter exit/entry route doors should also include a mechanical deadbolt for manual locking in the event of a SACS failure.

For clarification please contact the College Fire and Security Engineer.

4.1.2.2 Secondary Online Access Control

ASSA ABLOY Aperio Escutcheon (Online)

Type 1 - Aperio L100 V3 Escutcheon

Medium security doors requiring an audit trail, door status monitoring and centralised management via the LENEL•S2 Onguard administration software, e.g., ICT CWC's, residence doors etc.

Certified for use on fire doors and escape doors.

- Aperio wireless battery-operated locking with door status monitoring.
- L100 escutcheon providing free egress at all times from the secure side and controlled access via integrated RFID reader from the non-secure side.
- The locking element is included in the Aperio L100 Kit.
- For fire door and escape door compliance, an Aperio L100 reader plate must be installed.
- Mechanical cylinder to provide key override in the event of device failure.
- Single Europrofile Cylinder – To Imperial College London Key suiting schedule. See Aperio notes below.

Type 2 - E100 V3 Escutcheon

Medium/Low security doors requiring an audit trail and centralised management via the LENEL•S2 Onguard administration software, e.g., internal office doors, store cupboard doors etc.

- Aperio Wireless Battery-operated locking without door status monitoring.
- E100 handle providing free egress at all times from the secure side and controlled access via integrated RFID reader from the non-secure side.
- Locking element, auto deadlocking mortice night latch (the locking element is not included in the E100 kit).
- Mechanical cylinder to provide key override in the event of device failure.
- Single Europrofile Cylinder – To Imperial College London Key suiting schedule. See Aperio notes below.

Type 3 – Aperio H100

Low security doors requiring an audit trail and centralised management via the LENEL•S2 Onguard administration software, e.g., internal office doors.

- Aperio Wireless Battery-operated locking without door status monitoring.
- H100 handle providing free egress at all times from the secure side and controlled access via integrated RFID reader from the non- secure side.
- Locking element, auto deadlocking mortice night latch (the locking element is not included in the H100 kit).
- Mechanical cylinder to provide key override in the event of device failure.
- Single Europrofile Cylinder – To Imperial College London Key suiting schedule. See Aperio notes below.

Aperio Notes

- Aperio Escutcheons are **not suitable** for deployment in the following applications:
  - Bi-directional control of a door;
  - Interlocked Doorsets;
  - OEM interfacing e.g. laser locking systems;
  - Double leaf doors where both leaves are active;
  - External doors to the open air;
  - Automated doorsets;
  - Red/Amber Categorised Laboratories;
  - NaCTSO compliant suites;
  - Doors requiring remote release e.g. via a button on a reception desk;
  - When LENEL•S2 Onguard special reader functions are required.
- Lock cylinder type ABLOY euro profile CY326U, length suitable for the thickness of the door e.g., external size to centre.
- ABLOY NOVEL Mechanism suited to Imperial key schedule VL040 (for guidance, please contact the College Fire and Security Engineer for Residence Building cylinder suiting)
- For correct key suiting, when ordering cylinders for the Aperio E100/L100/H100 lock type, it is the responsibility of the installation contractor to procure the cylinders suited to the correct Imperial College London Novel cylinder suiting schedule (for guidance, please contact the College Fire and Security Engineer).
- Update's to the VL040 suiting schedule require formal approval from the College Security Office (for guidance, please contact the College Fire and Security Engineer).
- Aperio AH40 Gen5 1 to 64 Communication Hubs are to be used with **LENEL•S2 Embedded Mercury Firmware**;
- Aperio AH40 Gen5 1 to 64 Communication Hubs are not to be located behind a physical obstruction e.g., above suspended ceilings, within a riser, behind a wall;

- Aperio AH40 Gen5 1 to 64 Communication Hubs are to be labelled (black text on white background) with the devices wireless MAC address;
- A clear line of sight between the Aperio escutcheon and Hub must be maintained;
- An existing Aperio Hub with sufficient spare capacity may be used for connection of additional Aperio locks providing the deployment location is within the manufacturers recommended operational range, and in addition, the requirements set out in 4.1.2.2 are met. When there is insufficient capacity to connect an additional Aperio lock to an existing Hub, an additional AH40 Gen5 1 to 64 Communication Hub (including ariel) must be deployed;
- Aperio type to suit application and compliance requirements e.g. fire doors/escape route doors;
- **Two** (x2) LENEL•S2 Onguard system licences are required when installing an Aperio escutcheon, x1 standard reader licence and x1 partner device lock licence. An Aperio lock will not be allowed to be commissioned onto the system without both licences being provided. (for guidance please contact the College Fire and Security Engineer).
- **Aperio AH40 Gen5 1 to 64 Communication Hubs can only be connected to Lenel•S2 'X' type access panel.**

4.1.2.3 Secondary Offline Access Control

1) Codelocks CL5010 / CL5010 BB

Low security doors requiring an offline coded lock without door status monitoring e.g., Office doors, storage room doors.

Notes

For correct Codelocks key suiting, locks are to be supplied directly from Codelocks, quoting the Estates Facilities Codelocks building schedule number.

Imperial College London Building Managers co-ordinate code allocation.

2) Mechanical locks

Cylinder type to be specified by the Imperial College London Security Office.

4.1.3 Access Control Centralised System Hardware Specification

4.1.3.1 Power Supplies Unit (PSU)

Chosen from the LENEL•S2 Life Safety product range. Each Power Supply Unit (PSU) will require a dedicated 240v non-switched, neon indicated fused spur fitted adjacent. All PSU's must be CE Listed and dedicated for Security Access Control System use. The PSU must be able to deliver a maximum of 5A @13.6v DC output loading, with charging of standby batteries to be considered an addition to the output load. The Power Supply output will then be sub-divided, so each connected device is individually fused i.e. LENEL•S2 DRIM, ISC or locking device etc. PSUs are to be housed in a suitably sized enclosure with cooling and ventilation to manufacturer's recommendations. Provision for a minimum of 4 hours standby battery backup on mains failure is required to keep all connected hardware fully operational in the event of a temporary power outage. Ideally PSU batteries should be contained in the same enclosure as the PSU, however when this is not practically possible, they may be housed in a separate enclosure as long as it is directly adjacent to the PSU enclosure. PSU batteries are to be chosen from Yuasa/Power Sonic ranges and date stamped on installation and routine periodic testing

All PSUs are to be monitored for lid tampering.

All System PSUs should be able to be independently isolated from its 240V supply, via a non-switched neon indicating spur.

4.1.3.2 LENEL•S2 Dual Reader Interface Module (DRIM)

LNL-1320

Application, to provide interfacing of hardwired access control door hardware. The DRIM is to be sited adjacent to the first connected door, a second door can be connected as long as it does not exceed 20M from the DRIM location. Each DRIM will require a dedicated Power Supply Unit (see 4.1.3.1). The DRIM communicates to the system controller via a 2 wire RS-485 bus and is to be installed to manufacturers recommendations

4.1.3.3 LENEL•S2 Input Control Module (ICM)

LNL-1100

Application, to provide connection for sensor monitoring and interface to OEM systems. Each LNL-1100 will require a dedicated Power Supply Unit (see 4.1.3.1). The LNL-1100 communicates to the system controller via a 2 wire RS-485 bus and is to be installed in line with manufacturers recommendations

4.1.3.4 LENEL•S2 Output Control Module (OCM)

LNL-1200

Application, to provide connection for output control and interface to OEM systems. Each LNL-1200 will require a dedicated Power Supply Unit (see 4.1.3.1). The LNL-1200 communicates to the system controller via a 2 wire RS-485 bus and is to be installed in line with manufacturers recommendations

4.1.3.5 LENEL•S2 Intelligent System Controller (ISC)

LNL-X3300

Application, to provide upstream interface of downstream devices to a host system, deployed for system expansion. Each LNL-X3300 will require a dedicated Power Supply Unit (see 4.1.3.1). The LNL-X3300 communicates to the system Host via an Ethernet connection and via a 2 wire RS-485 bus to downstream I/O interfaces, the ISC is to be installed in line with manufacturers recommendations.

4.1.3.6 LENEL•S2 Intelligent Dual Reader Controller (IDRC)

LNL-X2220

Application, to provide upstream interface of downstream devices to a host system, deployed for system expansion, in addition the direct connection of one or two doors. Each LNL-X2220 will require a dedicated Power Supply Unit (see 4.1.3.1). The LNL-X2220 communicates to the system Host via an Ethernet connection and via a 2 wire RS-485 bus to downstream I/O interfaces, the LNL-X2220 IDRC is to be installed in line with manufacturers recommendations.

General LENEL•S2 Access Panel Notes

- A LENEL•S2 LNL-8000 Star Multiplexer Board is to be installed with each LNL-X3300 ISC for distribution of the RS485 communication network.

- Intelligent System Controllers (ISC) are to be installed within college approved ICT CWC rooms.
- Cable type and system wiring to meet LENEL•S2 specifications.

4.1.3.7 LENEL•S2 System/Dual Reader Controller Connectivity

Connection of LENEL•S2 access panels onto the College's Onguard Security Access Control System (SACS) is to be via the College LAN. Cabling to a local network socket will be required to achieve College LAN connectivity, with the preferred method being the installation of the data point within the ISC enclosure itself. The device will need to be set to DHCP and power cycled to pick up the registered Host Name and IP address.

To allow Imperial College London Information and Communication Technology (ICT) to register the device, the following information is to be submitted to the Imperial College London Fire and Security Engineer, for formal registration.

Information to be formatted and sent as a Microsoft Excel table:

- Location of Panel e.g., campus, building, level, room;
- Type of Controller;
- MAC Address of the Device;
- Serial Number of the Device; and
- Network Socket Number.

Notes

Seven (7) working days' notice is required.

Access panels are not to be connected to the College LAN until network registration has been confirmed.

4.1.4 Locking Devices

Locking devices are to be agreed with the Imperial College London Fire and Security Engineer.

Examples of approved magnetic and electromechanical locking devices:

ASSA/ABLOY EL560/561: Series electronic locks are the **preferred** locking method and are to be fitted where possible. See cylinder notes below.

Maglocks: To be installed on suitable door types with the correct mounting brackets for the door opening orientation, a minimum of 1200lbs holding force is required and 2M clearance from the lowest point of the maglock to floor level. Maglocks are to be secured using thread lock and safety straps for the armature plates. See notes below.

ASSA/ABLOY EL512/513. See notes below.

TRIMEC ES 8000 V-Locks. See notes below.

TRIMEC ES 6000 Hook Locks. See notes below.

EFF EFF 351M.80 Motorised Strike. See notes below.

Notes

- ABLOY euro profile CY326U cylinders incorporating the ABLOY NOVEL mechanism are to be specified for electromechanical locks. ABLOY cylinder length suitable for the thickness of the door e.g., external size to centre.
- For correct key suiting when ordering cylinders, it is the responsibility of the installation contractor to procure the cylinders suited to the correct Imperial College London Novel cylinder suiting schedule.
- All locks fitted onto Escape or Fire Doors are to have suitable compliance accreditation.

For guidance, please contact the College Fire and Security Engineer.

4.1.5 Request to Exit Buttons (RTE)

The primary method of signalling a RTE is to come from the operation of the exit handle when using an electromechanical lockset.

When there is no mechanical means of egress a high Impact, green dome type button marked “Press to Exit” is to be used.

4.1.6 Green Emergency Break Glass Units (BGU’s)

Specialized Security Products type CP3-LSRC-DB must be used.

BGU devices must be green in colour, triple pole, resettable, incorporate bi-colour LED’s, sounder and marked - Emergency Door Release.

LED status indication for normal operations is green.

On activation four actions are to be met.

1) Both legs of the lock power are to be mechanically isolated.
2) LED indication changes to red.
3) Activation of a local sounder automatically silenced by resetting the BGU.
4) Door forced event signalled on the LENEL•S2 Onguard Alarm Monitoring screen.

Notes

Door forced priority classification to be set by the Imperial College London Security Office.

Internal door BGU's must be fitted with a clear plastic cover.

BGU's that form part of the access control hardware on entry/exit doors to the open air may require STI-15C20 Euro Stopper Call Point Cover (Alarmed) This is to be agreed with the Imperial College London Security Office and Fire and Security Engineer.

4.1.7 Door Monitoring:

Door status monitoring is required on primary access controlled doors and fire escape doors to the open air. When the doorset is double leaf, each leaf is to be monitored.

Notes

Magnetic contact type must be suitable for the application.

Built in maglock door status sensors are **not** to be used.

4.1.8 Key Override Switches

ASEC AS9853 maintained and key retrievable must be used.

4.1.9 Final Escape Doors to The Open Air

Escape route door locking mechanisms are to be discussed with the Imperial College London Security Office, Fire Safety Office and Fire and Security Engineer, the equipment installed onto each door is to include the following.

- Locking element
- Local Sounder

- BGU
- STI-15C20 Alarmed Euro Stopper Call Point Cover. Deployment is to be agreed with the Imperial College London Security Office and Fire and Security Engineer.
- Fire Alarm Connection
- Monitoring contacts.

Centralised control and monitoring are required, to achieve this there may be a requirement to connect door hardware onto both an LNL-1200 Output Control Module and an LNL-1100 Input Control Module board.

For guidance please contact the College Fire and Security Engineer.

4.1.10 Additional Alarm Points

All additional alarm points e.g., Panic Buttons, Intruder Alarm Systems etc., are to be connected to the access control system via LNL-1100 Input Control Module board via supervised connections.

4.1.11 Fire Alarm Connections

Interface into the building Fire Alarm System via a Fire Alarm I/O unit is required on all access controlled door locking elements with the exception of doors that have a mechanical means of egress, and/or there is a specific design objective agreed with the Imperial College London Security Office, Fire Safety Office and Fire and Security Engineer. Activation of the fire system I/O will initiate a mechanical break in power to the associated lock/locks.

Software driven release of access controlled door locks on fire, will **not** be accepted.

The fire alarm contractor will provide a suitable length coil of fire rated cable, and a red cable gland. The cable will be terminated in the fire alarm interface by the fire alarm installer, such that a healthy condition will be indicated by a set of closed contacts. It is the responsibility of the Security specialist to pull the cable into the security system control panel and terminate it.

When connecting locks through a Fire I/O the maximum rating of the contact is 1amp, lock surges could exceed this limit, in this instance a suitable relay is to be fitted to avoid damage to the units.

4.1.12 Commissioning

4.1.12.1 Alterations and amendments to an existing system

The following procedure applies to the connection of all additions and/or amendments to the College's LENEL•S2 Security Access Control System (SACS). The management and maintenance of the College's Access Control System is the responsibility of the maintenance section of Imperial College London Estates Operations. Prior to undertaking any works to extend or amend the College's system, the proposals shall be submitted for review, to the College Security Office, and Fire and Security Engineer using the **Form EP.03**. [60]

Only the College's appointed maintenance provider may commission additional devices onto the system or isolate existing device from the system. Therefore, the Project Manager/ Works Initiator is required to retain the services of the College's appointed maintenance provider to undertake these works, this is to ensure the whole system performs correctly on completion.

To initiate the commissioning/isolation works described above, the following process will need to be observed.

- System Validation and report submitted to the Project Manager/Works initiator. Imperial College London incumbent contractor;
- Device Isolation. Imperial College London incumbent contractor;
- Temporary access control deployment. Imperial College London incumbent contractor;
- Device installation. Installation contractor with Lenel•S2 VAR accreditation;
- Device commissioning. Imperial College London incumbent contractor;
- Full mapping of devices onto the Lenel Onguard system to provide a visual representation of the floor layout and deployed devices.

For guidance please contact the College Fire and Security Engineer.

[60] This form will be packaged in a folder along with this BESPR document. For any enquiries please contact the Engineering, Energy and Environment Team.

4.1.12.2 New buildings

The commissioning process for Security Access Control delivered as part of a new building can be complex with specific roles and responsibilities, the steps below are not exhaustive and should be used as a guide for the connection of a new buildings security access control system onto the College's centralised system. This process is to be coordinated by the Project Manager with support from the College Fire and Security Engineer, Security Office and ID Cardholder Office, all associated work is to be at the project's cost.

- College ID Cardholder Office notified of planned commission schedule and completion date as soon as is practicably possible.
- College data network (LAN) available for connection to all security network devices.
- Network device registration onto the College data network. See Section 4.1.3.7.
- Segment created in LENEL•S2 Onguard. Action for Imperial College London incumbent contractor, Project Manager to coordinate.
- Installation contractor setup as a LENEL•S2 Onguard system user with full administration permissions to the newly created segment. Action for Imperial College London ID Card Office, Project Manager to coordinate.
- Updated Onguard PRO Flexnet licence file (with all relevant licences) submitted to the Imperial College London Fire and Security Engineer. Project Manager to coordinate.
- Updated licence file applied to SACS. Action for College ICT, College Fire and Security Engineer to coordinate.
- Reader naming convention submitted to installation contractor. Action for Imperial College London ID card office, Project Manager to coordinate.
- Cardholder access rights table to be submitted to the ID Cardholder Office. Project Manager to coordinate.
- Dedicated Workstation deployed with minimum LENEL•S2 Onguard Client 7H High Performance specification, and LENEL•S2 Onguard client software installed. Project Manager to coordinate.

- College contingency worker account setup to allow the project installation contractor to access the workstation and College network. Project Manager to coordinate.
- College pre-programmed test cards supplied to the project installation contractor for test and commissioning purposes. Action for ID Card Office, Project Manager to coordinate.
- College specific access panel 'function sets' to be agreed with College Fire and Security Engineer during commissioning process. PM to coordinate.

4.1.13 Badging Station Printers

For guidance please contact the College Fire and Security Engineer.

4.1.14 Local Door Signalling

Primary Access Controlled Doors require Local Door Alarm Sounders to be installed adjacent each door location.

- Sounder type – Piccolo Internal sounder.

Notes

The sound emitted from this device must be clearly discernible from other audible system sounds i.e. Fire Alarm, Freezer Alarm etc.

Local door sounders may be omitted to meet a specific design objective, authorisation from the Imperial College London Security Office will be required in this instance.

4.2 Video Surveillance Systems (VSS)

4.2.1 Introduction

All VSS Systems are to be installed to current BS EN Standards and comply with the Imperial College London CCTV Code of Practice and Imperial College London Data Protection Policy.

4.2.2 General

Software - FLIR United Video Management System (VMS). Contact the Imperial College London Fire and Security Engineer for the current operational version.

Platform – Latitude (Enterprise)

4.2.3 Camera Type

Cameras are to be chosen from the Bosch Professional Video Surveillance range, specific to the application.

FLIR and/or AXIS cameras can also be considered to meet a specific design objective, in these instances approval is required for the Imperial College London Security Office (for guidance please contact the College Fire and Security Engineer).

Mandatory locations for camera deployment.

- Entire building curtilage;
- Exit/entry points to the open air (internal/external;)
- Fire exits to the open air (internal/external;)
- Lift Lobbies;
- Cycle store/racks;
- Laundry rooms;
- Building receptions;
- Vehicle barriers (in/out); and
- Safe Rooms;

The list above is not exhaustive, there may be a need to meet a specific design objective or the need to mitigate an enhanced security risk with additional VSS coverage, in these instances, all proposed locations are to be approved by the Imperial College London Security Office.

A cameras performance specification must be agreed with the Imperial College London Fire and Security Engineer prior to deployment.

Standard device capabilities are to include:

- Internet Protocol compliance;

- POE Compatible;
- ONVIF S compliance;
- DHCP compliance (no request timeout);
- Hostname compliance; and
- Remote auto focus

Connection is to be via the College LAN.

Cabling to a local network data point will be required, where practically possible the network data point will be installed within 2m of the camera location. Network data point's for VSS use are to be mounted in a polycarbonate adaptable box, of suitable size, with clear plastic cover, cable entry must be by suitable cable glands.

To allow ICT to register network devices the following information must be submitted to the Imperial College London Fire and Security Engineer:

Information to be formatted and sent as a Microsoft Excel table:

- Location of device e.g., campus, building, level, room;
- Type of device;
- MAC Address of the Device;
- Serial Number of the Device; and
- Network Socket Number.

Notes

ICT require seven (7) working days' notice when registering new cameras.

Each camera will need to be set as DHCP and power cycled so that the unit picks up its registered IP address.

In situations where cameras are deployed in **excess of 90M** from the ICT switch, network infrastructure topology is to be agreed with Imperial College London ICT Dept. and Fire and Security Engineer.

All proposed camera deployment will require approval from the Imperial College London Security Office.

The security camera validation process requires the completion of the Imperial College London Security Camera Commissioning Form submitted to the Imperial College London Fire and Security Engineer, part of this process also requires a snapshot of each camera in day and night scenarios, generated via the VMS (not a web browser) and sent for approval to the Imperial College London Security Office.

All security cameras are to be mapped onto the FLIR VMS.

External dome cameras mounted on a vertical plane must have an on camera weather protector fitted.

Cameras are not to be connected to the College LAN until network registration has been confirmed.

For guidance, please contact the College fire and Security Engineer.

4.2.4 Camera lenses

Lens focal length to suit design objectives.

4.2.5 Camera Power Supply

All cameras are to be POE compliant; where High POE is required, POE Injectors are to be used.

4.2.6 Archiving and Monitoring Systems

4.2.6.1 Specification and Configuration (Servers)

System server configuration and the deployment location is to be agreed with the Imperial College London Fire and Security Engineer.

Server form factor and VMS parameters should as a minimum meet the requirements below:

- Rack mounted;
- 31 days continuous archiving of all connected cameras;
- All connected camera's archived at their maximum resolution;
- Medium compression;
- 25fps internal cameras;
- 12fps external cameras;
- 20% archiving diversity at point of deployment;

- Six client connection licences included;
- Six web client connection licences included; and
- FLIR System monitoring application tool licence included.

4.2.7 Monitors

Please contact the Imperial College London Fire and Security Engineer for monitor specification.

4.2.8 VSS Encoders

Please contact the Imperial College London Fire and Security Engineer for encoder specification.

4.2.9 VSS Decoders

Please contact the Imperial College London Fire and Security Engineer for decoder specification

Note

All proposed amendments to the College's Security Systems are to be approved by Imperial College London Security Office and the Fire and Security Engineer. This will require the submission of **Form EP.03**[61].

4.3 Intruder Alarms

4.3.1 General

Intruder and Holdup Alarm Systems are to be installed to Current BS EN Standards and Industry Best Practice

System Security Grading and Environmental Classifications are to be set by the Imperial College London Security Office.

4.3.2 Intruder Alarm Panels

4.3.2.1 Intruder Alarm Panel Type

Chosen from the Honeywell Galaxy range.

[61] This form will be packaged in a folder along with this BESPR document. For any enquiries please contact the Engineering, Energy and Environment Team.

4.3.2.2 Detectors

Grade 3 Dual-Technology detectors are to be used.

4.3.2.3 Connectivity

Intruder Alarms are to be interfaced into the College's LENEL•S2 OnGuard Software via a LENEL•S2 Intelligent Control Module (ICM) via a supervised connection.

Alarm notification acknowledgement criteria to be set by the Imperial College London Security Office.

4.3.3 Panic, Lone Worker and Man Down Alarms

System type to be agreed with the Imperial College London Safety Department and Imperial College London Security Office.

4.3.4 Scaffold Alarms

System type, notification method and acknowledgement criteria to be agreed with the Imperial College London Security Office and Fire and Security Engineer.

4.4 Intercoms/Help-Points/Public Address

Primary system providing call cascading for 24/7 monitoring by the College's security control rooms.

Commend UK devices are to be specified.

Software Platform: Commend VirtuoSIS (please contact the Imperial College London Fire and Security Engineer for current version).

Operational requirements are to be agreed with the Imperial College London Security Office.

To allow ICT to register network devices the following information is to be submitted to the Imperial College London Fire and Security Engineer:

Information to be formatted and sent as a Microsoft Excel table:

- Location of device e.g., campus, building, level, room;
- Type of device;

- MAC Address of the Device;
- Serial Number of the Device; and
- Network Socket Number.

Secondary system providing local communication within a single building without 24/7 monitoring by the College's security control room.

System manufacturer BPT

For guidance, please contact the Imperial College London Fire and Security Engineer.

4.4.1 Accessible Toilet Alarms

System type to be agreed with the College Fire and Security Engineer.

Physical Security Notes

Operational Requirements are to be set by the Imperial College London Security Office.

Cables that enter control boxes are to be protected by suitable glands /grommets and run through/on suitable permanently fixed containment.

External containment must be galvanized trunking and/or galvanized tube, if galvanized tube is used all inspection boxes are to be fitted with gaskets and appropriate precautions taken to prevent oxidization.

All system Boards etc. are to be permanently fixed into their enclosures. The use of adhesive or adhesive fixings is **not** permitted.

System Manufacturer's Installation and Wiring Guides are to be adhered to at all times.

All parts of the installation are to comply with the relevant standards and industry best practice.

4.5 Automatic Door Integration with Security Access Control System

4.5.1 General

The following sets out the requirements for the Electrical services works to be carried out by the selected Contractor and Specialists.

Design and installation must be EN16005 compliant.

4.5.2 Operation

System configuration and access control interfacing to meet the operational requirements, this must be reviewed on a 'case by case' basis by the Imperial College London Duty Holders.

4.5.3 Controls

4.5.3.1 Doors

The powered door activation and safety features shall include intelligent electronic sensing devices to ensure the door responds appropriately as people approach. The use of threshold and side screen safety shall be incorporated to meet the requirements of BS EN 16005.

Typically sensors shall be mounted on the top of the door frame internally and externally to ensure satisfactory response and operation of the door assembly as people approach the door.

The door system shall also incorporate wiring and fixed terminals to enable the interfacing of the access control system, these terminations should be accessible by the SACS system specialist without the need to access the automatic door operator controls.

The powered door system shall have the minimum interfacing capabilities listed below.

- UPS monitor – N/C on power fail (plus indicator on door transom)
- Swipe control input – N/C to open doors.
- Door locking – N/C to lock doors
- Door status monitor – N/C with door closed.
- Emergency open – N/C loop – open circuit to automatically drive doors open in emergency.

The door operating system shall be fully integrated and shall incorporate a surface mounted control unit (Bedis function switch), which enables options to be programmed regarding the operation of the door. The control unit setting shall be capable of being locked to prevent unauthorised reprogramming of the door functions. This control is to be sited within close proximity of the doors at a height of no more than 1700mm.

4.5.3.2 System Interfacing (Automated doorset/sacs)

During normal hours, the door shall be controlled by its own operating system. During other times, overnight etc., the operation of the doors shall be controlled by the College Security Access Control System (SACS).

Programming of the College's SACS is to be undertaken by the maintenance incumbent security contractor to automatically lock and unlock the automated doors at an agreed time.

The SACS hardware is to be provided and installed by the College's incumbent security contractor and interfaced with the automatic door controls.

SACS control equipment to comprise of the following equipment:

- LNL X3300 Intelligent System Controller (ISC) Only to be installed if there isn't an existing access control network available with the capacity to connect additional LNL1320 (DRIM).
- LNL 1320 S3 (DRIM).
- Internal Swipe Card reader.
- Internal green Emergency break-glass Unit.
- Local Siren for operation when the Emergency Break-glass Unit has been activated.
- External Swipe Card reader.
- Cat 5e data point for ISC network connection (If LNL X3300 is required). For network registration please refer to section **4.1.3.7**

Use of a valid access control card presented to the access control reader shall enable the door controls to operate during the secure period and enable access to, or egress from the building. Operation of the green Emergency Break-glass Unit (EBGU) shall automatically open the doors and permit egress from the building in an emergency.

The access control readers and green emergency BGU shall be mounted at 900mm above floor level to meet accessibility requirements, positions to be agreed on site.

The specialist security contractor shall allow for all control wiring, final connections, testing and local commissioning of the completed system.

Installations are to be 100% validated by the installing contractor then passed to the Main Contractor/Imperial College who are to appoint the incumbent specialist security contractor to commission the hardware onto the centralised Lenel Onguard access control system. The installing contractor is required to include costs for all such commissioning and programming work.

4.5.3.3 Fire Alarms

The control systems of the automatic doors shall be interfaced to the Building Fire Alarm systems. The Fire Alarm Interface(s) shall be provided and installed by the College incumbent fire alarm contractor as set out in Section 3.15.

The College incumbent fire alarm contractor-will carry out the testing and commissioning of the Fire Alarm works. The green emergency BGU contacts are to be wired in series with the Fire Alarm interface unit contacts, thus forming a normally closed loop. During a Fire Alarm activation or the operation of the green emergency BGU the normally closed loop shall be opened, and the automated doorset shall automatically open, and remain in the open position, until the Fire Alarm system and/or emergency BGU has been re-set.

4.5.3.4 Uninterruptible Power Supply (UPS)

To ensure satisfactory operation of the automatic door assembly should an electrical power failure occur a battery powered UPS is included by the door manufacturer incorporated into the door head assembly to provide sufficient power to operate the doors for a specific period of time. An indicator will be provided in the underside of the door controls cover that will illuminate when the door system is operating on the batteries. The status of the mains Electrical supply shall be monitored by the College SACS and during a loss of the mains supply the SACS shall register an alarm in Security via the Alarm Monitoring Screen.

4.5.4 Commissioning

4.5.4.1 Attendance

All Contractors, Specialist Contractors and Manufacturer's representatives shall attend site at the same time during the testing and commissioning of the completed door and Security systems installation.

4.5.4.2 Documentation

All installation works, testing and commissioning shall be fully completed before the installation is offered for demonstrating to the Project Manager or his representatives.

The following commissioning data shall be provided prior to the demonstration:

- Electrical services Test Certificates to the current BS 7671 guidance.
- Certification that the Security system is complete and meets the requirements of the Specification complete with all programming details.
- Commissioning Certificates for the Fire Alarm system.
- Certification that the door system is complete and operates to Specification.

4.5.4.3 Tests

The following tests shall be certified as having been carried out:

- Door operation under normal conditions including safety features and all functions of the Bedis panel.
- Emergency operating of the door by use of:
    - Green emergency break-glass unit.
    - Fire Alarm interface. (Door should remain open when the audible alarm is cancelled)

Notes

If it is not convenient to operate the Fire Alarm system, the cable cores may be disconnected at the Fire Alarm interface relay for the purposes of this demonstration. Notification must be made however to the Building Manager and Fire Safety Office for the satisfactory operation of the doors under fire conditions to be witnessed during the very next Fire Alarm test.

- Power failure – observe satisfactory operation of doors and indicator illuminated. Alarm satisfactorily relayed to Sherfield Security via the College monitoring system.
- Verification of the College Security system operation:
    - Door locking and unlocking under timed programming.
    - Operation of swipe card functions.
    - Door open alarm functions to Sherfield Security.

After submission of the satisfactory test results the Contractors, Specialist Contractors and Manufacturers shall demonstrate the same to the Project Manager or his representatives.

4.5.5 Record Documentation

4.5.5.1

Record documentation is to be discussed and agreed with the Imperial College London Records and Archives Officer prior to works being undertaken.

https://www.imperial.ac.uk/estates-projects/space-management/information-management/

4.6 Automated Vehicle Barriers

4.6.1 General

Prior to commencing the design concept, operational requirements are to be agreed with the Imperial College London Security Office. This may lead to the application of an enhanced level of performance “designed to satisfy a specific risk objective” which exceeds the performance of the standard deployment automated barrier detailed below e.g., an enhanced level of impact resistance. In this instance please contact the Imperial College London Fire and Security Engineer for further guidance.

4.6.2 Type (Standard Deployment)

FAAC B680h (Steel Blue - RAL 5011), LED beam lighting, barrier housing integrated red and green lights.

FAAC B680h and associated system components to be installed to manufacturers recommendations.

Design Consideration Notes

- The preferred access for cyclists is via a dedicated cycle route, however if cycle access is to be combined with vehicle access, the barrier boom length should allow cyclist to pass unhindered.
- Sufficient ambient light should be provided at the barrier location.
- Traffic calming measures including road markings (SLOW and STOP.)
- ANPR .
- Intercom (A/V communication.)
- Remote wireless activation.
- Remote activation via a control consul
- SACS.
- VSS.
- Physical protective measures for barrier control cabinets e.g., static bollards and/or raised plinth.

4.7 Electronic Security Systems in Hazardous or Sensitive Areas

4.7.1 Controlled Access Areas

Specific design objectives are to be agreed with the College Security Office, Safety Department.

The **Yellow, Amber and Red** colour coding described below is detailed in the College Code of Practice entitled 'Controlling access to hazardous or sensitive areas' This is available online in the Safety Department section of the Imperial College London website.

4.7.2 Yellow coded areas

This includes general laboratory areas such as most chemistry labs or most containment Level 2 biological laboratories. It also can include such areas as workshops or autoclave suites.

4.7.2.1 Intrusion and Hold-up Systems (IHAS)

IHAS requirements are to be determined by the Imperial College London Security Office, Safety Department and User Group.

IHAS performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

4.7.2.2 Access Controlled Doors
Primary Access Control is to be installed on Entrance Doors to the Building.

Access control requirements for the entrance doors to the floor/suite must be agreed with the Imperial College London Security Office, Safety Department and User Group.

Access control performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

4.7.2.3 Video Surveillance System (VSS)

VSS requirements are to be determined by the Imperial College London Security Office, Imperial College London Safety Department and User Group.

VSS camera performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

4.7.3 Amber and Red coded areas

Red coded areas include very high security or very high risk areas such as Containment Level 3 Biological labs or Irradiator rooms.

Amber coded areas are high security or high risk areas and can include the clean corridor areas of Containment Level 3 suites, CBS corridor areas and plant rooms.

4.7.3.1 Alarm Systems - Intrusion and Hold-up Alarm Systems

All IHAS Systems to be installed to Current BS EN Standards

IHAS requirements are to be determined by the Imperial College London Security Office, Safety Department and User Group.

IHAS performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

4.7.3.2 Access Controlled Doors

Primary Access Control is to be installed on Entrance Doors to Building.

Access control requirements for the entrance doors to the floor/suite must be agreed with the Imperial College London Security Office, Safety Department and User Group.

Access control performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

Design consideration notes

An entrance interlock is the preferred access arrangement.

Pin and Proximity readers are the preferred card reader technology.

Electronic Locks such as Abloy EL560 locks are the preferred lock type.

Electronic locking should be configured to Fail Secure.

The strategy for interfacing the locking element of the controlled door into the fire alarm system must be agreed with the Imperial College London Security Office, Safety Department, Fire Safety Office and User Group.

4.7.3.3 Video Surveillance System (VSS)

VSS requirements are to be determined by the Imperial College London Security Office, Safety Department and User Group.

VSS camera performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

4.7.4 Areas covered by the Anti-Terrorism (Crime and Security) Act

4.7.4.1 Alarm Systems - Intrusion and Hold-up Alarm Systems

IHAS requirements are to be determined by the Imperial College London Security Office and Imperial College London Safety Department and Counter Terrorism Security Advisor (CTSA).

4.7.4.2 Access Controlled Doors

Primary Access Control is to be installed on Entrance Doors to the Building.

Access control requirements for the entrance doors to the floor/suite must be agreed with the Imperial College London Security Office, Safety Department and User Group and CTSA.

Access control performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

Design consideration notes

- An entrance interlock is the preferred access arrangement.
- Pin and Proximity readers are the preferred card reader technology.
- Electronic Locks such as Abloy EL560 locks are the preferred lock type.
- Electronic locking should be configured to Fail Secure.
- The strategy for interfacing the locking element of controlled doors into the fire alarm system must be agreed with the Imperial College London Security Office, Safety Department, Fire Safety Office, User Group and CTSA.

Design objective enhancements e.g. PAS24 doorset accreditation or Security Rating accreditation are to be approved by the Imperial College London Safety Department, Security Office and CTSA.

4.7.4.3 Video Surveillance System (VSS)

VSS camera requirements are to be agreed with the Imperial College London Security Office, Safety Department, CTSA and User Group.

VSS camera performance specification to meet the design objectives to be agreed with the Imperial College London Fire and Security Engineer.

5 Equality Act 2010 Electronic Systems

The Equality Act 2010 and Building Regulations Approved Document M (HM Government, 2015) should be consulted with regard to provision in this area.

5.1 Access and Egress - Access Control and Automatic Doors

5.1.1 Introduction

Where access control is installed, the following, guidance set out in the British Standard Industry Association (BSIA) A Guide to Assist in Compliance with the Disability Discrimination Act (now Equality Act 2010)" should be considered.

5.1.2 General

Access doors should be so designed as to permit operation by one person in a single motion with little effort. Power-operated doors are preferred for people with accessibility needs.

5.1.3 Door types

- Automatic doors: can be of the sliding or swinging type. In general sliding doors are preferable to swinging doors.
- Automatic doors are useful when traffic is heavy.
- Automatic doors should have an adequate opening interval.
- Guard-rails can be installed near double swinging doors to indicate a door opening area and to prevent people from being hit by the door.
- Revolving doors: - not suitable for use by disabled people or people with prams unless fitted with built in Sliding Door Function.
- Wherever there are revolving doors, an adjacent accessible swinging or sliding door should be provided.
- Auxiliary gates should be provided next to turnstiles.
- Pivoted doors: - should swing in the direction of escape wherever possible.
- Pivoted doors in series are considered as vestibules.
- Sliding and folding doors: - manual sliding and folding doors are recommended for narrow spaces not heavily used by the public.

5.1.4 Access Control Readers

Readers on entrance doors should be mounted at a comfortable height between 0.90m and 1.00m from the floor.

5.1.4.1 Automatic Doors Hardware

Automatic doors can be activated by:

- Push buttons located at a comfortable height between 0.90m and 1.20m.
- Activating mats which can also serve as a location cue.
- Access Control Readers: readers on entrance doors should be mounted at a comfortable height between 0.90m and 1.00m from the floor.
- Remote control.
- Movement Detection Devices.
- Remote transmitter.

Note

Contact the Imperial College London Fire and Security Engineer for further detail on Access Control interfacing into Automatic Door Operators.

5.1.5 Turnstiles

Turnstiles are often used in the reception areas of a building or its perimeter. These are used to provide a higher level of security than a door, by checking each individual is authorised and denying access to those who are not. Here is a summary of the types of turnstiles available along with a brief introduction to their operation and suitability.

In all circumstances turnstiles must be interfaced into a buildings fire alarm system so on activation, they automatically provide free egress.

For guidance please contact the College’s Fire and Security Engineer.

5.1.6 Optical Turnstiles

5.1.6.1 Typical Application

Well managed reception areas where aesthetics and speed of throughput are the key design objectives.

5.1.6.2 Operation

Optical Turnstiles are designed to replace traditional fixed arm turnstiles used to control building access. They utilize infrared beams between pedestals to remove the need for the physical barrier. Optical Turnstiles provide a similar level of security as a traditional half height turnstile, yet the open appearance created by an optical turnstile ensures acceptance in most office environments where the overall design is of paramount importance to the aesthetics of the building. Optical Turnstiles automatically monitor the passage of every individual entering and leaving a building. Security staffs are therefore only required to deal with exceptions such as unauthorised users or visitors without a valid pass.

Lane widths can be adjusted to accommodate wheelchairs without the need for a separate pass gate; therefore all system users utilise the same technology. Audible and visual feedback is required.

5.1.7 Half Height Fixed Arm Turnstiles

5.1.7.1 Typical Application

Constantly manned reception areas where appearance is not the highest requirement.

5.1.7.2 Operation

Fixed arm turnstiles are available in a wide variety of formats and can be made up of three stainless steel tubes making a tripod mechanism or glass panels to make a more discreet finish.

A half height turnstile is not compliant in its own right. This type of turnstile may be compliant if a ‘reasonable adjustment’ is made i.e. a separate pass gate is installed. Although not stated explicitly in the Act it may be argued that a pass gate is discriminatory because it forces disabled users to use a different kind of technology and to be supervised or even aided – often a guard needs to be summoned to open the gate (rather than the person using a card like other people) so they can make sure only one person goes through when the gate is open. Normally pass gates and turnstiles do not feature audible and visual feedback so this should also be considered.

5.1.8 Speed Gates

5.1.8.1 Typical Application

Reception areas where aesthetics, speed of throughput and security are key design objectives.

5.1.8.2 Operation

Speed gates combine features of optical turnstiles and physical turnstiles. A lane is monitored by infrared beams and a physical barrier is used to physically deter entrants.

They are available in normally open or normally closed models and combine the open look and speed of throughput of optical turnstiles with the deterrent factor of traditional turnstiles. This combination of benefits makes the speed gate an ideal choice for the corporate office lobby.

Most manufacturers make compliant versions. However, for some units, this can mean a significantly wider pedestal is needed to accommodate the longer barriers (which will affect the aesthetics and available space). Most models also feature audible and visual feedback.

5.1.9 Full Height Turnstiles

5.1.9.1 Typical Application

Full height turnstiles are normally used on external perimeters in unguarded areas or higher security sites e.g. football stadiums etc. They are a good option for commercial and industrial facilities where security and guarding costs are more important than appearance.

5.1.9.2 Operation

Full height turnstiles are designed to stop people jumping over the units hence they can be unmanned. In some designs it is possible to get 2 people in a section at one time. The barriers are normally finished in steel, but some units use clear Perspex to give an improved aesthetic appearance.

Full height turnstiles are generally not compliant. They cannot accommodate wheelchairs. Alternative measures need to be provided.

Additionally turnstiles do not normally feature audible and visual feedback so this should be considered as well.

5.1.10 Tailgate Detection Devices

5.1.10.1 Typical Application

Primarily used on the main entrance for small sites and back doors and key doors within larger sites, e.g. cash rooms, computer suites etc.

5.1.10.2 Operation

Tailgate Detection devices uniquely answer the problem of tailgating at access controlled doors by creating an infrared field across the door opening to monitor the passage of every individual entering and leaving through that door. In the event of an unauthorised person following an authorised user through a door after it has been opened the system can provide local and remote indications to alert the individual concerned and security. Additionally the system can lock doors and trigger cameras to monitor illegal transactions and ensure events are recorded for later analysis. This ensures only one person gains access through a secured door for each valid card transaction thereby providing improved security at any access controlled door.

Detectors can operate at up to 2.5 metres apart (subject to door widths) to accommodate wheelchairs; therefore all system users utilise the same technology with minimal supervision and no discrimination.

They can be used across wide corridors and double doors; however, people should be restricted to passing through single-file i.e. one door leaf should be secured for normal application. Most models also feature some form of audible and visual feedback.

5.1.11 College Preferences

5.1.11.1 Access Control Reader Types

- Contactless Proximity Card Readers with read range of 2-5cm. (Refer to Section 4.1.2.1.)

5.1.11.2 Door Types

- When choosing Automatic door openers they have to be fit for purpose (preferably to be manually operated when used by able bodied persons).
- Revolving Doors with built in Sliding Door or additional Swinging or Sliding Door.
- Half Height Fixed Arm Turnstiles with additional Swinging DDA Pass gate for Internal Areas.
- Full Height Turnstiles with additional Swinging or Sliding Pass door for External Areas.

Please contact the College's Fire and Security Engineer for further detail.

5.2 Fire Alarms

5.2.1 General

Guidance is given in BS 5839-1: Code of practice for system design, installation, commissioning and maintenance.

"Impairment of hearing does not mean that a person is completely insensitive to sound. Many people with severe impairment have sufficiently clear perception of some types of conventional audible alarm signals to require no special provision for warning of fire. There will be, in some situations, other people present who can alert people who are Deaf and hard of hearing to the need for evacuation, and in this case, it might be necessary to put procedures in place that rely upon others to provide the necessary warning.

However, in circumstances, such as buildings with a significant number of people who are Deaf and hard of hearing, buildings in which one or more people who are Deaf or hard of hearing work in relative isolation, and buildings in which one or more people who are Deaf or hard of hearing tend to move around the building to a significant extent (including into toilet areas), additional means of giving warning to these people might be appropriate. If the occupants in question tend to be located for a large proportion of their time within a limited area of the building, visual alarm signals might be appropriate in that area (and associated toilets). If they sleep in the building, tactile devices, with or without associated visual alarm devices, might need to be considered (e.g. for compliance with the accessibility requirement imposed under Building Regulations [2, 3, 4]). These devices, which can, for example, be placed under pillows or mattresses, may be wired into fire alarm device circuits or be triggered by radio signals.

Alarm devices for the hearing impaired may be fixed, movable or portable."

5.2.2 Emergency Messaging Systems

Portable equipment is equipment designed to be in operation while being carried. (e.g. radio pager! or other system using radio communication"). For the purposes of this clause, portable alarm devices are:

- Intended for carrying by the hearing impaired;
- Capable of giving visual and/or tactile signals;
- Normally radio controlled but other methods are not excluded; and
- Normally require control equipment for transmission of signals to the portable devices, interfaced to the fire detection and alarm control equipment.

Fixed equipment is equipment fastened to a support or otherwise secured in a specific location, or equipment not provided with a carrying handle and having such a mass that it cannot easily be moved (e.g. a fire alarm system control panel screwed to the wall.

Moveable equipment is equipment which is not fixed equipment, and which is not normally in operation while the location is changed (e.g. a local unit or controller which is placed on a table top and operates a vibrating pad in a bed.

Note

No British Standard specifications for alarm devices for the hearing impaired are available at present in the UK. Nevertheless, wherever possible, the recommendations of this clause should be followed, and any variations ought to be subject to a risk assessment to ensure that no hearing impaired person is exposed to undue risk.

5.2.3 College Preferences

5.2.3.1 Fire Alarm System Communication Systems

- Sounders and visual alarm devices to be fitted in W.C's and Meeting/Seminar Rooms.
- WASOL DeafWatch pager system (licenced with OFCOM).

Note. DeafWatch pagers are to be provided by the Fire Safety Office who will be responsible for their issue.

5.3 Refuge Areas

5.3.1 Emergency Voice Communication Systems

Where Refuge Areas are required, as per **Part M Building Regulations** "The need for Management arrangements to provide assisted escape" the following from **BS 9999 Code of practice for means of escape for disabled people** should be adhered to:

"The use of refuges within a building can be of great advantage in the evacuation of disabled people as it enables their escape to be managed in a way that does not hinder that of other users of the building."

*"There is an essential requirement for independent communication between the occupants and evacuation management personnel" with guidelines set in **BS 9999 Use of Refuges** as below.*

"Refuges are places of relative safety where people whose abilities or impairments might result in delayed evacuation can await assistance from building management with the next part of their movement to a place of ultimate safety.

1) *The disabled people in each refuge should be assured that their presence there is known to the building management/security team.*
2) *In order to avoid anxiety and confusion, the disabled people in each refuge should be kept informed of the situation and told about the action that building management/security team is taking in order to affect their safe evacuation.*

To address these issues there has to be a system of two-way communication between those temporarily waiting in each refuge and building management/security team members who are organizing the evacuation of *the building. The two-way communication system needs to be such that it is readily operated by, and comprehensible to all persons likely to use them."*

To comply with the above, the BS 5839:9 Code of practice for the design, installation, commissioning and maintenance of emergency voice communication systems; should be adhered too.

5.4 Signage

5.4.1 General

The following recommendations are applicable.

Refuges and evacuation lifts should be clearly identified by appropriate fire safety signs.

Where a refuge is in a lobby or stairway, it is essential that the sign is accompanied by a blue mandatory sign worded "Refuge keep clear".

5.4.2 College Preferences

5.4.2.1 Refuge Areas

Two systems are currently in operation;

- Commend UK Refuge System with hands free 2-way communication, permanently active refuge terminals.
- Baldwin Boxall "Vigil CommuniCare Advance" Refuge System with hands free 2-way communication, permanently active refuge terminals.
- Main Control Panel to be located adjacent to the Building Fire Alarm Panel.

For guidance on system choice please contact the College Fire and Security Engineer.

5.5 Sanitary Accommodation

5.5.1 Emergency Assistance Alarm (EAA)

As per Part M Building regulations, any emergency assistance alarm system must incorporate:

- Visual and audible indicators to confirm that an emergency call has been signalled.
- A reset control reachable from a wheelchair and the WC, or from the wheelchair and the shower/changing seat.
- A signal that is distinguishable visually and audibly from the fire alarm.

Imperial College London Security Control Rooms are to be notified of an emergency assistance alarm activation.

To enable this functionality the EAA is to be:

- Interfaced via supervised connections into the College Security Access Control System.
- Mapped onto the Lenel Onguard software for a visual representation of the alarm location e.g., building, floor, room.
- Local audible and visual signals of alarm activation.

5.5.2 Fire Alarms

Fire system signalling should follow Building Regulations part M Guidance.

5.5.3 College Preferences

Fire Alarm signalling to include both sounder and visual alarm devices.

The preference for visual alarm device location is wall mounted.

6 BMS

6.1 General

This document has been prepared to ensure that all future developments to the Imperial College Building Energy Management System are of the required Imperial College London (Imperial College London) standard, consistent with existing installations and that all information is represented in an approved format.

The standards set out in this document will act as guidance to Imperial College London approved suppliers on the principal of design, engineering, and installation.

To achieve the above requires designers, installers and those responsible for commissioning and validation, to comply with the standards set out in this document. The requirements and standards for particular items of equipment will be listed in the relevant chapters within this document, and special attention should be paid to these additional requirements.

The requirements contained within this document are supplementary to those contained in any other contract documentation or standard policy document. Throughout all works, suppliers should follow the Imperial College London BMS Project Procedure and refer to CIBSE Guide H.

The College currently has one of the largest Trend BMS systems in Europe. Managing such a system is time consuming and requires consistent installations of a high standard.

The College employs two Engineers to oversee the BMS. The Controls Engineer is primarily concerned with projects works, the BMS Engineer with maintenance activities. The Engineers work closely together, and in the event of one being absent, the other will provide cover. All works on site are to be carried out by a Controls Specialist company, who will be an approved Trend Technology Partner who is familiar with working at the College. Any works to the existing BMS or providing new controls must only be undertaken with the approval of either the Controls Engineer or the BMS Engineer.

6.2 Selection of Equipment

6.2.1 Control Devices

Trend IQ4 series controllers are to be utilised. Programmable IQEco terminal unit controllers may be used where appropriate, networked to a 4NC. TONN, IQX and XNC devices may not be used unless approved by the Controls Engineer. Where interface or OEM controls are part of a project, these are to be compliant with ICT network requirements, and provide all required monitoring and control points. Where possible, each control device will only be responsible for one item of plant, to reduce the impact of a controller failure.

6.2.2 Packaged Plant

Packaged plant controls will also utilise Trend controllers for their final control. Where Trend controllers cannot be fitted, a full BACNet IP read / write interface shall be provided. A spare OEM controller, set up ready for direct replacement of a faulty unit, should be handed to the Maintenance Manager for the building at handover.

Where packaged controllers are used, it is the responsibility of the Mechanical Contractor to confirm with the Controls Engineer if the packaged controller is suitable for use at the College. The Mechanical Contractor shall also provide all necessary interfacing information to the Controls Specialist for the project and the Controls Engineer. The Controls Specialist will not set up or commission the packaged controls and will not attempt to interface them to the BMS, until they have been fully commissioned and witnessed by the Mechanical Contractor.

In the case of a VRF system, a full read/write interface will be provided for each unit. The VRF network interface shall be selected after approval from the BMS Engineer. Standalone cooling units (for example in CWC rooms) shall be monitored for fault and shall have the provision to be reset via the BMS. A space temperature sensor shall be provided in each area served by a standalone unit to confirm cooling system operation.

Controls for pressurisation and booster units will be packaged, they must provide fault and low-pressure signals via volt free outputs.

Should there be a need to deviate from these requirements a full discussion should take place with the Controls Engineer before a detailed exception report is presented to the Head of Engineering, Energy and Environment.

6.2.3 Outstation Type

All outstations and network nodes shall be the 230VAC BACNet version with the current stable firmware release at the time of handover, if refit works utilise an existing controller, this will have its firmware upgraded by the contractor as part of the works. Outstations will be supplied complete with all necessary input/output cards or modules required to provide a fully operational controls package. FCU outstations can be 24VAC if fed from the FCU manufacturer's equipment. This shall be confirmed with the FCU supplier.

6.2.4 Current Loop Networks

No new or replacement devices may be put onto current loop networks. All devices should be of the Ethernet type, including controllers replaced during refit works. This may require re-engineering of ICComms, and care will need to be taken to ensure that the remaining current loop LAN operates correctly. MS/TP networks may be used for terminal units.

6.2.5 OEM Controls and High Level Interfacing

Where outstations are supplied and fitted within other manufacturer's equipment it will be the responsibility of the appointed Controls Specialist to: -

- Ensure the strategy complies with this document.
- Commission the communications.
- Connect to the College network.
- Provide the graphic pages required by this document.

Where there is a requirement for an interface between manufacturer's equipment and the Trend control system, it shall be the manufacturer's responsibility to supply the required interface device. They should liaise with the Controls Specialist to determine the College requirements. Wherever possible, this interface should be over BACNet/IP, and must allow full read/write functionality. All devices which are connected to the ICT network must comply with ICT networking standards.

An interface provided for high level interfacing of any kind (including plant, VRF systems, metering etc.) should be capable of communicating with additional devices without the need for additional engineering from the Controls Specialist. Where interfacing software is provided which is 'locked', the interface should be programmed to its full capacity, even if all points are not used in the field.

Where automatic windows or vents are provided on a project, these should interface with the BMS, and should be adjustable via the BMS head end.

Where Modbus devices are used, each device on the network shall be addressed as required, but no device shall have an address below 11. This is to prevent devices remaining at their default address and clashing with devices which are subsequently added to the network.

6.2.6 Control Circuit

All modulating control valve and damper actuators shall have a power supply voltage of 24VAC and a control voltage of 0-10 VDC, with the exception of fan coil units which may use raise/lower actuators. 4-20mA output signals should not be used unless unavoidable for that item of equipment. 0V shall correspond to a closed signal, and 10V to fully open.

6.2.7 Field Devices

All field devices are to be of approved manufacture, unless prior approval is obtained from the Controls Engineer.

It is the Control Specialist's responsibility to select and locate all field devices to ensure that adequate protection is provided against water and dust ingress, mechanical damage, UV degradation and the effects of temperature.

All sensors used by the BMS in a control calculation must be calibrated in situ (with a UKAS (or similar) certified device), and a record of this will be included in the information provided before the College 10% witness takes place. Sensors are to be Thermistors, unless a high degree of accuracy is required for a specific project. If non thermistor sensors are used, this must be highlighted in the O&M to ensure that frequent recalibration takes place.

6.2.8 Control Valves

Control valves shall be of approved manufacturer and shall be installed to meet the requirements of their data sheets. Control valves fitted to steam and MPHW shall be manufactured from: -

- Nodular Iron on systems up to 2 bar or 50mm diameter.
- Cast Steel shall be used on all other installations.
- Actuators should be the spring return type.

6.2.9 Motor Drives

Variable speed drives for controlling motors shall be linked to the BMS to control speed, enable signal, monitor run and fault conditions. Where possible, control and monitoring of the drive (except for start/stop and direct speed demand) shall be sent/read over BACNet, either IP or MS/TP. If the drive has the capability to control itself to a given setpoint, the control sensor may be wired directly to the drive.

When a stop command is received, the drive will immediately remove power or actively slow the motor.

Special care shall be taken when selecting the drive to ensure that EMC and power supply harmonic pollution are minimised.

Where EC motors are fitted to main plant, and it is available, a high-level interface (typically Modbus) will collect information from the motor drive.

6.2.10 Air Proving

Where an air handling unit operates under pressure control software, a differential pressure switch should still be fitted across the fan to confirm airflow. Switches and pipework for smoke clearance or life safety fans should be metal, not plastic.

6.2.11 Filter Monitoring

Monitoring of filters shall utilise differential pressure sensors with dirty filter indication on the schematic pages originating from the alarm bit. Depending on the application it may be necessary to provide a variable filter dirty setpoint. A filter dirty lamp shall be provided on the panel fascia, operated from the outstation filter dirty alarm.

6.2.12 Lighting Hardware

Where complex lighting control is required, a dedicated lighting control system should be installed. This should interface to the BMS to provide time zone, PIR and (where applicable) colour temperature settings and information.

Further details of the College lighting policy can be found in the relevant section of this document.

6.3 Control Panels

6.3.1 Manufacture

Control panels shall be supplied and manufactured by the Controls Specialist selected for the project. Panels are to be RAL7035, there is no requirement for white backplates. DIN rails will be of the Top Hat type, with all components fixed using DIN rail wherever possible.

6.3.2 Panel Layout

Control panels shall be divided into two sections, one for power and one for controls (Form 2), unless there is no outgoing power from the panel. Where it is more practical, the plant may be fed from a separate distribution board, with the MCC (Form 1) only providing control.

The controls section shall be lockable using an approved key (E455). If there is a power section, the door shall be isolator interlocked. The power section shall not contain any items of equipment likely to be accessed during normal plant operation and maintenance. All panel items will be labelled using Dyna Tape labels, for cross referencing against panel drawings. Where panels are updated, labels will be fitted to the updated items.

6.3.3 Lighting

Each section of the control panel will incorporate an LED light arranged to extinguish on door closure, fed from the live side of the panel isolator. When required, AHU lighting shall be powered from the control panel. It shall be the Control Specialist's responsibility to wire up to the AHU lighting switch, which will be provided with the AHU.

6.3.4 Power Socket

The controls section shall incorporate a 13A RCD protected socket outlet to supply power for a laptop computer. Where items within the panel require a 13A socket for their power supply, this shall be fitted in addition to the laptop socket.

6.3.5 Control Circuits

All control circuits shall be low voltage 24VAC and supplied from a transformer with an appropriate rating allowing for future additions. Circuits will be divided and protected by separate MCBs where a level of subdivision is required. Terminals providing 24VAC to field devices shall be of the hinge disconnect type or individually fused.

6.3.6 Panel Wiring

Panel wiring shall follow the current wiring regulations. Currently this is:

Table 39 – Panel wiring colour coding

Application	Function	Colour coding
Phase colours	L1	Brown
	L2	Black
	L3	Grey
	N	Blue
230V control circuits (if required)	Live	Red
	N	Dark blue
ELV circuits	24VAC live	White
	24VAC 0V	Light blue
	24VDC live	Violet
	24VDC 0V	Violet
	Circuits where power is from elsewhere (e.g., providing a volt free contact)	Orange

Where terminal bars are used, these should be the same colour as the cables connected to them.

All sensors, 0-10V signals, and 4-20 mA signals should be wired from the controller terminals to the outgoing terminals in screened cable. If screened cable is recommended for a network (e.g., RS485, Trend Current Loop), this should also be used inside the panel. Careful attention should be paid to the earthing requirements for the screen.

The cable should be made off with 'Hellermann' type expanding sleeves with the screen sleeved in green / yellow. This includes RS485 networks which should have the screen for the network grounded at the master device (the screen will be wired straight through the incoming terminal rail. If the master device does not have a ground terminal, a ground point should be added adjacent to it). Where a terminator is fitted in the field, its position should be identified on the network diagram in the O&M manual. It is recommended to wire both ends of the MSTP or Modbus network to the control panel.

Cable termination ferrules shall be utilised, and markers shall be used to identify all control panel and field terminations in line with the control specialists wiring diagram.

6.3.7 MCBs

MCBs shall provide protection for all power and control circuits. Fuses shall not normally be used.

An MCB identification chart shall be supplied and permanently fixed in the section of the control panel housing the MCBs, listing device number, plant served, breaker rating and type. It shall also give a colour coding for the conductors used within the panel.

6.3.8 Panel Lamps

Panel fascia indication shall be by means of multi cluster LEDs with a minimum intensity of 240cd/m². Colour configuration shall be as follows:

Condition	Colour
Run indication (positive feedback)	Green
Enabled indication (no positive feedback)	Amber
Fault indication	Red
Frost indication	Blue
Control circuit live indication	White
Filter Dirty	Orange

A lamp test facility shall also be provided.

6.3.9 Relays

Where a combination of different coil voltages for plug in relays within a control panel exist, bases with a different pin configuration shall be used for each voltage present.

6.3.10 Contactors

Contactors shall have coils rated at 24VAC.

6.3.11 Shrouding

All exposed live electrical terminations and equipment within both power and control sections shall be shrouded against accidental contact.

6.3.12 Panel Fascia

Fascia switches and indicators shall be identified with engraved labels. Switches to override automatic operation shall have the inscription 'Hand/Off/Auto. The control panel shall have its designated name and number engraved on a label. All labels shall be fixed to the panel using nuts and bolts. Label text shall clearly indicate the plant served, for example only showing a pump reference would not be acceptable.

Where labels and switches are provided for future equipment, it shall be clear (using Dymo labels if necessary) that this item of plant is for future use. Each section shall be fitted with appropriate voltage and isolation warning labels.

6.3.13 Switch monitoring

The status of all plant switches on the control panel facia shall be monitored by a single digital input. This input will be used to indicate on the plant schematics when any piece of plant is NOT in auto. The not in Auto monitor will send an alarm to the Maintenance manager for that building each day that the panel is not operating in full auto. Switches for plant which is not fitted at the time of project completion will be linked out to prevent false indication.

6.3.14 Spare Capacity

25% spare input and 25% spare output physical capacity (room on DIN rails within the panel) shall be allowed to accommodate additions to the system. Any spare fitted IO will be wired to the panel terminal rails. (In the case of spare digital outputs, they should be wired in orange as detailed above).

The use of multiplexed input and output modules will not be permitted other than to drive panel indicator lamps or monitor noncritical inputs for information. Single relay modules may be used to convert analogue outputs to digital. Distributed IO may be considered if it is appropriate for the project, as will networked (i.e., Modbus) field devices if no additional setup is required for the interface device, and it provides no intelligent functionality.

6.3.15 Plant Reset

A master plant reset button shall be incorporated on the control panel facia. The function of this push button is to reset all software lockouts for plant controlled from the panel. The operation of this button shall have no effect on plant that does not require a reset. The button provides a local duplicate of the reset button shown on the graphics pages for that plant.

The reset button may be omitted providing there is no plant within the control panel that may require resetting.

6.3.16 Interface Enclosures

Where there is a requirement to fit an interface away from an MCC (for an FCU network, Modbus network, remote IO on an AHU etc), this may be fitted in a single section enclosure. There is no requirement for a panel live lamp, or internal lighting. However, a nearby socket to locally power a laptop, and a datapoint are still required.

6.3.17 Outstations mounted in Panel

Outstations mounted within a control panel shall have all input/output terminals wired to terminal rail located at the top or bottom of the panel, including spare IO points. Where more than one outstation is fitted in a panel, it should be possible to isolate individual controllers (typically from an MCB).

6.3.18 UPS

If there is a requirement to fit a UPS within the panel, it should be possible to bypass the UPS without any wiring works (for example using IEC60320 C13/14 plugs). The BMS shall monitor the state of the UPS, and generate an alarm in the event of the UPS being in fault, or in the event of a power failure. The use of a UPS should be avoided unless it is critical to monitor during power outages (the controller and control circuit may still be operating, but plant and possibly the ICT network will not). Where a panel is fed by an ATS, the status of this switch shall be monitored.

6.3.19 Panel Drawings

A copy of the "as fitted" panel wiring diagram shall be located within the controls section of the control panel in a mounted document wallet. A list of jumper and switch settings for devices within the panel shall be included with the wiring diagrams. No other documentation or spares shall be stored within the panel. The wallet shall be securely fixed, double sided tape or pads are not acceptable. The requirements for panel drawings are listed in the documentation section of this document.

6.4 Installation

6.4.1 Sensor Locations

Sensors must be located in a location which gives a good indication of the condition of the service being controlled or monitored. For example, pump dp sensors will be fitted to an index leg, not across the pumps, AHU pressure and temperature sensors will be situated in a suitably straight run of duct, away from the AHU itself and any other sources of turbulence, and shall be within the airstream, not at the edge of the duct.

Internal AHU sensors (such as off frost coil) will be situated within the air stream and should also be used to protect the AHU in the event of frost (in addition to the frost stat, which will be of the capillary type, laced across the downstream side of the frost coil, the switching mechanism will be located inside the AHU).

For FCUs, room sensors will be used for control. If a return sensor is to be used, this must be agreed with the Controls Engineer. Any return sensor which are used should be located in a ceiling return grille, not in the ceiling void, to attempt to give a reasonable indication of space temperature.

Sensor locations will be indicated as part of the mechanical design for each item of plant or space.

Each building in the South Kensington Campus will receive the outside air temperature from the central weather station, however there should be one backup sensor per building, to use in the event of Comms failure. It is the Contractor’s responsibility to ensure that this is working correctly before witnessing takes place.

6.4.2 Outstations mounted on Plant

Outstations located remotely (i.e. FCUs) shall be isolated adjacent to the outstation and not in a position were accidental isolation can occur. Prewired sensors (eg FCU supply and return sensors) will be wired and supplied coiled ready to be installed in a representative location (in this example, ductwork or ceiling grilles) once on site.

6.4.3 Field Device Installation

Field equipment that requires specialised wiring or device set up should be clearly documented. Devices requiring to be set up using switches, jumpers or other method will, in addition to the documentation, have these details included in the panel document wallet. This information will also be included in the O&M documentation.

Where field devices are part of a set, careful note must be taken of the numbering of the plant. If no design numbering exists from the design, all field devices should be assumed to be numbered from left to right when facing the plant form the normal access point.

6.4.4 Equipment Identification

All main plant field devices are to be identified with identification labels, with the label being attached as close as possible to the device, but not on it (with the exception of sensors located in pipework with no other nearby containment). Directly printed plastic labels may be used, however handwritten labels will not be accepted.

6.4.5 Field Wiring

All field equipment shall be wired using manufacturers recommended cable.

Field wiring shall be wired individually from the control panel, the use of multi-core cables with marshalling boxes will not normally be permitted, however where packaged plant is utilised, or separate wiring would be impractical, an exception can be raised. If a marshalling box is used, a list of all terminals will be securely fixed to the inside of the box lid. Controls related equipment shall be wired via isolation or fused terminals. Control cables (low voltage) and power cables will not be run in the same section of trunking.

All field and network cables shall be numbered at each end using the same numbering topology used for the associated control panel terminal numbers. The cable will be marked every 10 meters or change of direction with an engraved or printed label fixed to the cable using cable ties:

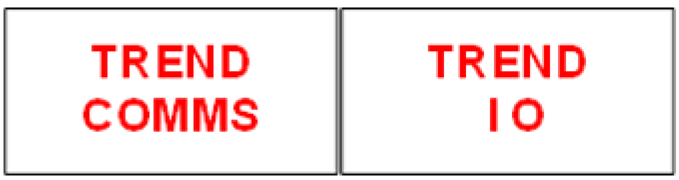

Figure 13 – Labels for BMS field and network cables

The above requirement can be omitted providing the cable is marked throughout its entire length with 'Trend'.

Power wiring and signal/network cabling should be run separately. Data or fire/security containment should not be used unless this has been agreed with the project manager.

6.4.6 Network Cabling

SWA Network cable will be used outside of plant room areas for distances exceeding 10m unless the cable is run in containment (excluding FCU networks). Network cable shall meet manufacturer's recommendations.

6.4.7 Fire Alarm Interlock

The fire alarm installer will provide a suitable length coil of fire rated cable at the control panel gland plate, and a red cable gland. The cable will be terminated in the fire alarm interface by the fire alarm installer, such that a healthy condition will be indicated by a set of closed contacts. It is the responsibility of the Controls specialist to pull the cable into the control panel and terminate it.

6.4.8 Access to Devices

Where possible, all field devices shall be situated such that maintenance and replacement can be carried out quickly and efficiently, without the need for access equipment or to close off an area to the normal users of the space. If the mechanical design shows control equipment in a poor location, this should be brought to the attention of the project manager immediately.

If it is necessary to site field equipment where cabling would be impractical, it may be possible to use wireless or networked devices or remote IO interfaces. This should be discussed with the College Controls Engineer before it is included in any design.

6.4.9 Data Connection

Where there is a requirement for ICT data sockets to be installed, this work is to be undertaken by a College approved ICT Data installer. Data sockets will be installed within MCCs or packaged plant. A separate socket is required for each Ethernet device, and one per panel for connection of an Engineer's laptop. The panel manufacturer will install cable management and a socket backbox (from the MK logic range, with access for the IT cabling pre-cut in both the socket and the control panel gland plate) for the ICT installer to wire and fit a faceplate. Patch leads within the MCC will be red, and will be numbered at both ends to allow identification. It should be noted that the College is now using CAT6 cable in many areas, which has a much larger minimum radius than CAT5E.

6.4.10 Hostname provision

It is the responsibility of the Controls Specialist designer to advise the PM of the quantity and location of the data sockets for each project. Unique outstation addresses, LAN numbers and device Hostnames must be applied for as early as possible by the Controls Specialist from the Controls Engineer using Table 44. Please note that the MAC addresses of each Ethernet device will be required at this time. The request will be passed to ICT to allow the sockets and switches to be enabled as early as possible. It may take up to 7 working days to register a device on the network, and this should be allowed for by the Contractor.

6.5 Control Software

6.5.1 Standard Strategy

A copy of the latest standard strategies, and the standard numbering and labelling conventions should be requested from the Controls Engineer at the start of the project works. These should be used to build up an outstation configuration or be used in full in the case of fan coil units. The strategy will then be adjusted to suit the individual project. The requirements for IO will be provided by the Mechanical sub-contractor to the BMS specialist.

6.5.2 Strategy Philosophy

Strategy design should be carried out in a consistent, structured manner and be kept as simple as possible whilst providing effective and efficient control to the specific requirements of the project. Innovative solutions which provide a long-term benefit to the College will be welcomed for consideration with the Engineering, Energy and Environment Team.

In general, the demand for primary plant shall be sourced from terminal units.

OSS will be used, where applicable, for both heating and cooling. If the room is to be covered by the room booking system, the standard room booking software switches will be included. Heating OSS will hold off primary air plant until occupation time, cooling OSS will make as much use of free cooling as possible. Night purge should also be used on primary air plant.

Duty/standby plant will changeover during normal working hours to ensure that staff are available to respond to any issues. The changeover will be based on hours run, rather than just fixed times.

The frost control strategy shall operate as follows:

The frost coil valve will operate to open proportionally to the outside air temperature. Typically, the frost setpoint will be 6°C (outside air temperature), and the valve will open 25% for every degree the outside air temperature falls below this setpoint.

In the event of the frost thermostat detecting a frost condition, the AHU will be shut down until the condition clears. A frost alarm will be generated. The frost coil valve will drive to 100%, the chilled water valve to 50% and the reheater valve to 50%. When the frost condition clears, the AHU will revert to normal operation. Should a frost condition occur 3 times within 60 minutes, the AHU will lock out, and a frost lockout alarm will be generated. The AHU will remain in a lockout condition until the frost condition clears, and a manual reset is performed from either the plant reset button on the MCC, or the software reset on the head end graphics.

Plant will start-up in a sequence which reduces instantaneous electrical loads (i.e. don't start primary and secondary pumps or all FCUs on a floor together)

All overrides (including room adjuster setpoints) will reset at midnight each day, setpoint limits will prevent room adjusters or graphical adjustments from taking a room setpoint beyond the College Building Temperature Protocol. A setpoint will generally be the middle of a deadband. Setpoints for plant which has heating/cooling capability will have a deadband applied to comply with the Building Temperature Protocol wherever possible. The size of the deadband in use will be determined by the occupancy of the room, which will be detected by a PIR. Where possible this will be the same device used for the lighting control.

6.5.3 IO labelling

Each point in a controller shall be labelled in a unique and unambiguous manner. Any reference to room numbers should ensure the final College room number is used and not project numbers. Room numbering is obtained from the Imperial College London Space Management Team.

6.5.4 Main Plant Controllers

The identifier of a controller or device should indicate the area and / or plant that is being controlled. Please see Section 7.6.

6.5.5 FCU Controllers

The identifier in fan coil unit controllers should indicate the final College room number to allow for the use of generic graphic pages. Room numbering is obtained from the Imperial College London Estates Space management Team. In zones where more than one FCU serves the space, the FCUs should be arranged as master/slave, with only one sensor value (averaged if in a large room) used for temperature control. The identifier or other label in software should indicate which controller is the master, and which are slaves. This should also be shown on related graphics pages.

If an FCU has a condensate pump, the fault status should be monitored by the FCU controller.

6.5.6 Logging

Sensors, calculated setpoints, inputs, loop outputs and driver demands shall be logged at 1-minute intervals until witnessing is complete (unless overnight/weekend tests are being run). At this point the plots will be uploaded and changed to 15-minute logging periods. For IQEco controllers, the logging will be set at 15 minutes throughout the project, unless an area is experiencing particular problems.

Points to be logged will include (depending on hardware fitted):

- Space Temp;
- Supply Temp;
- Return Temp;
- Valve Positions;
- Loop Outputs;
- Fan speed demands;
- Pump speed demands;
- Supply and Extract duct pressures;
- Water pressures; and
- HWS Flow, Return and Storage Temperatures.

6.5.7 Inter Controller Communications

When engineering the system, consideration should be given to keep communications traffic to a minimum. It is the Controls Specialists' responsibility to ensure that no conflicts occur with the existing College network.

In general, all common items of plant shall be controlled from a single outstation and not from two smaller ones.

BACNet points should only be collected by a controller where they are necessary for control.

6.5.8 Time Synchronisation

For a new installation, the lowest numbered outstation on the main plant LAN shall be the time master, and use NTP synchronisation. Where additions are made to an existing system, special attention should be taken to the time module compatibility between different types of device.

6.5.9 Security

Prior to witnessing, the Control specialist will ensure that every outstation has two maximum level user/password/PINs set up, the details of which will be provided by the Controls Engineer.

6.5.10 Alarm Grouping

Alarm reporting will be filtered using point labels and LAN addresses. Alarms shall be assigned to groups to allow flexibility.

6.5.11 Critical Alarms

The Project Manager shall co-ordinate with the maintenance manager, the appointed Controls Specialist and the BMS Engineer to create a list of the critical alarms required, their priority and destination addresses. Alarms shall only be reported when the associated plant is intended to be operational. It is the Controls Specialists' responsibility to ensure that alarm levels and time delays are set at realistic settings. Care should be taken to ensure that cascade alarms do not occur (ie in the event of a damper failure, the fan and airflow alarms should not be generated). The Controls Specialist shall inform the Project Manager if the requested settings will not be achievable.

The Project Manager should then co-ordinate the appropriate action to rectify any design issues.

6.5.12 Alarm Transmission

All alarms will be set up in strategy by the Controls Specialist, but the transmission will be left disabled. It will be necessary to demonstrate successful alarm operation to the College IQVision BMS head end during witnessing.

6.6 Modifications to Existing Systems

6.6.1 Introduction

New and additional works shall comply fully with the other sections of this document. Before starting works on any existing system, the BMS Engineer must be notified of the works. Failure to notify the BMS Engineer may result in all activities being immediately stopped.

6.6.2 Initial Documentation

Existing documentation will be 'back engineered' where necessary (the majority of the College controllers will now have been programmed using SET) and provided as an exported SET file and in PDF format.

6.6.3 Firmware

Outstation firmware shall be updated to the current version for that type of hardware.

6.6.4 Redundant Equipment

Redundant field and control panel equipment shall be removed and offered to the BMS engineer as spares. The project manager should be notified of the asset numbers of any equipment which is removed. Any holes left in control panel doors shall be covered with permanent labels.

6.6.5 Equipment Condition

Where existing equipment is to be re-used it is the Controls Specialists' responsibility to ensure it is in good working order at the start of the project. The Project Manager should be advised if a replacement or remedial works are required.

6.6.6 Plant Interlocks

Additions to the existing system shall be engineered to fully integrate with existing plant. This shall include but is not limited to:

- Boiler interlocking for heat demands;
- Chiller interlocking for cooling demands;
- Frost protection requirements;
- Interlocking of time zones and calendar scheduling;
- Valve exercising routines;
- Water treatment and antistagnation routines;
- Night purge; and
- Building OSS.

Where an interlock would normally be hardwired, the safety circuit shall be extended to cover the new plant, sending interlock signals over the BMS network will not be

6.7 Graphics

6.7.1 College BMS Head End

The College supervisors are being upgraded to Trend IQVision. All new works will be provided with IQVision graphics. Graphics updates will be completed by the controls specialist, uploads to the College IQVision server should be arranged with the College maintenance provider.

Access to the servers will not be available to the Controls Specialist until the graphics pages for a project have been witnessed. New projects will be added to the Engineering machine only to allow the new pages to be fully tested and witnessed by the Imperial College London Controls Engineer. Once this process is completed the Project Manager will notify the College BMS maintenance provider that the project is ready to transfer from the Engineering PC to the BMS servers. This will be completed and demonstrated by the Controls Specialist, who will then relabel any obsolete pages on 963 and replace them with a link to IQVision.

6.7.2 Server and Network Connection Provision

Access to BMS schematic pages shall be with a client PC via the BMS Server. No other stand-alone supervisors will be connected to the College network, except an Engineer's laptop being used for commissioning and witnessing. No touchscreen displays are to be fitted to control panels.

Before attending site, the mac addresses of any Engineering laptops which are to be connected to the College network will be required. At least one week's notice is required for a connection.

6.7.3 Schematic Pages

Schematic graphic pages shall be provided for each item of plant. These pages will follow the format detailed later in this document and will operate from the existing BMS server. Pages provided for the IQVision server will be made from the Trend 2D SVG library, any additional items required will be made from SVG images. Existing pages which will have links to the new pages, and site summary pages (such as dashboards) will be updated to include any new plant.

6.7.4 Existing Pages

The Controls Specialist shall obtain the latest graphics standards before commencing schematic page construction. No additional files will be added to the standard libraries without authorisation.

6.7.5 Page Layout

Schematic pages shall be provided for each item of plant supplied on the project. Plant will logically flow from left to right on the page. Plant that is only monitored by the control system will also have a schematic page with a note on the page indicating that the plant is not controlled by the BMS.

Each page will have a description of the location of the item/plant on the page. Beside the timeclock at the top of the page will be a hidden button (high PIN level) to open a VIEWPOINTS type window for that page.

6.7.6 Required Pages

A standard schematic page format for an item of plant shall consist of two pages. The first page shall be a view only page indicating the true operation of the plant. BMS enable points and read-back points shall be utilised, indicating that the plant is demanded and operating. Temperatures and demand signals shall be displayed from internal sensors so that these points may be graphed. Unless there is a specific project requirement, all temperatures, water circuit pressures, electrical frequencies (including VSD outputs) and voltages will be displayed to 1 decimal place, air pressures, actuator commands and enumerated points (which cannot be shown as text) will only display whole numbers.

The second page shall consist of an adjustments page showing plant settings which a maintenance Engineer or Supervisor would be expected to adjust. Any other adjustments should be completed by a BMS Engineer using Engineering software.

For groups of FCUs an overview page shall be added, listing device LAN, Address, Name, Attributes, sensed temperature, setpoint, supply temperature, heating demand, cooling demand, fan demand and occupancy state. Master and slave units should also be indicated. Care should be taken to divide the devices across a number of pages, to prevent the page refresh from being too slow.

Navigation will be in line with the existing College graphics to split up plant, floors and zones. The services menu will include a button to provide a list of all devices in each LAN of the building, showing the devices which would be expected to be present, and from each device, dynamic points of label, outstation status and current time.

Plant shall include navigation to the primary plant which serves it, for example FCU coils which will link to the FCU secondary pump page. Primary circuits shall include links to the secondary circuits which are served, and an indication of the secondary plant which is demanding it (this may need to be a separate summary page on larger buildings).

All sensors, setpoints and demand signals will follow the College colour standard.

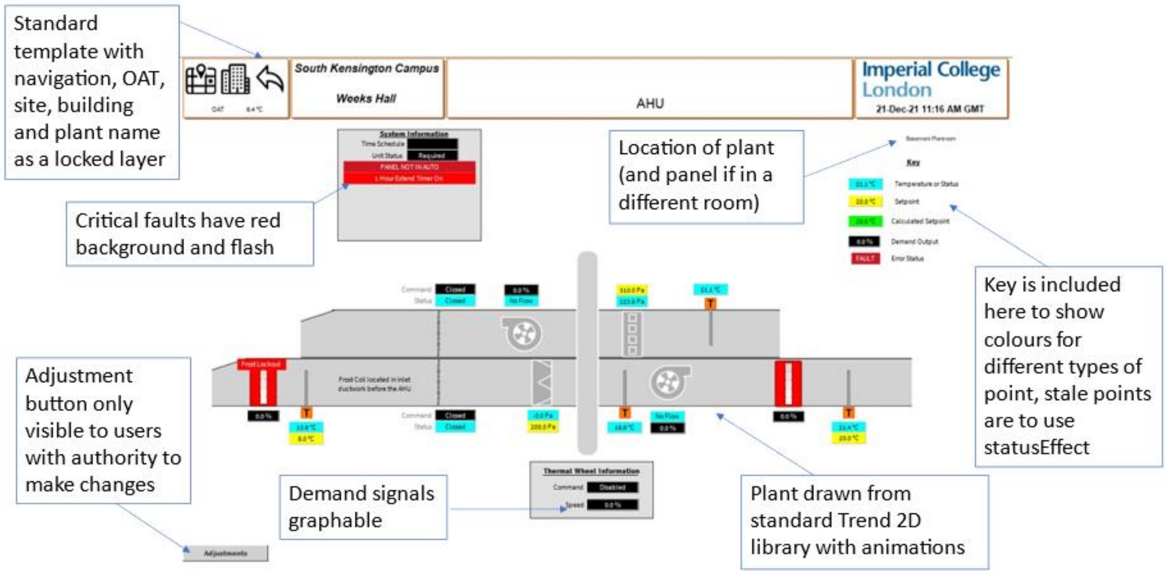

Figure 14 – College BMS graphics standard

6.7.7 Floor Plans

Floor plans shall be provided to the Controls Specialist by the main contractor, detailing locations of plant and final College room numbers. They shall be provided before commissioning starts. Files shall be in DWG format, then inserted onto an Imperial College blank backdrop and saved as a SVG image.

Navigation buttons will be provided to floors above, below and adjacent areas, as well as to the overview page for that area.

Where multiple AHUs serve a floor, the areas served by each AHU should be shown on the floor plans, and links provided to navigate to the AHU pages. The location of BMS equipment (MCCs, CEs, Network interfaces etc) will be shown on floor layout pages, and each item of plant will have a locate button which will link to the floor plan showing the location of the plant. Terminal units displayed on floor plans will utilise a standard module showing various operating parameters for the unit.

6.7.8 Adjustments Page

Buttons on the adjustments page should be provided to:

- Override control valve and damper actuators;
- To enable the valve exercise routine;

- To operate a 1-hour plant extension routine; and
- These buttons are to be set with a PIN level of 49.

Knobs are to be provided on the adjustments page to: - Position valve and damper actuators when in override. Allow adjustment of set points. These buttons are to be set with a PIN level of 10 for standard set points and overrides, 50 for Engineering set points and 90 for critical set points that would have a detrimental effect on the system operation. It should not be possible for the user to permanently override an item of plant into auto operation. Plant overrides and setpoints (from digital room adjusters) shall be reset daily.

6.7.9 Time zones

Time zones should be accessed via a button on the adjustments page set at a PIN level of 90. Where a non-Trend device or interface has been fitted, the time zone for that equipment should be located in an IQ controller to allow the time zone to be managed from the BMS server. This includes any lighting control which is interfaced to the BMS.

Uploading Graphics Pages

Following the completion of witnessing and testing, the schematic pages can be installed onto the BMS server.

The format for witnessing of the schematic pages to the Controls Engineer shall be:

- Confirm file structure and pages to be copied;
- Issue files to the College BMS maintenance provider for uploading onto the server; and
- Witness 100% operation of pages and points ensuring compliance with strategies. Graphics will be demonstrated on a range of devices.

6.8 Commissioning

6.8.1 Primary Systems

Final commissioning of the control system shall only commence when all associated air and water systems are fully balanced. This will be confirmed in writing by the project M&E Engineers to the project manager.

6.8.2 Commissioning Requirements

Commissioning and Witnessing will follow the requirements set out below and in section 7.12, however note should also be taken of the requirements of CIBSE Commissioning Guide C.

6.8.3 Network Connection

Where a network is required to prove operation of a system, the Controls specialist should notify the College controls Engineer of the requirements well in advance of commissioning. This may typically be achieved by setting controllers to a temporary UDP. Once witnessing is complete, all unnecessary vCNCs and supervisor ports will be removed, and the GUIDs will be matched to the existing site.

The details which must be submitted to request connection to the College network are listed in Table 44.

6.8.4 Documentation for Witnessing

Prior to witnessing, the Project Manager shall ensure the following documentation is supplied to the College Controls Engineer:

- Network wiring drawing for the project including location of terminators;
- Description of operation;
- Panel wiring diagrams;
- Location drawings for MCCs, FCUs, BMS Network devices and field devices;
- Strategy diagrams;
- Control sensor calibration offsets; and
- Commissioning sheets showing an independent point and operation check to graphics by a College appointed validation Engineer.

6.8.5 Witnessing

The format for witnessing to the Controls Engineer by the Controls Specialist shall be:

- Review of the documentation.
- Inspection of the field equipment.
- Review updates to the software supplied at the design stage.

- Functionality test of the software and graphics pages, which will include at least 10% of the IO points, with adjustments made to test the security levels set up.
- Operational stability of the system, including stable operation data over a suitable time period (typically 2 weeks).

6.9 Metering

6.9.1 Metering Requirements

7 Please refer to the Sustainability

7.1 Introduction

7.1.1 College sustainability strategy

Imperial College London (Imperial College London) recently published 'Sustainable Imperial' which outlines its vision, strategy, target for achieving net zero carbon emission by 2040 (long term). The short target is to reduce carbon emissions by 15% by 2025 – 26 against a baseline emission for 2018 -19.

The 2021-26 detailed strategy can be found in the link below:

https://www.imperial.ac.uk/media/imperial-college/about/sustainability/public/Imperial_Sustainability_Strategy_2021-26.pdf

Estates Operations is a key stakeholder tasked with this target and recognises the challenge and opportunity to reduce its carbon emissions.

These will be met by the following actions:

- Reduce energy consumption
- Identify and minimise scope 3 emissions
- Increase where possible renewable energy generation
- Improve control of all building energy use and enhance data gathering
- Increase water efficiency through design, operation, and maintenance
- Improve building fabric insulation

- Minimise all environmental impacts through challenging embodied and operational carbon in construction and operational use.
- Report agreed Key Performance Indicators (KPI) during each key building project phase (e.g., RIBA construction plan)
- Always expect the highest standard of sustainable construction
- Minimise waste and maximise recycling
- Protect, maintain, and enhance university estate local biodiversity
- Reduce environmental risk and pollution via good Health Safety & Environmental practices
- Comply with legal and other environmental requirements
- Promote sustainable procurement and consider circular economy
- Promote the use of life cycle costing
- Engage with students, faculty departments and other key College stakeholders in maximising sustainability opportunities during building projects
- Raise awareness of sustainability issues and provide opportunities to develop skills and knowledge

7.2 Process

Members of Estates Operations will work with the appointed College "Sustainability Champion" and Engineering, Energy and Environment team in identifying the appropriate actions.

The process will be required to evaluate the procurement, design, construction, and operation of a development against targets that are based on performance benchmarks.

7.2.1 Energy Use Intensity (EUI) benchmarks to be used.

Leading building industry recommend that by 2030 all new building must operate at net zero carbon to meet the current carbon emission targets for UK. The industry is moving towards the EUI target benchmark for electricity and fossil fuel measured as $kWh/m^2/yr$ (GIA) measured at the meter (regulated and unregulated, excluding on site generation). These benchmark targets are derived from predicted energy use modelling, review of best practicing buildings in the UK and preliminary assessment of the renewable energy supply for the UK. Target range (best to typical practice) are shown below and expect all new building projects to be delivered to within the best practice range.

Table 45 – Minimum required Energy Use Intensity (EUI) benchmark

Building type	Fuel Type	Best practice kWh/m²/yr (GIA)	Typical practice kWh/m²/yr (GIA)
Science labs	Electricity	131	193
	Fossil Fuel	135	194
Academic (non- lab)	Electricity	57	89
	Fossil Fuel	83	116
Residential	Electricity	49	64
	Fossil Fuel	148	199

7.2.2 BREEAM

Imperial College requires all new buildings to achieve a minimum of BREEAM "Excellent" rating and refurbishments over £5M to achieve BREEAM very good.

7.3 Assessment Tools

7.3.1 Building Thermal Models

The specification and standard performance of the thermal elements and controlled services is to be monitored throughout the design and construction process to ensure that the standards approved by the College are implemented and incorporated into the finished building. If there are any significant changes to the building or engineering systems design, an assessment should be undertaken to ensure the changes do not compromise the objective of meeting the sustainability targets.

7.3.2 Life Cycle Costing Analysis

To evaluate the financial efficiency of the measures proposed to meet the carbon reduction requirements, the Project Team shall provide a life cycle cost assessment for each proposal where appropriate. This is required to enable the Project Board to assess benefits of each proposal considering the carbon savings as well as maintenance and replacement costs.

A life cycle cost assessment is to be produced for any improvement measures proposed for achieving the targeted ratings including full financial and environmental costs. This will give the Project Manager the opportunity to present a case to the Project Board to seek extra funding if the benefits of increased efficiency can be demonstrated.

The ownership of life cycle cost model shall be with Project Manager and, with technical input from the design consultants.

A Life cycle cost assessment for a 25-year period is to be carried out for each proposal made with costs to be assessed for the following:

- Capital cost;
- Expected life and replacement cost;
- Installation and commissioning cost;
- Disposal cost;
- Energy and environments cost including lifetime forecast;
- Reliability and durability based on maintenance feedback; and
- Financial appraisal to include future cost based on today's value (NPV).

If the life of the project is known to be less than 25 years, the accounting period should be the same as the life of the project.

For further advice on whole life costing methodology, refer to the Green Book issued by the Treasury, and the College Sustainability Toolkit.

http://greenbook.treasury.gov.uk/

The life cycle cost assessment for each design proposal is to be submitted to the Project Board to enable the benefits to be assessed, with input from the Director of Facilities Management and Engineering Manager as necessary. The Project Board will then issue instructions regarding the appropriate level of implementation.

Factors to be assumed in whole life cost analysis:

Accounting period	25 years
Discount rate	4.5%

7.3.3 Building Regulation Part L

The Building Regulations set out requirements for specific aspects of building design and construction. Regulation 26 of the building regulations states that “Where a building is erected, it shall not exceed the target CO2 emission rate for the building…”, and Schedule 1 – Part L Conservation of fuel and power states that provision for conservation of fuel and power shall be made by: limiting heat gain and losses and providing building service which are efficient, have effective controls and are properly commissioned and that information is provided so that the building can be operated efficiently.

7.3.3.1 Consequential improvements

Consequential improvements refer to energy efficiency improvements required by regulation 28 of the Building Regulations, guidance for which appears in Section 6 of Approved document L2B: Conservation of fuel and power in existing buildings other than dwellings.

The regulation relates to proposed works to existing buildings (other than dwellings) with a total useful floor area of over 1000m^2, and include:

- An extension.
- Installation of new fixed building services (other than renewable energy generators).
- Increasing the capacity of fixed building services (other than renewable energy generators).
- The improvement works must be technically, functionally, and economically feasible.

In most circumstances, this means that the payback period for the consequential improvements required does not exceed 15 years (or less if the expected life of the building is less than 15 years).

Consequential improvements may include:

- Upgrading heating, cooling, or air handling systems.
- Upgrading lighting systems.
- Installing energy metering.
- Upgrading thermal elements.
- Replacing windows.
- On-site energy generation.

- Applying measures proposed in a recommendations report accompanying an Energy Performance Certificate.

7.4 Considerations

7.4.1 Examples of energy efficiency opportunities for consideration

The following are examples of passive design measures and efficient building services strategies which should be considered for each new building.

The optimum combination of measures should be selected to suit the building strategy.

7.4.1.1 Optimising Passive Design Features: (General considerations)

- The amount and type of glazing, along with the shape, location, and functionality of the windows, are key factors in the effective control of heat losses and gains to the building. The proportions of glazing should be optimised on each façade to balance the energy requirements with the need for views out and the specific internal environments required.
- Optimising daylight access should be considered to limit the need for artificial lighting.
- Reducing the thermal transmittance of the building envelope by increasing insulation will help reduce heating demand and result in lower heating energy consumption. U-values for external wall, glazing, roof, and floor are likely to exceed the minimum target requirements of Part L.
- Minimising air leakage through airtight construction methods can reduce heating/cooling loads and help reduce draughts.
- Low energy ventilation strategies such as natural ventilation or mechanical ventilation with efficient heat recovery should be evaluated.
- Thermal mass is useful to stabilise internal temperatures in winter and summer. Exposed concrete allows buildings to benefit from night-time cooling, therefore reducing demands for mechanical cooling.

Efficient Building Services Considerations:

- Centralised heating and cooling plant can allow the selection of large, high efficiency, engineered central plant.
- Reduced ventilation requirements
- Specify lean (i.e., energy efficient) equipment
- Ventilation control and Building Management Systems will help to reduce fan energy when not in use. Please refer to the College Building Engineering Services Particular Requirement for further information.
- High efficiency motors incorporated into all building services.
- High efficiency boiler plant and chillers.
- Air to air heat recovery and variable speed fans installed within air handling plant, where provided, to recover the heat in the extract airstreams prior to the exhaust of vitiated air to atmosphere and minimise energy use required for supplying and exhausting air.
- High efficiency electronic lighting ballasts and high efficacy lamps.
- Passive infra-red and daylight responsive lighting control.

Metering section of this document.

7.5 Documentation

7.5.1 Additional Documentation

The documentation required by this document is over and above the College operation and maintenance manual requirements and should be supplied direct to the College Controls Engineer. The installation works will not be considered complete and handed over if the documentation required by Section 7.5.2 is not in place.

7.5.2 Final Documentation

On completion of the commissioning and witnessing a soft copy of the documentation on a CD or flash drive shall be supplied in addition to the requirements of the main project team. The following documentation shall be supplied to the College Controls Engineuer within 5 days: -

- Description of services controlled by each device (DOC format).
- Control strategy drawings (PDF format).
- Control strategy files (SET format).
- List of setpoints and sensor calibration offsets in their commissioned state including tuned loop settings (PDF format)
- A backup of the finished graphics pages
- Description of operation for each plant (DOC format).
- List of potential alarms or major faults, their possible causes and effects on other parts of the system.
- Schedule of equipment including College Asset Numbers (DOC format).
- Control panel wiring diagrams (PDF and DWG format).
- Location drawings for MCCs, FCUs (including node addresses), BMS Network devices and field devices (DWG format)
- Network wiring drawing for the project including location of terminators

7.6 Network Addresses and College Codes

This section details the standard Imperial College London codes to be used for outstation identifiers. Device information should be written in full wherever possible, where the plant is not covered by the existing IO templates. Further information regarding additional codes can be obtained from the College Controls Engineer. Refer to the Space Team regarding Campus and Building codes, and room numbering.

Identifier construction should follow: -

- Site Code-Building Code (3 or 4 characters)-Floor Code-BMS (LAN number)-Outstation number).

The only exception to this shall be FCUs which should follow: -

- FCU Reference-Building Code (3 or 4 characters)-Room number.
- Labels should be taken from the standard IO list and follow the naming pattern in the list.

Table 40 – Floor Codes

Floor code	Floor
SB	Sub-Basement
B	Basement
LG	Lower Ground Floor
G	Ground Floor
01	Level 1 or 1st. Floor
02	Level 2 or 2nd. Floor (Continue until)
RF	Roof Level

Table 41 – Identifiers Examples

Example Outstation Identifier	SK-SHE-B-4-20
Example FCU Identifier	FCU3-30-321

Table 42 – Metering Equipment Codes

Equipment Code	Equipment
SM	Steam
GM	Gas
LTHW	LTHW
MTHW	MTHW
PWM	Process Water
LGHR	Low Grade Heat Recovery

CAM	Compressed Air
EM	Electrical
E	Un-Metered Electrical Supply
WM	Water
CHW	Chilled Water
EWM	Economy Water

Table 43 – LAN numbering Examples

Floor Served	LAN numbers
Primary LTHW and CHW plant	1
Basement	4-5
Ground	7-8
First	11-19
Second	21-29
Third	31-39
Fourth	41-49
Fifth	51-59
Sixth	61-69
Seventh	71-79
Eighth	81-89

Generally, a main Ethernet LAN on a floor will be the lowest number (e.g. IQ4 devices on the third floor will be LAN 31), the next four are reserved for fan coil and terminal units (e.g. 32-35), two for lighting control (36 and 37) and two for metering (38 and 39).

On each LAN, one controller will be set up to provide vCNC access to IQVision. All 3 vCNCs will be set up, addresses 111-113, nodes 10111-10113 (connections from IQVision will be 10112 and 10113). This template will not be suitable for every project, and in cases where additions are being made to an existing building. If a major deviation is required from this principle, it should be discussed with the College Controls Engineer.

If a new LAN is created, one vCNC should be set up for IQVision to use, with an address of 116, port 10009. Please confirm this and any other requirements with the Controls Engineer before setting up.

Where BACNet devices are used, the network numbers should be used which match the LAN numbers, a BBMD should not be set up without approval from the College Controls Engineer.

Table 44 – ICT Connection Request

Device	LAN	O/S	Location	IP/DHCP Hostname	ICT Socket No.	Mac	UDP	Device Identifier	Comments
	**	**		**			**		
	**	**		**			**		
	**	**		**			**		

** To be added by Controls Engineer

7.7 BMS Project Procedure

RIBA Stage 3

- Following outline M&E design, M&E engineer will produce an outline operation description for the control system. This will be presented at ERM

RIBA Stage 4

- M&E Engineer produces detailed operation description and IO points list following design updates and Stage 3 ERM comments.
- Exception Reports related to the design submitted for approval.
- final Stage 4 design completed following comments from ERM and TAG.

RIBA Stage 5

- BMS contractor employed by Principal/M&E contractor to produce final BMS design to M&E Engineer's description.
- Final Stage 5 design issued to Independent Validation Engineer, M&E supervisor, and Controls Engineer for comments.
- Construction, installation, and initial commissioning works completed on site
- M&E commissioning completed
- M&E commissioning documentation issued to project manager
- BMS final commissioning completed
- BMS commissioning and as installed documentation issued to Independent Validation Engineer
- Independent Validation Engineer carries out 100%-point check and functional testing as per Scope of Duties.

- Validation Engineer confirms final validation process complete, and issues reports to Project Manager and the Engineering, Energy and Environment Team.
- Main Contractor confirms that system is available for Engineering, Energy and Environment Team witnessing.
- Engineering, Energy and Environment Team carries out 10% check.
- Following the 10% witnessing the BMS Contractor adds the graphics files onto the server for validation.
- BMS Contractor issues final documentation and software to the Engineering, Energy and Environment Team to enable final checks.
- Engineering, Energy and Environment Team issues final report to Project Manager.
- Project Manager informs Head of Maintenance and Head of Engineering, Energy and Environment of state of project.
- Head of Maintenance and Head of Engineering, Energy and Environment inform Project Manager if project is suitably complete for BMS to be handed over.
- BMS Contractor adds graphics pages onto main BMS server
- Controls familiarisation to be given to Estates Maintenance and Controls Maintenance Contractor via the project team with all appropriate documentation available.
- Completion of BMS Controls Granted and first line response responsibility for the system passes to Controls Maintenance Contractor.

8 Sustainability

8.1 Introduction

8.1.1 College sustainability strategy

Imperial College London (Imperial College London) recently published 'Sustainable Imperial'[62] which outlines its vision, strategy, target for achieving net zero carbon emission by 2040 (long term). The short target is to reduce carbon emissions by 15% by 2025 – 26 against a baseline emission for 2018 -19.

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These will be met by the following actions:

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- Improve control of all building energy use and enhance data gathering
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- Improve building fabric insulation
- Minimise all environmental impacts through challenging embodied and operational carbon in construction and operational use.
- Report agreed Key Performance Indicators (KPI) during each key building project phase (e.g., RIBA construction plan)
- Always expect the highest standard of sustainable construction
- Minimise waste and maximise recycling
- Protect, maintain, and enhance university estate local biodiversity

[62] https://www.imperial.ac.uk/sustainable-imperial/about-the-strategy/our-vision/

- Reduce environmental risk and pollution via good Health Safety & Environmental practices
- Comply with legal and other environmental requirements
- Promote sustainable procurement and consider circular economy
- Promote the use of life cycle costing
- Engage with students, faculty departments and other key College stakeholders in maximising sustainability opportunities during building projects
- Raise awareness of sustainability issues and provide opportunities to develop skills and knowledge

8.2 Process

Members of Estates Operations will work with the appointed College "Sustainability Champion" and Engineering, Energy and Environment team in identifying the appropriate actions.

The process will be required to evaluate the procurement, design, construction, and operation of a development against targets that are based on performance benchmarks.

8.2.1 Energy Use Intensity (EUI) benchmarks to be used.

Leading building industry[63] recommend that by 2030 all new building must operate at net zero carbon to meet the current carbon emission targets for UK. The industry is moving towards the EUI target benchmark for electricity and fossil fuel measured as kWh/m^2/yr (GIA) measured at the meter (regulated and unregulated, excluding on site generation). These benchmark targets are derived from predicted energy use modelling, review of best practicing buildings in the UK and preliminary assessment of the renewable energy supply for the UK. Target range (best to typical practice)[64] are shown below and expect all new building projects to be delivered to within the best practice range.

Table 45 – Minimum required Energy Use Intensity (EUI) benchmark

[63] UK GBC, RIBA, Better Building Partnership (BBP), London Energy Transformation Initiative (LETI) and CIBSE
[64] https://www.cibse.org/Knowledge/Benchmarking (Climate Action Plan)

Building type	Fuel Type	Best practice kWh/m²/yr (GIA)	Typical practice kWh/m²/yr (GIA)
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	Fossil Fuel	135	194
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8.2.2 BREEAM

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8.3 Assessment Tools

8.3.1 Building Thermal Models

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8.3.2 Life Cycle Costing Analysis

To evaluate the financial efficiency of the measures proposed to meet the carbon reduction requirements, the Project Team shall provide a life cycle cost assessment for each proposal where appropriate. This is required to enable the Project Board to assess benefits of each proposal considering the carbon savings as well as maintenance and replacement costs.

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If the life of the project is known to be less than 25 years, the accounting period should be the same as the life of the project.

For further advice on whole life costing methodology, refer to the Green Book issued by the Treasury, and the College Sustainability Toolkit.

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Factors to be assumed in whole life cost analysis:

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Discount rate	4.5%

8.3.3 Building Regulation Part L

The Building Regulations set out requirements for specific aspects of building design and construction. Regulation 26 of the building regulations states that "Where a building is erected, it shall not exceed the target CO2 emission rate for the building…", and Schedule 1 – Part L Conservation of fuel and power states that provision for conservation of fuel and power shall be made by: limiting heat gain and losses and providing building service which are efficient, have effective controls and are properly commissioned and that information is provided so that the building can be operated efficiently.

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The regulation relates to proposed works to existing buildings (other than dwellings) with a total useful floor area of over 1000m^2, and include:

- An extension.
- Installation of new fixed building services (other than renewable energy generators).
- Increasing the capacity of fixed building services (other than renewable energy generators).
- The improvement works must be technically, functionally, and economically feasible.

In most circumstances, this means that the payback period for the consequential improvements required does not exceed 15 years (or less if the expected life of the building is less than 15 years).

Consequential improvements may include:

- Upgrading heating, cooling, or air handling systems.
- Upgrading lighting systems.
- Installing energy metering.
- Upgrading thermal elements.
- Replacing windows.
- On-site energy generation.
- Applying measures proposed in a recommendations report accompanying an Energy Performance Certificate.

8.4 Considerations

8.4.1 Examples of energy efficiency opportunities for consideration

The following are examples of passive design measures and efficient building services strategies which should be considered for each new building.

The optimum combination of measures should be selected to suit the building strategy.

8.4.1.1 Optimising Passive Design Features: (General considerations)

- The amount and type of glazing, along with the shape, location, and functionality of the windows, are key factors in the effective control of heat losses and gains to the building. The proportions of glazing should be optimised on each façade to balance the energy requirements with the need for views out and the specific internal environments required.
- Optimising daylight access should be considered to limit the need for artificial lighting.
- Reducing the thermal transmittance of the building envelope by increasing insulation will help reduce heating demand and result in lower heating energy consumption. U-values for external wall, glazing, roof, and floor are likely to exceed the minimum target requirements of Part L.
- Minimising air leakage through airtight construction methods can reduce heating/cooling loads and help reduce draughts.
- Low energy ventilation strategies such as natural ventilation or mechanical ventilation with efficient heat recovery should be evaluated.
- Thermal mass is useful to stabilise internal temperatures in winter and summer. Exposed concrete allows buildings to benefit from night-time cooling, therefore reducing demands for mechanical cooling.

Efficient Building Services Considerations:

- Centralised heating and cooling plant can allow the selection of large, high efficiency, engineered central plant.
- Reduced ventilation requirements
- Specify lean (i.e., energy efficient) equipment

- Ventilation control and Building Management Systems will help to reduce fan energy when not in use. Please refer to the College Building Engineering Services Particular Requirement[65] for further information.
- High efficiency motors incorporated into all building services.
- High efficiency boiler plant and chillers.
- Air to air heat recovery and variable speed fans installed within air handling plant, where provided, to recover the heat in the extract airstreams prior to the exhaust of vitiated air to atmosphere and minimise energy use required for supplying and exhausting air.
- High efficiency electronic lighting ballasts and high efficacy lamps.
- Passive infra-red and daylight responsive lighting control.

[65] https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/estates-projects/public/resources/guides/ep01bespr.pdf

9 Metering

9.1 Introduction

This Document defines the metering configurations, together with the hardware and software systems to be provided with Imperial College projects to fulfil the College's requirements for energy, quality metering and remote monitoring facilities associated with its mechanical and electrical services and networks. Where metering is required, it will be established via the College's Technical Advisors Group (TAG) and Engineering Review Meeting (ERM) processes.

9.2 General

College's metering strategy is aimed in two parts:

1) Firstly, utility services (including fiscal meters) are to be metered at building level; and
2) Secondly, all electrical power in LV switchroom to be metered completely.

All new fiscal /utility meter must be fitted with an Automatic Meter Reader (AMR) meter). This includes water supplies of all capacity. Unless otherwise agreed all meters must be provided with Modbus connection option.

Examples of services are:

- Hot Water Services (HWS)
- Cold Water Services
- Heating (derived from LTHW, Steam, Gas, MPHW or Electricity)
- Chilled Water (derived from Steam or Electricity)
- Lighting
- Small Power
- Mechanical plant electricity usage
- Sub-station transformer feed
- Principal / Main Contractor to provide meter strategy

The Engineering, Energy and Environment (EEE) team will determine if a proposed metering strategy (provided by the Principal Contractor (PC) is in line with the College's stated goals and Value for Money (VFM) with reference to CIBSE TM39 guideline.

Meter Instrument Directive (MID) approved meters are required for billing purposes under UK national legislation (carried out by National Measurement and Regulation Office and Office of Gas and Electricity Markets.)

It is the responsibility of the Principle Contractor (PC) to determine with Engineering, Energy and Environment Team whether MID approved meters are required.

The PC is to request asset codes for each meter from the Engineering, Energy and Environment Team.

Unique meter channel addresses (UPCA) will be provided by the BEMS contractor, to assist the PC in completing the strategy drawings.

Existing meters must not be isolated, temporarily or permanently disconnected and/or removed without prior written approval from the Engineering, Energy and Environment Team.

Existing SIP DataPoint and DataPointTemp databases are not to be changed, adjusted or added to without written approval from the Engineering, Energy and Environment Team.

9.3 Meter specifications

9.3.1 Heated and chilled water

Endress and Hauser Promag P220 2 wire or suitable sized equivalent.

Endress and Hauser TR10 matched pair temperature sensors probe TR10-AFA1CAS5KA00B (Including local display).

Endress and Hauser RH33 Heat calculator (Part number = RH33-AA2A+AAD1) with integral Modbus TCP/IP, 24V (AC).

Endress & Hauser should be used for the commissioning of all meters supplied by them.

For district heat primary fluid use at points of hydraulic separation, following points to be measured:

- Consumption (kWh);
- Instantaneous values for:
    - Flow temperature (°C);
    - Return temperature (°C);

- Flow rate m^3/h;
- Load in kW.

9.3.2 Water

Domestic cold-water meter to be MID Class B or C and configured to provide a Modbus output, if unavailable pulse output (m^3) TBA.

9.3.3 Gas

Utility / billing meter (s) will be specified and installed by the gas supplier. These meters installations must be co-ordinated with the Energy Engineer so that the correct College gas supplier is appointed with associated supply contracts.

For sub metering applications where the minimum gas flow is low (less than 0.1 m^3/hr) a diaphragm positive displacement gas meter will be used. This type of meter has a very wide measuring range designed for low pressure and low medium flow ranges.

For each sub gas meter will be provided with a dedicated volumetric output. All meters to be installed with Modbus connection. A chatterbox to be used only where Modbus is not available. Chatterbox isolation to be provided and each meter will be configured to provide a pulsed output +/- 1.5 %.

9.3.4 Electricity

Utility / billing meter(s) will be specified and installed by the electricity supplier. These meters installations must be co-ordinated with the Energy Engineer so that the correct College electricity and Meter Operator (MOP) supplies are appointed with associated supply contracts. **Refer to the Appendix for new utility electricity meter installation process.**

For sub meters Schneider PM750 meter (for all outgoing supplies), PM5300 (for all incoming supplies) to be supplied on all transformer incoming panels and major switchboard incoming panels where the incoming switch is either an ACB or PCCB. These meters will be equipped with RS485 communications output modules only. The data will be monitored via Modbus.

If only one meter monitored, use ethernet connection otherwise for more than one meter, use RS485 connection with Modbus solution over TCP/IP.

The following parameters are to be recorded:

- Total Active Energy (kWh);
- Active Power (kW);
- Apparent Power Total (kVA);
- Reactive Energy Total (kVArh);
- Amps - L1 (A), L2 (A), L3 (A), and N (A);
- Volts - L1-N (V), L2-N (V), and L3-N (V);
- Total Harmonic Distortion (THD):
    - THD L1, L2, L3, and N for current; and
    - THD V for voltage.

All other supplies that require metering to use Socomec A20 meters with an RS485 connection. These are to be configured to monitor kWh (active energy) meter values only.

A separate cubicle will be provided for the termination of all metering outputs and external control circuits forming part of major switchboards and Power Distribution Units. **No other live circuits/conductors shall be present in this cubical.**

The RS485 Comms output modules will be 'daisy chained' using screened twisted pair + drain wire, Belden type cable to an RS485 to Modbus converter. The RS485 network wiring must meet the minimum requirements as set out by the manufacturer. The circuits should be terminated.

It will be the responsibility of the PC to ensure that the meters are correctly wired before the switchboards and panels leave the manufacturer's works and that all CT ratios and addresses are programmed into the meters before the primary circuits are commissioned. No device must remain at its default address.

The number of meters connected to a single chain will not exceed 32.

A separate power supply circuit will be provided for each instrument, connected to the supply side of the main switch, thus ensuring the output module remains active, does not generate error messages when the main contacts open and when in the off position. The instruments will not be powered from the voltage reference inputs. Warning labels are to be provided in accordance with the electrical section of the Building Engineering Services Particular Requirement

9.3.5 Saturated Steam

Each steam meter will comprise of a Spirax Gilflo ILVA pipeline mounted unit, M610 differential pressure transmitter and a M750 display unit.

Each steam meter will be configured to provide a pulsed output in kg.

Where recharging of internal tenants is required, metering should be designed to allow consumption of all utilities to be established.

Where external tenants will be billed MID compliant meters, type to be agreed with the Energy Team prior to installation, are to be installed.

9.4 Connectivity and hardware

9.4.1 General Connectivity

Modbus is the preferred metering connectivity protocol. Where meters produce a pulse, a pulse to Modbus converter is required and converted to a Modbus address. This is done by using a Modbus pulse collector (e.g., part IME Conto IF4C001 IMP Pulse Acquisition module.

A Modbus pulse collector will be used to integrate the meter onto the Modbus network. Where a Modbus pulse collector is used the meter multiplication factor will be added to the MODM/D/1VIQ NOT the Modbus pulse collector.

9.4.2 Changes to existing metering systems

All proposed changes to existing metering configurations, hardware or software, will require the prior approval of the Engineering, Energy and Environment Team. Subject to receiving approval, all changes will be accompanied by an amended metering strategy (or new strategy where none currently exists) in accordance with the requirements of this document.

9.5 Information required by the College

Metering information needs to be provided to the College so the devices can be setup in the Colleges Energy Management headend software.

Contact Engineering team for further details and latest versions.

9.6 Roles, responsibilities and witnessing

Witnessing correlation of meter advances with advances in queried Modbus values at handover must be done, see the witnessing process in Section 9.6.1.

The designer will avoid positioning meters in locations that duplicate meters at another point in the system. Meters must not be in inaccessible locations and must not require special access equipment to read or maintain.

It is the responsibility of the PC to ensure that the overall metering design and installation complies with the project metering strategy, including coordinating mechanical and electrical metering interfaces.

The PC is to request asset codes for each meter from the Engineering, Energy and Environment Team.

Installation of all meters and devices described in this document are to be fitted as per manufacturer's instructions

The PC via the main M&E controls contractor must validate all meters, connections and ensure that total energy monitored match the sum of the submeters for all connection.

9.6.1 Commissioning & Witnessing Process

1) Mechanical & Electrical Contractor to commission meters & setup addressing as per issued schedule.
2) Controls Contractor to apply for connection to the Imperial network for the Modbus or master devices (Imperial Patch Point Number and MAC address required) via contractual chain.
3) Energy Engineer to confirm with BEMS contractor which points are to be data logged.
4) Controls Contractor to programme & commission Meters and devices & setup Modbus slaves.
5) Controls Contractor to witness 100% to Imperial independent validator proving correct points in data base.
6) Controls Contractor to witness 10% to Imperial BEMS engineer.
7) Energy Team to create and verify each point in the Sigma database and update metering spreadsheet. Metering spreadsheet to be sent to Energy Engineer for metering strategy update.

9.7 Strategy drawings; Responsibilities & Demarcations

This section describes the responsibilities and demarcation for the metering strategy drawings and is to be read in conjunction with the procedure in the Section **Error! Reference source not found.**.

9.7.1 Designer

Before developing a metering strategy, the Project Manager will request from the Engineering, Energy and Environment Team, a copy of the current strategy. This strategy will include schematic diagrams, floor plans and spreadsheet. This will form the 'working copy' which the designer will amend in accordance with any proposed changes/additions.

All proposed changes to the working copy will be clouded so that they can be easily identified. This applies to all drawings through all design stages, including the tender. All proposed changes will similarly be identified on the spreadsheet. Where there is no existing strategy available, the designer will develop a metering strategy, the scope of which will be agreed with the Energy Engineer, and which may extend beyond the metering services defined by the project scope. Strategies will be developed fully in accordance with the requirements of this document and presented in AutoCAD .dwg format as per examples included in the appendices of this section.

The draft strategies will be agreed with the College's Engineering and Energy Teams, prior to submission as part of the normal design review process. To enable the metering proposals to be assessed in the context of the services being measured/monitored, each strategy presented to the Engineering and Energy Teams will be accompanied by the relevant services schematic.

Following approval and incorporating any changes required by the Engineering and Energy Teams, the strategy is to be issued as part of the tender documentation.

9.7.2 Contractor

The Principal Contractors are responsible for completing the metering schematic and strategy drawings with input from the Controls Designer. These will then be issued to the College for approval with associated asset numbers for each meter.

On receipt of approval, the completed metering strategy will be passed to the appointed Controls Contractor for the addition of the unique meter channel address (UPCA).

UPCA references will be provided by the Controls Contractor in the format shown in the example below to assist the contractor in completing the strategy drawings.

Hostname_Device_number e.g. 172.18.42.91:502/1000/flebs/1/holding

The Controls Contractor will add these to the Strategy, together with the meter serial numbers, addresses and issue to the Energy Engineer/Engineering, Energy and Environment Team, for comments /approval.

At practical completion, the metering strategy drawings (plans and schematics) together with the spreadsheet will be issued as part of the O&M documentation, and will be used by the Engineering Team to update the master set.

All amendments/additions to the tender drawings and schedules will be carried out using a different colour or some other notation so that changes can be easily identified.

9.8 Appendix

9.8.1 Electricity Meter Installation on New Supplies

Table 46 – Acronyms used in this section

Acronym	Definition
HH	Half-Hourly
NHH	Non-Half-Hourly
MPAN	Meter Point Administration Number
DNO	Distribution Network Operator
ECOES	Electricity Central Online Enquiry Service
EEE	Engineering, Energy & Environment
PM	Project Manager
CT	Current Transformer
DC	Data Collector
DA	Data Aggregator

9.8.2 Scope

This document outlines the various stages and parties involved in the meter installation process for an electricity supply and is applicable to both HH and NHH supplies.

Please contact the Engineering, Energy & Environment team who will assist in adding the MPAN to Imperial's supply contract and can advise should you require assistance or further clarification on the process.

9.8.3 Pre-requisites for Meter Installation

- DNO has provided a valid MPAN and registered it with the ECOES.
- DNO has installed CTs.
- MPAN has an appointed supplier and is covered by a supply agreement.
- MPAN has a valid MOP contract in place, whether through the College's 5-yr MOP contract with Siemens, or a standalone agreement (only to be used if not remaining an Imperial College London supply).

9.8.4 Process

Table 47 – Perquisition for fiscal electricity meter installation

	Task	Who?
1	New MPAN brought on to supply contract with the College's current electricity supplier	EEE
2	Appoint the College's contracted MOP, DC and DA Complete and submit a post-contract addition form to provider Instruct electricity supplier to make the MOP, DC and DA appointment	 EEE EEE
3	Provide the following to EEE: site address, MPAN, CT ratio, CT installation date, kVA, site contact and, if known, DNO reference	PM
4	Request meter installation through electricity supplier	EEE
5	Raise a job (D0142 flow) with the appointed MOP to install a meter as per the provided specification *Typical new meter install is 10 days*	Supplier
6	MOP will arrange a date and time with the College provided contact	MOP
7	Once meter has been installed, the meter details to be added ECOES and a flow sent to the supplier to advise completion	MOP
8	Supply energised once meter installed and details logged in ECOES	Supplier

9.8.5 College Sub metering approvals procedure

1) Project Manager (PM) to request existing building metering strategy from Engineering Team Energy Engineer.
2) PM issues existing strategy to M&E designer.
3) M&E Designer creates a "working copy" by amending the existing strategy in accordance with proposed works. Where no metering strategy exists the M&E Designer creates a new strategy in discussion with the Energy Engineer.
4) M&E Designers agrees strategy with the Colleges' Energy and Engineering Teams. Energy Engineer assesses the impact on algorithms.
5) Metering strategy issued as part of tender documentation.
6) Meters are installed as per contract requirements.
7) Controls Contractor to set up meters with addresses, update metering strategy and issue to PM.
8) Controls Contractor to setup slaves, masters and where necessary allocate virtual outstation points (this includes all points even via a pulse counter).
9) Controls Contractor to request address details once patch point & Mac details are known via contract chain.
10) Controls Contractor to install address details when issued.
11) Controls Contractor to update metering strategy, PM to forward this information to the Energy Engineer for comment.
12) Controls Contractor to commission meters.
13) Imperial independent validator to witness by Modbus query.
14) Engineering team witness and signoff 10% of meters ensuring meter advances are reflected in the corresponding by Modbus query.
15) Controls Contractor to issue to PM final excel spread sheet with all required information and create each point.
16) Energy Engineer updates meter records, checks and updates algorithms.

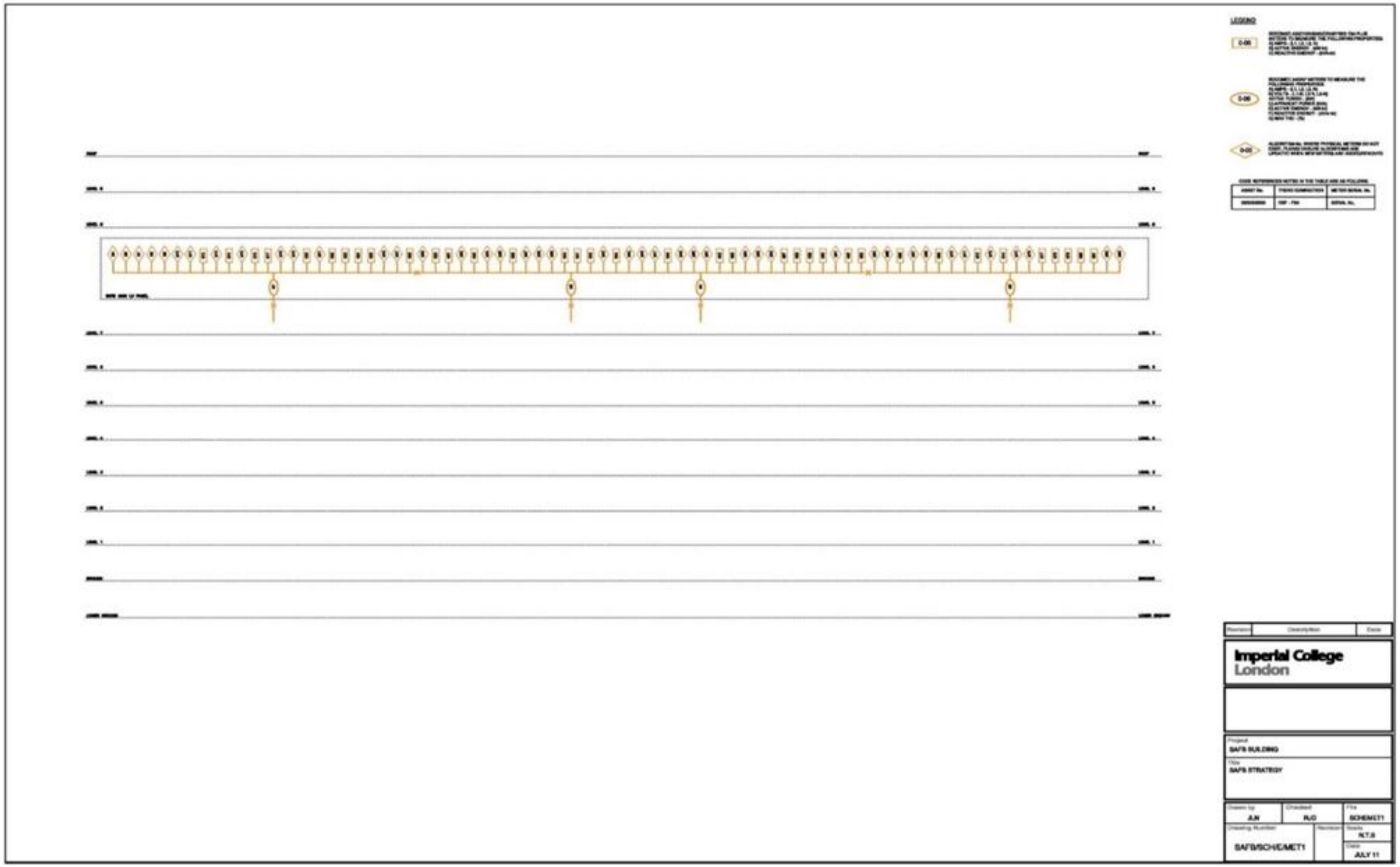

Figure 15 – Example of electrical meter strategy[66]

[66] For more information please contact the College's Energy Engineer.

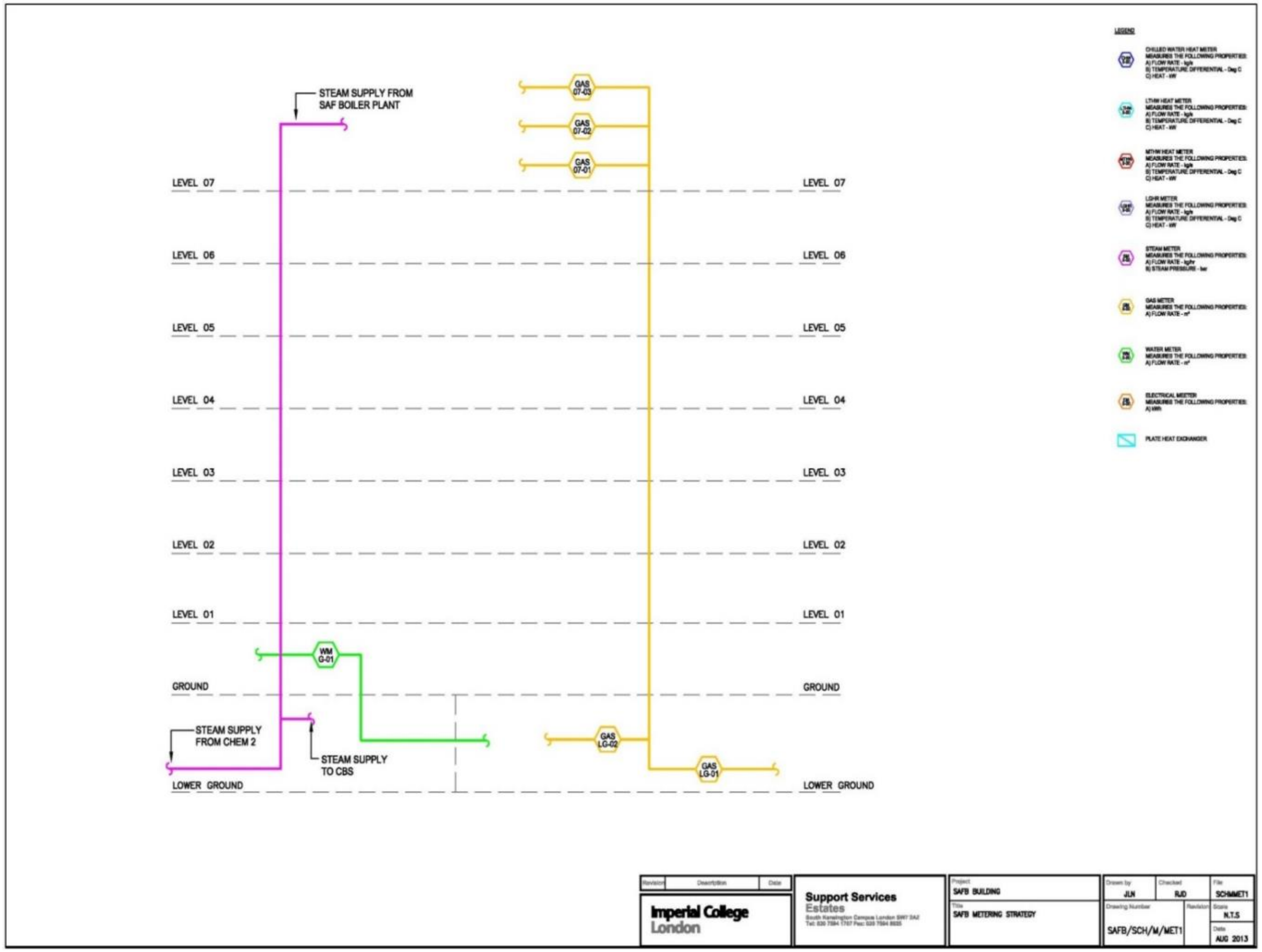

Figure 16 – Example of mechanical meter strategy[67]

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[67] For more information please contact the College's Energy Engineer.

Building	Floor	WorkSpace	Group	Name	Asset No.	Correction Factor	Installation Date	Location	MPAN	MPR	Manufacturer	Measured Units	Model	Sch-ID	Serial No.	Serving	System	Trend Info
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	AP	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0038		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	AP	M2	051332131	MAIN INCOMER 1 (TX T41)	EM	SK_SAF_G_21 L810103S89
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0024		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	AP	M3	051332182	MAIN INCOMER 1 (TX T42)	EM	SK_SAF_G_21 L810102S79
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0010		UNKNOWN	SWITCHROOM	UNKNOWN		SCHLUMBERGER	kWh	UNKNOWN	M4	AY56935	GENERATOR SUPPLY	EM	NOT CONNECTED
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0015		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M14	323207060116	RISER A NON ESSENTIAL	EM	SK_SAF_G_21 L810102S63
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0017		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M17	323207050432	SPARE (60)	EM	SK_SAF_G_21 L810102S67
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0016		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M16	323207420230	CP1	EM	SK_SAF_G_21 L810102S65
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	UNKNOWN		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M12	323208270068	HP13 N/ESS	EM	NOT CONNECTED
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0019		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M22	323207420396	CP3	EM	SK_SAF_G_21 L810102S71
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0021		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M24	323207080731	MCP3 NON ESSENTIAL	EM	SK_SAF_G_21 L810102S75
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0020		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M23	323207420232	MCP1 NON ESSENTIAL	EM	SK_SAF_G_21 L810102S73
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0018		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M20	323207060499	RISER D NON ESSENTIAL	EM	SK_SAF_G_21 L810102S69
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0022		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M25	323207060069	CHILLER 5 NON ESSENTIAL	EM	SK_SAF_G_21 L810102S77
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0034		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M30	323207070075	RISER A ESSENTIAL	EM	SK_SAF_G_21 L810103S81
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0023		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M28	323207420201	MCP7 NON ESSENTIAL	EM	SK_SAF_G_21 L810102S79
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0037		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M36	323207080224	CP2 PUMP ESSENTIAL	EM	SK_SAF_G_21 L810103S87
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0002		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M41	323207080321	CHILLER 2 ESSENTIAL	EM	SK_SAF_G_21 L810101S63
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0001		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M40	323207080060	RISER C ESSENTIAL	EM	SK_SAF_G_21 L810101S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0036		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M33	323207060528	MCP2 ESSENTIAL	EM	SK_SAF_G_21 L810103S85
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0004		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M44	323207070049	CP4 PUMP ESSENTIAL	EM	SK_SAF_G_21 L810101S67
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0006		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M52	323207420381	MCP3 ESSENTIAL	EM	SK_SAF_G_21 L810101S71
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0005		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M48	323207080327	RISER D ESSENTIAL	EM	SK_SAF_G_21 L810101S69
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0003		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M42	323207080241	MCP4 ESSENTIAL	EM	SK_SAF_G_21 L810101S65
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0008		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M57	323207060046	MCP1 ESSENTIAL	EM	SK_SAF_G_21 L810101S75
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0010		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M59	323207080319	MCP9 ESSENTIAL	EM	SK_SAF_G_21 L810101S79
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0009		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M58	323207080319	MCP7 ESSENTIAL	EM	SK_SAF_G_21 L81010????
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0007		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M53	323207060112	MCP5 ESSENTIAL	EM	SK_SAF_G_21 L810101S73
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0012		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M62	323207420247	MCP5/B	EM	SK_SAF_G_21 L810101S83
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0025		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M66	323207050532	RISER C NON ESSENTIAL	EM	SK_SAF_G_21 L810103S63
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0013		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M63	323207080322	HP13 - HP14 PUMP ESSENTIAL	EM	SK_SAF_G_21 L810101S84
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0011		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M60	323207060488	MCP8 ESSENTIAL	EM	SK_SAF_G_21 L810101S81
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0027		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M72	323207060476	MCP2 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S67
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0029		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M77	323207080372	MCP8 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S71
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0028		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M74	323207080016	CHILLER 4 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S69
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0026		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M69	323207080055	CHILLER 3 ESSENTIAL	EM	SK_SAF_G_21 L810103S65
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0031		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M79	323207060555	MCP6 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S75
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0033		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M81	323106480791	MCP5 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S79
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0032		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M80	323207070093	SPARE	EM	SK_SAF_G_21 L810103S77
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR00014		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M1	051332226	MAIN INCOMER 1 (TX T40)	EM	SK_SAF_G_21 L810102S61
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0030		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M78	323207120194	MCP4 NON ESSENTIAL	EM	SK_SAF_G_21 L810103S73
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0035		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M31	323207060526	CHILLER 1 ESSENTIAL	EM	SK_SAF_G_21 L810103S83
SIR ALEXANDER FLEMING BUILDING	SAFB-07	704	Meters	EM	SKSAFBLGEMTR0034		UNKNOWN	SWITCHROOM	UNKNOWN		SOCOMEC	kWh	A20	M30	323207070075	RISER A ESSENTIAL	EM	SK_SAF_G_21 L810103S81

Figure 17 – Example metering schedule[68]

[68] For more information please contact the College’s Energy Engineer.

9.8.6 Modbus master register

Contact Engineering Team for the details.

9.8.7 Electrical Warning Labels

As a result of the requirement set out in **Error! Reference source not found.**, l ive parts could be accessible within individual switch compartments, with the switch in the OFF position.

Warning labels will therefore be permanently screw fixed to the switch front cover, and within the switch compartment.

Labels will have a yellow background with black characters, bearing the following inscriptions.

External label: 'Caution, Live 230 V/415 V supply to meter with switch in the OFF position.'

The label will also bear a warning symbol as shown below. (Please make sure the correct voltage is put on the warning label i.e. 230V or 415V.)

Internal label: 'WARNING! Metering aux supply fed from live side of switch. Isolate at source before working on equipment'. The label will also bear a warning symbol as shown below.

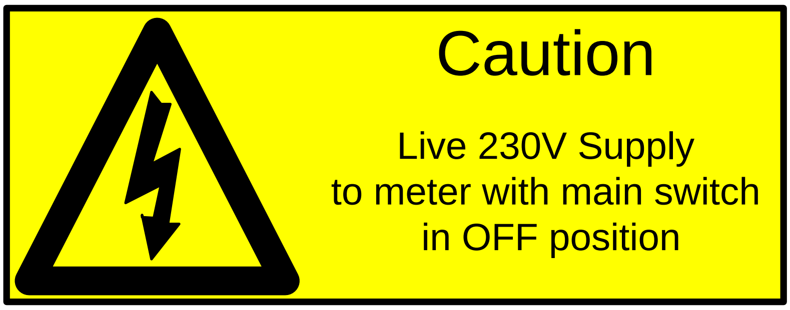

Figure 18 – External Label

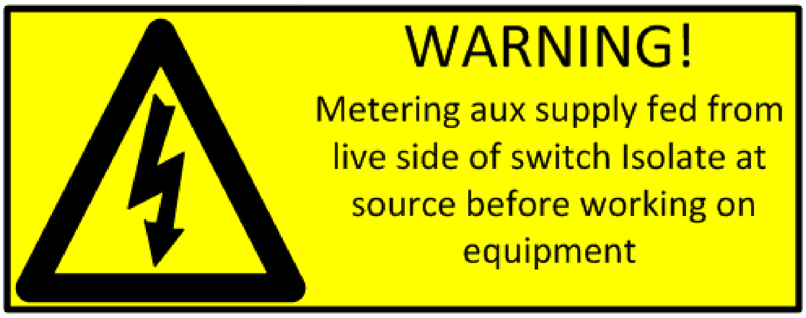

Figure 19 – Internal Label