UNIVERSITY OF LIVERPOOL

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Changes

Version	Reason for Change	Date
1.0	Initial issue of re-written Mech Des Requirements	19/11/2020
2.0	Approved Equipment Manufacturers List Updated	30/11/2020
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4.0		

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1.0 Guide to Mechanical Engineering

Introduction
This document provides guidance to Mechanical Design Engineers on the University's preferences for mechanical services installations. The guidance is not intended to be exhaustive or definitive, or to replace the University's Mechanical Standards.

If any significant deviations are intended from the guidance, the Design Engineer is asked to clarify the principals with the University's Senior Mechanical Engineer.

This document should be read in conjunction with the University's 'Mechanical Standards' document.

Other information is included as assistance to the Design Engineer.

Clients brief
It is the responsibility of the Consultant to obtain a detailed brief for the work and prepare detailed room data sheets. The brief and room data sheets must be recorded in writing by the Consultant and 'signed off' by the Client department.

1.1 General

1.1.1 Each RIBA stage report shall be supplied with Derogation report. The consultant is required to report on any deviations from the design team guide. In the event that no derogation report is produced then the design proposal and installations needs to be in full accordance with this document.

1.1.2 The Design Teams are to carefully consider their duties under Regulation 9 of CDM regulations 2015 & consider the usability and maintainability of all HVAC plant & equipment provide via construction projects. The design team shall ensure that all designs consider and facilitate ease of maintenance and replacement of component parts (i.e. filter replacements) to all HVAC systems throughout the life of the building. By implication this also means replacement of HVAC systems shall be considered and easily achievable.

1.1.3 In accordance with the CDM Regulations all plant and equipment shall be accessible e.g. ladders, platforms, fixed and mobile.

1.1.4 A plant replacement & maintenance strategy document shall be produced and submitted covering all main HVAC plant identified at Stage 2. The document shall consider how the equipment shall be accessed, maintained and replaced, including access routes, throughout the life of the installation. This shall include, but not be limited to, air handing units, chillers, fans, boilers, flues and water tanks.

1.1.5 A Mechanical HVAC calculations file shall be submitted with all projects that proceed to tender. The calculation file shall be submitted along with the Stage 4 RIBA stage report. Calculations that are required shall include the following as a minimum. This list below isn't exhaustive but should be used for guidance only:

Heating - Heat loss calculations including safety margin allowance (infiltration and conductive), U-Values, emitter selection, plant factor for pre heat, simultaneous maximum plant load , pipe sizing, pump sizing, pressurization unit sizing, safety valve selection, control valve selection, commissioning set selection.
Domestic Water Services - Hot & cold water pipe sizing (internal/external, gravity fed & boosted), booster set sizing, hot water circulation pump sizing, cold water storage volume, hot water storage volume, plate heat exchanger selection, calorifier heat up period, safety valve selection.
Ventilation - Minimum fresh air rates, air change rates, cooling/heating driven ventilation rates, ductwork leakage assumptions, fan volume & pressure, pressure regime, AHU heating coil sizing, cooling coil sizing, grille and diffuser selection, louver selection.
Cooling & Humidification - Heat gain calculations (sensible and latent gains), humidifier duty, control valve selection, commissioning set selection.
Above Ground & Rainwater Drainage = Gravity pipe sizing, rainwater tank selection
Natural Gas - Natural gas pipework sizing. Gas booster sizing.

1.1.6 Details of all plant installed shall be brought to the attention of the Head of Estates Planning in order that asset numbering can be carried out in accordance with University procedure and information manual. This information should be provided prior to any tendering or upon completion of Stage 4.

1.1.7 All redundant plant shall be formally offered to Head of Engineering and Maintenance Operations before disposal off site.

1.1.8 HVAC Room data sheets (RDS) shall be produced for all projects. The RDS shall highlight all mechanical service requirements within the room it relates to.

1.1.9 Where connections into existing system (pipework or ductwork) are required for a project, a statement is required from the designer as to how the integrity and system characteristics of the existing system will remain.

1.1.10 HVAC Consultants shall be required to conduct sufficient witness testing to verify the HVAC systems are fully working as per the design intent. Witness testing of all HVAC controls shall be as per the written control strategies as required in sections 1.9.3 & 1.10.12. This shall include, for example, simulating summer/winter strategies, full/part load conditions. The consultant shall be responsible for leading and organizing a pre-commissioning co-ordination meeting, with the contractor, to ensure the design intent of the system is understood. It shall also be made clear what level of testing is required to demonstrate the systems are working as per design intent. This is particularly relevant for complex HVAC systems operating with differing strategies for differing times of the day/year. The consultant shall produce a schedule of tests that are required to demonstrate & verify the installed system works as design. The HVAC consultants shall ensure that the University's Senior Mechanical Engineer are fully involved in this process for all projects. The consultant shall also be responsible for signing off all commissioning documentation.

1.1.11 Newly refurbished plant rooms shall ensure floors are provided with a levelling screed (if required) and finished with a anti-slip painted floor (refer to section 1.1.12 below). Plant plinths shall be painted in yellow, plant room floor in red with walkways/maintenance routes in green.

1.1.12 All HVAC plant that is to be floor mounted shall be mounted on a minimum of 100mm concrete plinth (or equivalent). No plant shall be mounted direct to the floor.

1.2 Plant Location

1.2.1 No equipment shall be installed outside Plant rooms on roof spaces, with the exception (if authorised) of refrigeration equipment.

1.2.2 All effort shall be made to locate plant within dedicated Plant Rooms. Where it is necessary to locate plant outside a Plant Room (Roofs / Ceiling voids etc.) this must be brought to the attention of and agreed with the Senior Mechanical Engineer as early as possible in the design process.

1.2.3 All heat rejecting equipment (i.e. chillers, ACCU) should be located externally and not inside buildings and include safe access. This is also true for faculty-based equipment.

1.2.4 No mechanical plant (i.e. AHU's, heat recovery unit, fans etc) shall be installed within emergency escape stairs.

1.3 Heating

Primary Heating Systems – General

The general method of supplying heating to the University's buildings is by the use the University's Combined Heat and Power installation located in the new Energy Centre Building located on Ashton Street in the main University campus. This generating plant produces High Temperature High Pressure primary heating water at a maximum temperature and pressure of 150°C and 10bar working pressure. The Energy Centre supplies the HTHW primary heating to the University's buildings via district heating installations. Although this is the current University strategy, designer shall be required to provide alternative systems detailing the life cycle implications including any associated carbon emissions implications.

The general method of converting the HTHW primary heating where it enters the buildings to LTHW secondary heating supplying the heating installations within the buildings is via the use of fully brazed plate heat exchangers, generally located in each building's plantroom.

1.3.1 Calorifiers, Plate Heat Exchangers, shall have fitted flow and return temperature sensors and gauges - the sensors shall be connected to the University's Building Management System (BMS). PRV, pump sets etc. shall incorporate pressure gauges prior and subsequent to the equipment to inform the pressure drop across the plant.

Heating and Plate Heat Exchangers
The preferred supplier is:
Vital Energy

1.3.2 Steam, condensate, MTHW/LTHW and domestic valve and flange bodies shall be insulated with easy removable muffs. In the case of the plate heat exchanger packages, these shall also be insulated and covered with a single easy removable muff.

1.3.3 Large steam-raising plant shall incorporate modulating control and be used to progressively increase the output of each boiler. The design shall ensure specification and comparison of plant to evaluate the efficiency at each stage of capacity and to ensure that full modulating control is available across as wide a range of the boilers. The design shall ensure ("turn-down ratio") are at the best possible efficiency. Boilers should be sized to satisfy the maximum hourly steam demand while operating within their maximum continuous rating (MCR).

1.3.4 All installations shall as a minimum comply with current Building Regulations and the Energy Performance in Buildings Directive.

1.3.5 Large buildings shall be broken down into separate heating zones by orientation and/or by user/department, with externally compensated internal temperature controls fitted, via the Building Management System

1.3.6 Where gas fired condensing and/or high efficiency boilers are specified, the design shall fully consider the utilisation of lower return temperatures to ensure full efficiency benefits are realised. All routes to drain associated with the condensate – shall be by gravity, where feasible. Multiple boiler arrangements shall, where individual modules are progressively switched on (sequenced) as the load increases, offer the greatest efficiency by ensuring the system matches the demand for heat more closely therefore each boiler shall perform close to its individual design duty.

1.3.7 Not in use

1.3.8 Where activities or specific processes produce a surplus of heat, designers shall assess in terms of suitability and cost effectiveness energy recovery systems to further reduce the requirement for heat and power. (e.g. Computer cluster heat rejection to adjacent offices.)

1.3.9 Internal temperatures and air change rates shall be as recommended in the CIBSE Guide/Building Regulations and agreed with the Senior Mechanical Engineer. All design criteria to be confirmed at RIBA stage 2.

1.3.10 Heating plant to include adequate capacity to and agreed warm up strategy to be agreed by the Senior Mechanical Engineer.

1.3.11 All pipe work shall match the existing specification, and shall be to BS EN 10255: 2004
H series, heavy gauge seamless tubing irrespective of use. All heating pipework shall be designed to be self-venting.

1.3.12 In the unusual circumstance where compression/crimped fittings/joints are approved for use, the contractor is required to demonstrate a robust on-site QA procedure to demonstrate no future joint failures shall occur.

1.3.13 Radiators shall be used in preference to natural or fan convectors.

1.3.14 In existing radiator circuits where single pipe arrangements exist, two pipe systems must not be introduced.

1.3.15 Ball valves (full bore type) shall be used to isolate LPHW heating systems up to 50mm pipe diameter; above 50mm lugged wafer valves with EPDM liners shall be used.

1.3.16 Drain-off valves should all be installed at suitable locations, i.e. all the low points of the system, throughout all pipework systems to facilitate pipework modifications without the need for a full system drain down. All rising pipework mains contained within mechanical risers shall be fitted with drain points.

1.3.17 Individual thermostatic radiator valves shall be specified for use on compensated circuits and their use shall be agreed with the Senior Mechanical Engineer.

1.3.18 The University has a mixture of STEAM, MTHW and LTHW installations. Under no circumstances shall STEAM or MTHW pipework be run through occupied areas. The route of this pipework shall be restricted to designated service risers and plant rooms.

1.3.19 All heating pipe work shall be insulated to minimise heat loss and prevent frost damage. All calculations must be provided to demonstrate the appropriate thicknesses in accordance with BS EN ISO 12241:2008 using specific conditions where applicable.

1.3.20 Drain off cocks shall be of a gland design. Air vent points will be double valved, have adequate cooling legs and safe discharge points.

1.3.21 Fan coil units are not the University's preferred method of heating/cooling. Where there use cannot be avoided, permanent access provision shall be provided to enable all maintenance activities (i.e. filter changes, motor replacement, drain downs etc.). Approval for installation of fan coil units shall be obtained from the Senior Mechanical Engineer.

1.3.22 Not in use

1.3.23 Not in use

1.3.24 All valve configurations on steam and air systems shall incorporate double block and bleed configuration to ensure adequate depressurisation in accordance with The Pressure Systems Safety Regulations 2000. Numbered valve charts shall be displayed within all plant rooms.

1.3.25 Not in use

1.3.26 All main heating plant shall be provided with a minimum redundancy level N+1.

1.3.27 For new internal pipework installations all attempts shall be made not to bury pipework in duct/trenches/ducts. Should this not be achievable all pipework shall be made fully accessible so as to enable easy inspection, repair or replacement.

1.3.28 Not in use

1.3.29 All newly installed heating installations shall be installed complete with a suitable corrosion inhibitor. For modification to existing installations, a sample shall be taken from the existing systems to determine if inhibitor is installed. The Senior Mechanical Engineer shall then be consulted.

1.3.30 Prior to stage 4, schematic drawings shall be produced and provided for all mechanical/HVAC works associated with the project or scheme. For refurbishment projects, this shall show the interface to the existing infrastructure.

1.3.31 Refer to sections 1.6.6. & 1.6.7 for pipework jointing requirements.

1.3.32 Heated air curtains should be installed on all main building entrances/exits to avoid the introduction of swathes of cold external air. This will prevent nuisance draughts and reduce energy consumption. All air curtains shall be LTHW supplied where locally available.

1.3.33 All complete new heating systems shall include the installation of a side stream filtration unit (e.g. Enwamatic unit). Units shall be complete with stainless steel vessel. For modifications to existing heating systems, please discuss with the Senior Mechanical Engineer the requirement for their inclusion.

1.3.34 In order to reduce energy consumption, all high bay areas (i.e. Atriums, Lecture theatres, Halls etc) shall include the installation of desertification fans.

1.3.35 Cast iron steam isolation valves are not permissible for use anywhere on UoL campus.

1.3.36 All secondary heating and chilled water circuits shall be installed complete with non-return valves. This will prevent inadvertent flow when some circuits are off (i.e. summer CT for hot water, VT off).

1.3.37 All pumps and fans shall be provided with a minimum of spare capacity of:

- 20% of volume.
- 25% on pressure

The main incoming HTHW primary heating flow and return pipes as they enter each building shall be fitted with parallel slide isolating valves and a double regulating valve complete with C to facilitate maintenance works and full balancing of all the sections of the HTHW primary heating installation. HTHW drain cocks shall be installed immediately after the incoming isolating valves on the building side of the valves.

1.4 Water services

1.4.1 All installations shall comply with the requirements of current British Standards (BS EN 806 and BS8558), CIBSE TM13, ACOP(s), The Water Regulations 1999 and the University Legionella Policy (FM00106).

1.4.2 Not in use

1.4.3 Drinking water outlets are to be labelled (see water regulations guide and workplace Health & Safety approved code of practice) as close to the rising main as is possible.

1.4.4 Following any work on domestic water services, ‘as-fitted’ drawings and schematics shall be provided together with all testing and commissioning documentation.

1.4.5 Not in use

1.4.6 Not in use

1.4.7 Not in use

1.4.8 Mains powered PIR controlled urinal flush controls with a hygiene flush cycle shall be installed. (Waterless urinals shall not be installed)

1.4.9 Schematic drawings of the system shall be provided with numbered and labelled valves charts. This will reduce confusion and save time in trying to identify appropriate isolating valves and other system components. In addition, the University’s schematic drawings associated with the Legionella Risk assessments shall be updated accordingly.

1.4.10 Low-use outlets, with a potential legionella/poor water quality risk such as showers, drinking outlets, shall be installed upstream of higher use outlets to maintain frequent flow; e.g. a safety shower can be installed upstream of a WC. (refer to appendix 1).

1.4.11 Potable water supplies shall not be used for the purposes as the primary cooling source for plant and equipment which results in excessive wastage therefore; reasonable provision shall be made in the installation to ensure water efficiently and for the prevention of undue consumption of water.

1.4.12 Where small DHW loads are required, consideration shall be given to local point-of-use water heating rather than centralised production and storage. Where local point of use water heaters are utilised they shall be of the unvented type non/minimum storage

1.4.13 Drinking water systems shall be designed with the provision for the pipework to be purged every four hours by incorporating in the design with other outlets such as toilet flushing boxes.

1.4.14 Drinking water outlets shall be installed in designated kitchen areas as close to the rising main cold water service as practicable.

1.4.15 Any modification to existing drinking water pipework shall be approved by the Senior Mechanical Engineer, and existing CAD drawings shall be updated to reflect the changes.

1.4.16 All water fittings shall be WRAS approved. Any final connection to showers, wash basins or any potable supply shall not be made with flexible hose connections, due to degradation of the material over a period of time causing potential Legionella & Pseudomonas colony formation.

1.4.17 Shower facilities shall be of the low flow type with the flow of water below 6 litres / minute. This shall be agreed with the Senior Mechanical Engineer.

1.4.18 Instantaneous water heaters for single or multi-point outlets devices serving one draw-off only and are either electrically or gas-heated shall follow the general principles and limitations of instantaneous water heaters are given in the latest BS EN standards. In essence:

a. The flow rate is limited and is dependent upon the heater's hot water power rating.
b. Where restricted rates of delivery are acceptable, the heater can deliver continuous hot water without requiring time to reheat.
c. This form of hot water heating should only be considered for smaller premises or where it is not economically viable to run hot water distribution to a remote outlet.

1.4.19 a. Trace heating shall be provided on non-recirculating hot water distribution pipework where the discharge temperature would not otherwise reach 50°C in 1 minute.

b. Unless agreed in writing with the Senior Mechanical Engineer electric trace heating as a means to maintain hot water service temperatures shall **not** be utilised. Where electrical trace heating is used, it shall be connected to the university BMS to enable data logs for continuous monitoring to ensure water temperature above 55°C.Care should be taken to ensure there are no cool spots.

1.4.20 Thermostatic mixing valves (TMV's) shall be sited as close as possible to the point of use. A single TMV should not serve multiple tap outlets and the mixed water pipework should be kept as short as possible. TMV's for showers and taps should comply with NHS Model Engineering Specification - D08 for Type 3 Valves. BS EN 1111 & 1287. Sufficient access shall be provided to enable regular temperature monitoring to take place with minimal disruption.

1.4.21 Where applicable, all domestic hot water calorifiers, cylinder and directlyfire water heater shall include de-stratification pumps to ensure continuity of temperature throughout the stored water supply and shall incorporate time controlled for energy reduction purposes.

1.4.22 All Direct Gas Fired Storage Water Heaters shall **not** be of the type that includes vitreous glass lining.

1.4.23 a. The storage capacity and recovery rate of the calorifier shall be selected to meet the normal daily fluctuations in hot water use without any loss in service and supply temperature.

b. For open vented domestic hot water systems the design shall ensure all vent pipe from the calorifier allows is sufficiently sized for the increase in volume, and suitably sited on the water circuit, to prevent hot water being discharged.

c. All drain and vent shall be discharged safely and via a tundish arrangement and in accordance with British standards and water regulations.

1.4.24 All calorifiers shall include a drain valve located in an accessible position at the lowest point of the vessel so that accumulated sludge can be drained easily and the vessel emptied in a reasonable time. A separate drain should be provided for the hot water system vent (particularly if the feed to the calorifier incorporates a non-return valve).

1.4.25 Hot water circulating loop shall be designed to give a return temperature to the calorifier of no greater than 5 °C and a minimum of 50°C. The pipe branches to the individual hot taps should be of sufficient size to enable the water in each of the hot taps to reach 50°C within 1 minute of operation. Immersion pockets shall be fitted on the flow and return to the calorifier and in the base of the calorifier in addition to those required for control.

1.4.26 All heating and plumbing installers shall be qualified and registered in the "Water Industry Approved Plumber Scheme" for heating and plumbing installers, demonstrating competence and knowledge of the Water Regulations (1999). All appropriate documents shall be retained by project teams and issued to the Mechanical & Energy Engineer.

1.4.27 All works associated with any water supplies shall be fully recorded in building Legionella Log book detailing the activity performed, name of company, name of operative, WRAS registration number etc.

1.4.28 Timed-flow taps or flow regulators are to be installed except those cold water services required for scientific purposes or required to provide untimed flow (e.g. cleaners sinks, kitchen sinks etc.)

1.4.29 Spray taps are not to be specified.

6.4.30 Water conservation measures such as auto control (electronic) for urinal flushing shall be installed.

1.4.31 Cisterns shall not exceed the current regulations and shall be dual flush type

1.4.32 Rainwater harvesting shall be implemented where viable.

1.4.33 The following shall not be specified:

- Drinking fountains (unless approved in writing by the Senior Mechanical Engineer
- Spray taps
- Venturi pump water taps
- Entrained air type shower heads
- Waterless urinals

1.4.34 In the course of refurbishment work all redundant pipework shall be removed to where the branch emanates from it's main. A 'dead legs, blind end or capped ends' shall not be left.
(A dead leg, blind end or capped ends) constitutes a redundant length of pipe exceeding 1.5 x its diameter in length).

1.4.35 a. Backflow protection should be strictly in accordance with BS EN 1717.

b. The local water supplier can provide advice on the level of backflow protection that should be installed. Wherever practicable, systems shall be protected against backflow without reliance on mechanical backflow protection devices; this shall be achieved by point of use protection, such as a "tap gap" above the spill over level of an appliance.

c. The use of RPZ valves shall be allowed with written consent by the Senior Mechanical Engineer

1.4.36 Urinal flushing in lightly used installations, a user-operated or actuated flush for individual stalls or bowls shall be fitted for water saving purposes

1.4.37 Where mains pressure is insufficient to supply the upper floors of a building, mains supply to the lower floors without pumping should be considered.

1.4.38 Water disinfection shall not be carried out no greater than 30 days prior to occupation. The system shall be flushed weekly to maintain a flow of water as described below. The design of the flushing programme should be in accordance with the HSE's Approved Code of Practice L8, Legionnaires' disease – The control of Legionella bacteria in water systems.

1.4.39 In cases, where more than 30 days elapse between the completion of system disinfection and handover of the project, routine flushing shall be carried out to mimic occupancy. Where this flushing does not take place, the building shall be representatively sampled and assessed for microbiological quality to evidence that water meets drinking water standards.
The following tests should be carried out on a weekly basis and be inclusive of:

- total viable counts (TVC) measured at 22 °C;
- TVC measured at 37 °C;
- Coliform bacteria;
- Pseudomonas aeruginosa;
- Legionella (species); and disinfection residuals (taken concurrently with the microbiological samples).
- All test shall be certified by UKAS accredited laboratory and provided in the test and commissioning data package and H&S files

1.4.40 No pipework shall be left buried in walls or floors with no future access provision.

1.4.41 University preference is not to use compression/crimped pipework & fittings for water services systems. Push fit fittings are not to be used at the University of Liverpool. Any deviation from this standard shall be agreed in writing with the Senior Mechanical Engineer.

1.4.42 Where there is no option but to use compression/crimped fittings and approval has been sought from the Senior Mechanical Engineer, a copy of the contractors QA procedure shall be submitted for approval. Equipment calibration certificates and user training/competency certificates shall also be submitted.

1.4.43 All domestic water service shall be installed in copper tube to BS EN 1057 table X. No plastic pipework shall be used.

1.4.44 Refer to sections 1.6.6. & 1.6.7 for pipework jointing requirements.

1.4.45 As per BS EN 15154-1: 2006: Emergency safety showers, potable water or water of a similar quality complying with European or national standards is required for body showers. Materials used in the construction of the shower shall not affect the water quality or contaminate the water supply.

1.4.46 Instantaneous 'point of use' electrical water heaters shall not be used to serve cleaners sinks. Where a buildings hot water services strategy is delivered via point of use water heaters, an unvented local storage unit shall be supplied.

1.4.47 In the selection and specification of taps and water outlets, care should be taken to select outlets that have a pressure drop that is suitable for the pressure available in the system (i.e. a low-pressure tank supplied system should not be provided with non-concussive taps that required a high minimum pressure). The mechanical design consultant shall ensure close coordination is held with the Architect/Surveyor in respect to tap specification.

1.5 Cold Storage Water Tanks

1.5.1 Cold water storage tanks shall be sized in order that the stored volume is displaced every 12 hours.

1.5.2 Dual or split tanks shall be installed with total water separation between the two water chambers. Inlets and outlets shall be arranged to ensure no stagnation occurs. Valves shall be installed so tanks shall individually be capable of a full drain down for ease of cleaning/disinfection without interruption to main building supply.

1.5.3 The tank shall have a water meter on each outlet, with remote reading facility the remote facility shall be connected the University's automated meter reading system.

1.5.4 Not in use

1.5.5 All cold-water storage tanks to be of GRP construction complete with integral insulated panels. The panels shall be all externally flanged so as to aid the cleaning and chlorination processes. Consideration shall be given to ensure the tank construction material shall be such to not promote blistering and osmosis issues or to include areas which will promote stagnation i.e. hollow legs.

1.5.6 The drain point shall be fitted at the base of the tank within a dished panel and shall be of minimum size of 32 mm.

1.5.7 All tanks and cisterns shall have air separation in accordance with the recommendation within the Water Regulations 1999, and delayed action float, or electronic resistance rod level control, in order to ensure that positive water displacement is maintained.

1.5.8 There shall be a minimum of two access points (where practical) including internal steps, at opposing ends of the tank, where this requirement cannot be met then alternative proposal to be submitted for approval by the Senior Mechanical Engineer.

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1.5.9 Tanks are to include external access ladders and safety rails to enable maintenance and visual checks required under the Control of Legionella L8 legislation.

1.5.10 DHW Calorifiers & multipoint heaters shall have fitted flow and return temperature sensors and gauges - the sensors shall be connected to the University's Building Management System (BMS).

1.5.11 Every cistern or water tank shall be placed and equipped so that the interior can be inspected and cleansed and the float operated valve can be maintained. A clear space of not less than 350 mm should be provided between the top of the cistern and any ceiling or other obstruction above the cistern. For small cisterns the overhead, unobstructed space may be reduced to 225 mm provided no dimension of the cistern exceeds 450 mm in any plane.

1.5.12 Where BMS availability is present temperature sensors shall be installed at the inlet and outlet points of the tank–the sensors shall be connected to the University's Building Management System (BMS).

1.5.13 Cold water tanks and Cisterns shall incorporate switched control system that 50% of each tank may be drained for disinfection purposes without interruption of the building supply.

1.5.14 Cold water storage tank should be sited in a cool place and protected from extremes of temperature by adequate thermal insulation. Piping should be insulated and kept away from hot ducting and other hot piping to prevent excessive temperature rises in the cold-water supply; not more than 2°C increase shall be allowed.

1.5.15 Access ports shall be provided on cold water tanks for inlet valve maintenance, inspection and cleaning.

1.6 Pipework Distribution Systems

1.6.1 Heat (and cooling) distribution systems shall be considered carefully in order to obtain maximum overall efficiency.

1.6.2 All designs shall ensure that heat or cooling from the boiler/chiller reaches the point of use with minimum change to the temperature inside the pipe by using the optimum level of insulation and considering the route of the mains.

1.6.3 The design shall ensure all routes of mains (particularly steam and condensate) are safely accessible for maintenance and can be routinely and easily monitored for leakage and damage to insulation. The building management system (BMS) shall be fully utilised to highlight steam trap failure and detecting mains which are not readily visible or are underground.

1.6.4 All designs shall ensure the heat or cooling from the boiler / chiller reaches the point of use with minimum pumping energy the system shall be designed for low resistance.

1.6.5 All designs shall consider the utilisation and future utilisation of the heat network to provide both heating and cooling requirements.

1.6.6 The University prefers not to use compression/crimped pipework and fittings for use in any pipework systems. Push fit fittings are not to be used. Any deviation from this standard shall be agreed in writing with the Senior Mechanical Engineer.

1.6.7 In the unusual circumstance where compression/crimped fittings/joints are approved for use, the contractor is required to demonstrate a robust on-site QA procedure to demonstrate no future joint failures shall occur.

1.6.8 Schematic drawings shall be produced and provided to the UoL PM and Uol FRCS ESG during stage 3,4,5 & 6 for all mechanical & HVAC works associated with the project or scheme. For refurbishment projects, this shall detail the interface to the existing infrastructure.

1.6.9 The utilisation of pulled bends shall be avoided, and only permitted with prior written agreement from the Senior Mechanical Engineer.

1.6.10 Thin wall carbon steel compression pipework & fittings shall not be permissible for use at the University.

1.6.11 For chilled water & domestic cold-water services systems, no fittings (unions, ball-o-fix valves, isolation valves etc) shall be specified/installed in copper/zinc alloys or DZR Brass. This is to prevent stress corrosion cracking.

1.6.12 Mechanical and electrical risers shall be physically separated along their complete length. No wet services should be located in the vicinity of electrical distribution boards, switch gear or main distribution panels.

1.6.13 All pipework & services shall be identified according to BS 1710: 2014: Specification for identification of pipelines and services.

1.6.14 All thermal insulation for HVAC services shall be in accordance with BS 5970: 2012: Thermal insulation of pipework, ductwork, associated equipment and other industrial installations in the temperature range of −100 °C to +870 °C.

1.7 Management of Water Systems - Estates

1.7.1 Where existing systems are to be modified in a building that is occupied and the responsibility for maintaining the existing water system shall remain with the FRCS Maintenance.

- Designer Risk assessments shall be approved by the UoL Responsible Person.
- The Project Manager, Design Engineer, CDM Co-ordinator and the contractor shall meet with the UoL Responsible Person (or nominated Deputy) and agree/record.
- How access to carry out tank inspections can to be achieved.
- How sentinel and additional random tap temperatures are to be undertaken and recorded.
- How water emergencies on the site are to be managed

1.8 Management of Water Systems – Contractors

1.8.1 Where existing systems are to be modified in a building that is part occupied the responsibility for maintaining the water system shall be with the Principal Contractor.

- Designer Risk assessments shall be approved by the UoL Responsible Person
- The Project Manager, Design Engineer, CDM Co-ordinator and the Principal Contractor shall meet with the Senior Mechanical Engineer and agree/record.
- The Maintenance regime that shall be implemented by the Principal Contractor for the management and control of legionella in the specified building(s)
- Details of the extent of the nominated contractor’s roles and responsibilities shall be clearly identified.
- Details (if any) of responsibilities that are to be undertaken by FRCS Maintenance complete with the methodology for carrying out these duties.

- The proposed/agreed methodology that the Principal Contractor shall use for carrying out the inspection and test regime for the management of legionella on the site and the remainder of the building for which he is assuming responsibility.
- How water emergencies on the site are to be managed
- Provision shall be made for independent checks to be carried out by the FRCS Specialist Water Company and/or Specialist Water Consultants as appropriate

1.8.2 New systems in a building that are not occupied and the full responsibility is with the nominated contractor:
- Designer Risk assessments shall in all instances be approved by the UoL Responsible Person
- The proposed/agreed methodology that the nominated contractor shall use for carrying out the inspection and test regime for the management of legionella on the site and the remainder of the building for which he is assuming responsibility shall be submitted to The Senior mechanical Engineer.

1.9 Building Management System

1.9.1 Please refer to BMS policy & specification, for detailed BMS requirements. This policy will override all consultant specifications unless agreed in writing by the Senior Mechanical Engineer.

1.9.2 The University Building Management System shall be utilized to provide environmental control and condition monitoring and in full accordance with the BMS specification which is under review. For holding document please contact the Senior Mechanical Engineer

1.9.3 A controls strategy shall be provided for each project. The controls strategy shall be derived by the M&E consultant and shall explain the workings and interaction of all HVAC/mechanical systems. This is of particular important for complex HVAC systems such as CL3 laboratories or clean rooms. This document shall for the basis for which the BMS engineer shall programme the Building Management System (description of operation). This document shall not be produced by the BMS engineer but shall be the responsibility of HVAC design consultant. This document shall also cover the relevant time scheduling of the various system (i.e. 08.00 -17.00 or 24/7) as this can often inform the outcome of the system design (i.e. 24/7 operation requiring separate plant).

1.9.4 All BMS cabling shall be installed in accordance with manufacturer's recommendations in particular with regard to compliance with the environment in which they are installed. Special consideration shall be given to the UV protection of cables when installed outside in direct sunlight.

1.10 Air Handling Plant & Ventilation

1.10.1 Heat recovery shall be included on all ventilation plant. Normally a pre- heater battery will not be required if heat recovery is installed.

1.10.2 Thermal wheels shall only be fitted in suitable areas for heat recovery. Water carry over from thermal wheels shall be avoided at all times. Hygroscopic wheels shall not be permissible for use.

1.10.3 Air handling units shall be direct drive incorporate an inverter control and comply with current legislation using an IEE3 or IEE4 motor. If not practical a minimum twin V belt drives are to be used. The space saver "SPZ" series shall not be used.

1.10.4 All air filters shall be 'A' grade energy rated pocket filters with a minimum of F7 primary and with F7 secondary rating. All filters shall be supplied with EN 779:2012 certification or later edition thereof. Filters should have common frame sizes of 600mm X 600mm, or 600mm X 300mm with vertical pockets. Filter frame headers should be in galvanised steel with a thickness of 25mm.

1.10.5 Space for future installation of carbon filters shall be included for in all installed air handling plant. This excludes small heat recovery units (HRU's).

1.10.6 As an alternative to Tundish Drains Self-sealing waste valves (e.g. HepvO) shall be installed where-ever possible. U traps may be installed to all HVAC plant with the appropriate access to replace biocide tablets to prevent the proliferation of Legionella.

1.10.7 Design of Duty / Standby plant shall be discussed and agreed dependent upon the application with the Senior Mechanical Engineer.

1.10.8 All HVAC assets shall be fully identified by applying unique asset numbers in accordance the University's current asset numbering protocol.

1.10.9 The Pre Heater Battery (or Frost Battery) shall be bare tube and will not require filtration. Finned type shall not be used.

1.10.10 Suitable access sections with opening doors shall be provided within all air handling units. Access shall be provided to all filters, coils, eliminator plates & fans. All access doors within AHU's shall all be provided with viewing port holes. All AHU's shall be provided with lighting within the units.

1.10.11 Where mechanically operated fire dampers are to be installed, local remote indication shall be installed which highlights if damper is open/closed. The fire damper control panel shall also visually indicate damper position

1.10.12 All ventilation systems shall be provided with a description of operation in a fire condition. This shall be discussed and agreed with the Senior Mechanical Engineer.

1.10.13 All Air Handling plant shall be fully controllable via the BMS. Packaged Air Handling Plant with on – board manufacturers controls shall generally not be permissible there may be small refurbishments where this unit type may be considered with formal approval from the Principal Mechanical and Energy Engineer.

1.10.14 As per guidance in 'BS EN 14644: Cleanrooms and associated controlled environments' & HSE guidance 'The Management, design & operation of microbiological containment laboratories' where any areas are designed to work under ether positive/negative pressure (i.e. clean room or CL 2/3 laboratories), consideration shall be given to incorporating a smoke or pressure test to the building/area envelope. This will ensure designed air flow cascades are achieved when commissioning. This will also ensure air leakage is kept to a minimum.

1.10.15 In accordance with the CDM Regulations all plant and equipment shall be accessible (e.g. ladders, platforms, fixed and mobile.)

1.10.16 Ventilation rates shall be fully compliant with Building Regulations Approved Document F. Air change rates shall, in addition shall be as recommended in the CIBSE Guidance and agreed with the Senior Mechanical Engineer.

1.10.17 Areas of highest heat gain should be identified and steps should be taken to reduce heat gains if that area is the one which is bringing on the main chiller plant. Alternatively, outside-air free cooling shall be used rather than running large chiller plant inefficiently at part load.

1.10.18 The ventilation plant shall be controlled using measured CO2 levels in the areas being mechanically ventilated. Systems that serve summertime and daytime loads shall be separated from those serving 24-hour loads. This shall avoid excessive fan and pump energy and the operation of centralised systems at low part-load efficiencies.

1.10.19 Where options are available, systems which minimise fan, pump and chiller energy in preference to saving heating shall be preferred, due to the former use of electricity being more costly and emits more carbon than using fossil fuels.

1.10.20 Access sections shall be provided adjacent to all filters, cooling and heating coils, heat recovery devices, attenuators and humidifiers to facilitate easy cleaning and maintenance requirements.

1.10.21 All rooms that are designed to have a pressure differential (i.e. CL2/3 laboratories or clean rooms) shall be installed with a pressure gauge adjacent/above all entrance points to the room. The gauge scale should be suitable for pressure which it is designed to work.

1.10.22 All new ductwork installation shall be handed over in hygienic condition. All new ductwork installations shall be provided with dust accumulation test and certificate. Acceptable levels of dust shall be as listed in the tables below (taken from BS 15780:2011 - Ventilation for building – Ductwork – Cleanliness of ventilation systems). If the test results fall outside the British Standard guidance, the ductwork shall be fully cleaned prior to project handover. Following cleaning the ductwork system shall be retested and certified.

Acceptable dust accumulation in new ductwork

Cleanliness quality class	Acceptable dust accumulation level Supply, recirculation or secondary air ductwork	Acceptable dust accumulation level Extract Ductwork
Low	< 0.9 g/m2	< 1.8 g/m2
Medium	< 0.6 g/m2	< 1.8 g/m2
High	< 0.3 g/m2	< 0.9 g/m2

Quality class

Low	Rooms with only intermittent occupancy eg. storage rooms, technical rooms
Medium	Offices, hotels, restaurants, teaching rooms, lecture theatres, shopping areas, exhibition buildings, sport buildings
High	Laboratories, high quality offices

1.10.23 Not in use

1.11 Local Extract and Fume Cupboard Ventilation

1.11.1 All Fume Cupboards shall be of the non-bypass type and comply fully with Appendix VI: NERC guidance on the safe use, maintenance and testing of laboratory fume cupboards. Fume cupboards shall also be designed installed and tested in accordance with BS 14175 parts 1-6.

1.11.2 The position and exit velocity of all fume extract stacks shall be as per ~~guidance in~~ BS14175. A drawing to be submitted for comment and approval to the Senior Mechanical Engineer that shows the proposal is in compliance with the requirements of BS14175. This drawing to show the building and roof outline and to be of a plan of the entire building. It needs to show the proposed fume extract location, any existing fume extract points, flues, air intakes, openable windows, accessible areas and roof plant. Sections are required to show the various roof level and distances. Where adjacent buildings exist that are the same height or higher then these need to be included. Where the proposal is not strictly in accordance with BS14175 then consideration will be given to a derogation but only where deemed safe and will normally be subject to increased efflux velocities or re-location of intakes and or plant.

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1.11.3 Fume Cupboards and the associated supply and extract system shall be specified on containment rather than face velocity. However, designs shall be based on a minimum of 0.4ms^{-1} as indicated in NERC guidance and HSG 258 (H.S.E. controlling contaminants at work: A guide to local exhaust ventilation). Designers shall ensure the users of all fume cupboards are consulted to determine the hazard classification of the substances to be used are determined. This will determine the containment level to be designed and tested to. In the absence of an informed user brief, the designer shall assume work case hazard classification.

1.11.4 As per NERC, guidance containment tests to BS 14175 shall be required for the following situations:

- All new installations
- Following major repairs or alteration to a fume cupboard.
- Prior to the start of a high hazard process.

1.11.5 All systems shall be designed to minimise supply and extract air when not in use.

1.11.6 All fume cupboard systems shall be allocated a distinct identification number which shall not be shared by any other system operating on that site. The number shall be clearly marked on all parts of the system, including ductwork and fans where these might be confused with components of any other system.

1.11.7 The fume cupboard system may contain and convey potentially dangerous or obnoxious fumes from the fume cupboard enclosure to an outside discharge point where it can be safely dispersed at low concentration. Please refer to BS EN 14175 1-6:2003 for detailed requirements.

1.11.8 The fume cupboard, ductwork and system shall be constructed of materials capable of resisting chemical or thermal attack from any substance or equipment used within it, including during escapes other than during normal operations. See BS EN 14175 for details on fume cupboard material selection.

1.11.9 Auto sash closers coupled with a variable air volume system should be considered and the implications identified for the Senior Mechanical Engineers consideration. This is to ensure energy consumption is minimised. The associated supply air system shall also be variable air volume to ensure maximum energy savings are realised. For the eventuality that auto sash closures are not incorporated, the enclosure shall have a movable sash which will normally be lowered during operation, but which can easily be positioned at a higher level to allow periodic access to equipment within.

1.11.10 The sash mechanism must incorporate a device to limit its movement such that a maximum aperture height of 0.54 m is maintained between the base of the cupboard and the underside of the sash. This is to be the considered as the maximum working aperture, and shall not be exceeded during normal operations. When it is necessary to exceed the maximum working aperture height, for instance whilst loading equipment during the setting up experiments, it shall only be possible to do so after deliberately activating a stop-release mechanism.

1.11.11 Where an experiment presents the possibility of accidental spillage of hazardous liquid within the enclosure, it will be necessary to incorporate features to contain the spill within the enclosure. The capacity of this feature must be capable of accepting the volume of the largest container housed within the fume cupboard.

1.11.12 With the exception of electrical supplies, the outlets to services shall be located on the inner surface of the enclosure. The controls shall be located on the external surfaces of the enclosure such that each control can be unambiguously associated with its outlet, and visibly marked in accordance with relevant standards.

1.11.13 All fume cupboards shall incorporate a means of unambiguously indicating to the operator that air is being extracted at a satisfactory rate. Where audible alarms are fitted with a mute facility, it is not permitted to carry out normal operation in the mute mode.

1.11.14 Ductwork shall be constructed of a material suitable for use with the materials intended for use within the fume cupboard. See BS EN 14175 1-6:2003 for comprehensive guidance on material selection.

1.11.15 Each fume cupboard shall have a dedicated duct system and fan set where possible. In the event of multiple fume cupboard extraction facilities must exist to indicate failure of any part of the system and communicate that failure to ALL other parts of the system likely to be effected. All fume cupboard extraction system shall be fully segregated from general and other ventilation systems.

1.11.16 Where systems are used which allow the fumes from more than one enclosure to mix, a comprehensive risk assessment must be made, and control measures introduced to prevent the simultaneous use of incompatible substances.

1.11.17 Internal surfaces of ductwork shall be smooth and free from obstruction.

1.11.18 The configuration of ducting shall be designed to avoid features likely to allow the collection or concentration of contaminant; for example any long horizontal duct runs should be slightly inclined, and incorporate suitable drainage points.

1.11.19 All ducting shall incorporate leak-proof inspection covers to allow easy internal inspections during periodic maintenance and examination.

1.11.20 All ducting between the fume cupboard enclosure and the fan which passes through any occupied space (i.e. offices or manned plant rooms) shall be at negative pressure to the ambient room pressure to prevent the leakage of contaminant into the room during plant failure.

1.11.21 Where possible, no ductwork shall violate the fire compartments of the building in passing between the fume cupboard and its final discharge point. Duct runs shall be external to the building wherever possible. Where ductwork does penetrate a fire compartment, it shall be suitably protected in accordance with Approved Document B of the Building Regulations. Where fire protected, all fume extract ductwork shall be provided with access panels at regular intervals. No fire dampers can be installed in fume extract ductwork.

1.11.22 Where it is proposed to use fire dampers to maintain fire integrity their use shall be agreed with the University Fire Officer and the Senior Mechanical Engineer. As a minimum fire dampers shall be of suitable corrosion resistant design, and be readily accessible for inspection and maintenance.

1.11.23 Where mechanically operated volume control dampers are located in a duct, they must incorporate a feature to deter the unauthorised operation. A lock-nut and an appropriate warning sign shall be sufficient. All parts of the fan likely to come into contact with the fume or its condensate shall be resistant to them, and be able to withstand the maximum working temperature.

1.11.24 For larger fume extraction systems, consideration shall be given to the use of heat recovery on the fume extract.

1.11.25 All fume extraction ductwork shall be specified to be able to withstand the maximum pressure rating of the fan (closed head) plus 10%. If this is in excess of 750Pa it is outside classification of DW 154 and ductwork should be designed accordingly. All fume extract ductwork shall be pressure tested to its design rating as per DW 154: Plastics Ductwork.

1.11.15 Pressure sensors (and their associated tubing) controlling fume extraction fan speed shall be constructed of a material able to withstand the atmosphere to which it will be subjected to (i.e. external air). Rubber tubing may not be sufficient. Please ensure that a secondary controls device is provided for the eventuality that the primary controls device fails.

1.11.15 All LEV (local extract ventilation) systems, shall be designed to HSG 258, 2017: Controlling airborne contaminants at works. All designers of LEV equipment (i.e. fume cupboards, canopy extract, dust control etc) shall be undertaken by a competent LEV designer. As per appendix 2, section 16 of HSG 258, professionally competent LEV designers shall have qualifications through BOHS, CIBSE or ILEVE.

1.12 Fume Cupboard Fans

1.12.1 The fan motor shall be situated outside the air stream to prevent the transmission of sparks to any potentially explosive fume within.

1.12.2 Not in use

1.12.3 All components of the fan must allow access for inspection and maintenance, particularly the internal drum of the fan and its casing.

1.12.4 Any belt drives must be adequately guarded to prevent accidental entanglement.

1.12.5 Fan sets and associated plant mounted externally at roof level should incorporate barriers and other safety features to prevent falls during maintenance activities.

1.12.6 Fan assemblies shall incorporate vibration damping gaiters between isolating ducting and discharge stack. This will reduce noise transmission and reduce the potential for fatigue failure throughout the duct system.

1.12.7 Designers shall consider separation of Fume Cupboards between 24 hour and non 24 hour Fume Cupboards. Large energy savings can be achieved by separating out 12 and 24 hr fume cupboards.

1.12.8 Fume cupboards shall not be used for general chemical storage in any circumstances.

1.13 General Extract Systems

1.13.1 For small localised systems, consider packaged units which supply make-up air via a heat exchanger; centralised systems shall be zoned to ensure that daytime-only areas can be controlled separately; Heat shall be recovered from extract systems wherever possible.

1.13.2 Prior to stage 4, schematic drawings shall be produced and provided for all mechanical works associated with the project or scheme. For refurbishment projects, this shall show the interface to the existing infrastructure.

1.13.3 Designs shall use passive infrared controllers (PIRs) to set back systems which are in intermittent use, such as Lecture theatres.

1.14 Motors and Drives

1.14.1 All designs shall incorporate IEE3/IEE4 premium efficiency motors on HVAC and pumps throughout the building service design or include high-efficiency motors (HEMs) of equal or greater efficiency. Specific fan power design shall aim to be 2 W/L/s or less to achieve best practice.
All designs shall incorporate IEE3/IEE4 premium efficiency motors on HVAC and pumps throughout the building service design or include high-efficiency motors (HEMs) of equal or greater efficiency. Specific fan power design shall aim to be 2 W/L/s or less to achieve best practice (and be in full compliance with building regulations).

1.14.2 Variable-speed drives (VSDs) shall be used where possible.

1.14.3 Direct drives are preferable to belt drives, where practical, except where motors need to be kept out of the airstream. If belt drives are used, consider modern, flat, synchronous or ribbed belt drives rather than traditional V-belts to reduce drive losses. Sensors shall be added to check the motor load so that the motor can be switched off if idling.

1.15 Cooling Plant / Refrigeration

1.15.1 Consideration shall be explored to reduce internal heat gains where possible to avoid the requirement to require cooling. In the unavoidable event by exploring natural ventilation methods free cooling shall be used increasing the cooling capacity of ambient air to directly cool the space by increasing the fresh air supply rate when the external air is at an appropriate temperature, part of the cooling load can be met, hence reducing the energy consumed by mechanical refrigeration plant. Peak lop close control shall be included to ensure the cooling is available when only absolutely necessary. Peak lop control shall be via the Universities BMS system. Generally, no local user control of any approved cooling shall be provided. Please refer to EPM PM22, air conditioning policy, for more detailed information.

1.15.2 All installation shall be in full accordance with the University Air Conditioning Policy. (under construction)

1.15.3 All cooling plant design shall be concluded without the aid of cooling towers or evaporative condensers.

1.15.4 No installation of cooling plant shall proceed without a completed Application form which are issued and authorised by the Senior Mechanical Engineer. Please refer Air conditioning/comfort cooling policy.

1.15.5 Where provision of comfort cooling cannot be avoided (ref section 1.15.2) consideration shall be given to the use of passive/active phase change materials.

1.15.6 The installation of new chilled water system within new building shall include for the inclusion of Glycol. And shall be to BS 8552:2012, BSRIA BG 29/2012, BSRIA BG 50/2013

1.15.7 Prior to stage 4, schematic drawings shall be produced and provided for all mechanical works associated with the project or scheme. For refurbishment projects, this shall show the interface to the existing infrastructure.

1.15.8 Areas of highest heat gain should be identified and steps should be taken to reduce heat gains if that area is the one which is bringing on the main chiller plant. Alternatively, outside-air free cooling shall be used rather than running large chiller plant inefficiently at part load.

1.15.9 All complete new chilled water systems shall include the installation of a side stream filtration (e.g. Enwamatic unit) should be installed. The unit shall be complete with stainless steel vessel. For modifications to existing chilled water systems, please discuss the requirement for their inclusion with the Principle Mechanical Engineer.

1.16 Compressed Air plant

1.16.1 All installations to be discussed on case by case situation and agreed with the Senior Mechanical Engineer.

1.16.2 All air compressors installed shall be remotely monitored using air flow gauges to prevent unnecessary use due to leakage.

1.16.3 Heat rejection from compressors shall not be introduced directly into plant rooms. This will avoid excessive ambient temperatures. Where possible, all heat rejection for air compressors shall be recovered reused within other HVAC systems. If heat cannot be recovered or it is not cost effective to do so, rejected warm air shall be ducted to outside. Please also refer to 1.2.3.

1.17 Isolation of Mechanical Services

1.17.1 The isolation of mechanical services within buildings can be extremely disruptive and dangerous if it is not well planned. The need to arrange isolation for a variety of reasons regularly arises however it is important that appropriate arrangements are put into place.

1.17.2 The de-commissioning and re-commissioning of mechanical services is un-likely to be undertaken by the Maintenance services Unit or their nominated term maintenance contractor. If they do provide this or assist in the isolation process then this will incur a charge that must be borne by the project. Requests for isolation of mechanical services shall be made in writing, with a minimum of 84 hours' notice (for certain buildings this period may be longer).

1.17.3 RAMS covering the proposed isolations with drawings and schematics to show what is being isolated, where and how along with schematics and layout drawings to show the areas affected need to be submitted in advance for approval to the UoL PM who will liaise as necessary with FRCS Maintenance, the building users, the Building Manager and the Senior Mechanical Engineer. Once approved the Contractor to carry out the isolations as per the approved RAMS.

1.17.4 It is imperative the relevant Faculty Estate team is kept involved in the arrangement of shutdowns as they liaise with building users.

1.18 Drainage & Rainwater Systems

1.18.1 Where a project involves working on Laboratory drainage this shall be planned in detail with the facility/building users due to the potential hazards that may be associated with particular departmental functions.

1.18.2 Requests for work to existing systems shall be made as per the Isolation of Mechanical Services.

1.18.3 Laboratory drainage systems to be assessed for suitable materials. The default system is vulcathene with fusion welded joints other than where connection onto equipment and to allow access for un-blocking, service or maintenance is necessary. The Designer needs to assess the suitability of vulcathene and if this not deemed suitable confirm this along with details why and what is proposed to the Senior Mechanical Engineer for approval.

1.18.4 Pumped drainage systems (such as Saniflo systems) and macerators are not to be used at the University. Designers shall influence room layouts so as to avoid the need for their inclusion.

1.18.5 In the eventuality that a pumped system is unavoidable, all systems of this type shall be provided with duty/standby pump, remote audible alarm in the room it is serving, appropriate signage & alarms/monitoring on the BMS. This system shall require a formal derogation report to be submitted to the mechanical engineering team. Before this derogation is submitted a discussion shall take place with the Senior Mechanical Engineering.

1.18.6 All plant rooms shall be provided with suitably located and an adequate number of gulleys. The gulleys shall be located so as to avoid low level pipework becoming a trip hazard. These shall be co-ordinated and be local to all relevant plant (i.e. Pressurization units, AHU's etc). All plant with a drain/overflow shall be hard piped to drain with a suitable fall. No plant item with an overflow shall remain unconnected and without pipework to drain.

1.18.7 All drainage materials shall be specified so as to be suitable for the temperature and hazardous nature of the fluids they shall carry. This is also applicable for 'blow off' drainage pipework for hot water or LTHW systems where standard UPVC pipework may not be suitable.

1.18.8 Syphonic drainage system shall not be used on University projects.

1.19 Sterilisation and Disinfection

1.19.1 Cascade systems shall be employed where conditioned air from the cleanest space (packing) flows to neutral then to dirty areas;

1.19.2 Where practicable, include sterilizer plant rooms adjacent to an external wall, preferably at ground-floor level, to enable heat within the plant area to dissipate naturally.

1.19.3 Steriliser and disinfecting equipment shall be considered on the basis of energy usage as well as performance – energy usage and whole-life costs can differ widely between manufacturers.

1.19.4 Heat recovery from washer disinfection extracts shall be included, ensuring the device can withstand moist, corrosive air; consider heat recovery from heat exchangers in sterilizer drainage (water cannot be re-used).

1.20 Compressed Gases & Pressure Systems

1.20.1 Modification to any existing fixed gas or cylinder installation shall require the production of a Written Scheme of Examination. This shall be procured through the project team and issued to the Project Manager as part of the H&S file.

1.20.2 The location of any pressurised gas cylinders requires input from the University Fire Officer and risk assessment by the school health & safety officer. The final location should be assessed based on a hierarchy of control. This is as per guidance in the Dangerous Substances and Explosive Atmospheres Regulations, Approved Code of Practice and guidance 2013. Guidance is also given in the NERC (Natural Environment Research Council) Guidance safe storage & Installation of Gas Cylinders.

1.20.3 Where compressed gases lines are installed into a room or facility the need for a gas detection system shall be risk assessed by the school H&S officer. This risk assessment should be documented and included in the H&S file for future reference.

1.21 Natural Gas

1.21.1 Natural gas outlets shall be hard piped. It is not acceptable to terminate gas connections to outlets via a flexible hose.

1.21.2 For detailed natural gas requirements please refer to the gas safety management system from University Gas Policy.

1.21.3 All installed natural gas pipework systems shall be sized to accommodate the full connected load. This shall include all connected gas fired appliances, even where resilience is provided. Controls interlocks and management arrangements are not an acceptable way of compliance for an annual Landlords gas safety test.

1.22 Guide to Energy Efficiency and Carbon Reduction

1.22.0 General

1.22.1 In accordance with the University of Liverpool's (UoL) Sustainability Strategy, the University is committed to reducing its carbon emissions to net zero by 2035. This strategy aims to socially invest in improving the lives of everyone who works and studies at UoL. The strategy further includes signing the UN's Sustainable Development Goals, UoL has committed to work to address the global challenges facing society and the environment today, by improving health and education, reducing inequality, ensuring economic sustainability, protecting its shared environment and its biodiversity and tackling climate change.

The Sustainability Strategy, specifically for project works and the associated energy and carbon agenda, looks to:

"To be a thought leader in practical and theoretical issues surrounding the sustainability of the built environment, using live projects on our estate to develop, test and design sustainability and assessment tools that can be adopted by industry."

"We will continue to push the boundaries of environmental sustainability in all our building work using our expertise, assets, and relationships, to lead the way in the sector."

In order to embed this agenda into the University's development plans, projects within the built environment are required to entrench the following within its work streams:

- Publish plans, progress, and performance targets, to measure UoL progress and adapt to feedback where necessary.

- Develop a high-quality and sustainable campus using our environmental management system to manage environmental performance.

Any factors of a project having implications on the consumption of energy, and or carbon emissions, shall therefore include the following:

1.22.2 For any project work involving renovation of a building, the target energy consumption post-renovation (both electricity and heating) shall identify designs that offer above and beyond Building Regulation requirements, at the time of design, 25%, 50% and >75% less than the pre-renovation figures. Consumption data figures may be obtained from the Energy Team. In specialist cases where a 25% 50% or >75% reduction is not achievable, this must be agreed with the Head of Engineering Services.

1.22.3 Designs relating to the usage of energy within new builds and substantial refurbishments shall be subject to the requirements of 1.22.2 and further produce a detailed Carbon Management Strategy (CMS) as per sections 1.24.1 – 1.24.4 All capital projects of a value of £3m+ to have a designated Sustainability Advisor.

1.22.4 All work and designs shall be carried out in compliance with all relevant legislation, Codes of Practice and industry standards.

1.22.5 The design must consider energy consumption for the purchase of all items of equipment and be fully compliant with current best practice.

1.22.6 Adapt new technologies and ideas into the design wherever proven and practicable, e.g. renewable energy, LED lighting, high efficiency motors etc...

1.22.7 The designers shall develop designs that maximize energy efficiency and give consideration to low and zero technologies, including, but not limited to:

- Solar Gain/Solar Shading
- Natural Ventilation
- Air-tightness
- Green-roofs
- High insulation levels

- Use of natural light
- Rain water harvesting
- Wind turbines
- Solar PV and Solar thermal
- Ground / Air / Water Source heat pumps
- Hydrogen fuel cells
- Biomass
- Combined Heating and Power

1.22.8 The Energy Performance of Buildings Regulations (2012) requires that when a building is erected, the person carrying out the work must provide an Energy Performance Certificate (EPC) to the owner of the building. The designer shall ensure this is included in the specification.

1.22.9 Whole Life Cycle cost analysis calculations shall be provided for all energy consuming equipment/systems. Where available building energy data shall be evaluated and a report issued, or incorporated within the CMS (see 1.23), demonstrating the overall reduction/increase in carbon emissions. Renewable heat sources shall be assessed for suitability and cost effectiveness. (e.g. Solar Thermal & Ground Source Heat Pumps, refer to 1.22.8 for further equipment).

1.22.10 As required in Approved document L of the building regulations, a building log book shall be provided for

- New Buildings
- Refurbished Buildings
- Where significant changes have been made.

The log book should give the University readily available access to information on the design, commissioning and energy consumption of the building. It will enable fine tuning of the building with consequential improvements in energy efficiency. The log book will also provide explicit information about the metering strategy implemented in the building, and on the scope for monitoring and benchmarking energy consumption. CIBSE’s TM31 Building log book toolkit should be used as the basis for all log books provided.

1.23 Carbon Management Strategy (CMS)

1.23.1 A Carbon Management Strategy shall be produced for all projects to identify the implications for energy/carbon consumption/emissions. The CMS shall make the case for sustainability installations which are above and beyond current strategies i.e. Building Regulations and BREEAM ratings. The CMS shall be submitted to the Head of Engineering during RIBA Stage 3/4 of the process.

1.23.2 Each Energy Conservation Measure (ECM) must be presented as a “mini business case” with detailed calculations and description of the measures and a summary table of all measures for simple reference including a brief description of the measure, initial energy, emissions, and costs, the predicted energy, emissions and cost post installation, and the simple payback. (see 1.23.3 for further details).

The CMS shall further include detailed information highlighting the embedded carbon implications of the project and details on the implications to reduce their impacts, (see section 1.23.3 & 1.23 for details).

The format of all details shall include a report in Microsoft Word and all detailed calculations in Microsoft Excel. In the event additional formats are required, see clarification from The Head of Engineering Services.
In order to calculate CO2 values, UoL will provide figures based on the carbon emissions associated with its Combined Heating and Power generation. For further details contact Rachael Hanmer-Dwight email: R.Hanmer-Dwight@liverpool.ac.uk.

1.23.3 The CMS will (as a minimum) comprise of the following sections:

- Present Energy Demands (KWh) and system overview including utility costs (£ costs/pa)
- Predicted Energy Demands (KWh) from new installation (£ costs/pa)
- U Values for glazing, insulation, cavity wall, wall cladding (if applicable)
- List of Legislative Requirements and how they are complied with
- Consequential Improvement Plan (for applicable projects)
- Carbon targets reduction (%) , and how these will be met
- Existing Emission (tCO2)

- Payback Period (years)
- Cost per Tonne of Co2 of installation (£/t CO2)
- Gross cost of installation (£)
- Impact reduction on the University (KWh)(tCO2)

1.23.4 For all Capital Projects a CIBSE TM54 (Evaluating operational energy performance at design stage) report is to be provided.

Ensure that energy conscious design is adopted in all new build and refurbishment projects with particular consideration throughout the design process, but not limited to, the following issues:

- Building massing and envelope design
- Heating Systems
- Hot and cold water services
- Water tank storage
- Water System Management
- Air handling plant
- Centralised and local cooling plant, refrigeration (exceptional circumstances only)
- Compressed air plant
- Electrical lighting and power installation
- Controls and BMS monitoring
- Monitoring and metering of all Utilities

1.24 Embodied Carbon

Net Zero carbon needs to be considered in the context of Whole Life Carbon (WLC). WLC includes operational and embodied carbon, and these need to be understood, and considered, very differently.

WLC includes embodied and operational carbon emissions associated with daily energy use. The purpose of using WLC is to move towards a building or a product that generates lowest carbon emissions over its whole life stages (sometimes referred as 'cradle-to-grave')

Clear areas for operational energy for various building types, and advice on how to achieve them are found throughout this Guide to Energy Efficiency and Carbon Reduction. This section however focusses on actions to reduce embodied carbon and specifically looks to the LETI Climate Emergency Design Guide. The guidance advocates introducing a commitment to Net Zero from the initial inception of a project, outlining how this should form the foundation of all RIBA stages of a project. While the guide is aimed primarily from a client perspective, it can be a useful document for all stakeholders across the industry. It makes clear how the whole project team, from client to sub-contractor to supplier, can deliver on net zero targets and how early involvement in design and procurement can inform the agenda.

It further outlines practical steps for each Stage in detail, offering between four and seven 'key points' for each. These are clearly set out and are practicable for all project types and sizes.

Example action points include:

- Stage 0 – Ensure cost forecasts account for the sustainability aspirations of the project
- Stage 1 – Establish operational energy and embodied carbon targets and identify measurement tools
- Stage 2 – Use embodied carbon assessment to inform decisions
- Stage 3 – Include a Sustainability Strategy with planning applications
- Stage 4 – Agree carbon reduction targets and options to influence specifications
- Stage 5 – Identify a site-based net zero carbon 'Sustainability Advisor ' and ensure all personnel understand the strategy
- Stage 6 – Simplify building user guides and training, detailing energy efficient operation, for all occupants
- Stage 7 – Compare predicted energy performance to actual energy performance

1.24.1 Interaction between embodied carbon and operational carbon

A table of information shall be produced and incorporated into the CMS detailing each activity presented. The table shall include, but not limited to the following:

- Reference
- Design Area
- Design element
- Base case
- Description of improvement measure
- Planning risk
- Implementation implications
- Programme impact
- Carbon saving tCO2
- Carbon saving embodied %
- Carbon
- Offsetting savings (£)
- Cost base case (£)
- Cost improved case (£)
- Cost uplift (£)
- Simple payback (years)

1.24.2 This information shall set against LETI embodied life cycle banding table detailing the overall achieved band as detailed below:

Life Cycle Embodied Carbon, A1-5, B1-5, C1-4

Band	Office	Residential (6+ storeys)	Education	Retail
A++	<150	<150	<125	<125
A+	<345	<300	<260	<250
A	<530	<450	<400	<380
B	<750	<625	<540	<535
C	<970	<800	<675	<690
D	<1180	<1000	<835	<870
E	<1400	<1200	<1000	<1050
F	<1625	<1400	<1175	<1250
G	<1900	<1600	<1350	<1450

LETI Embodied carbon targets based on typology (C/D is current best practice)

1.25 Digital Twin

The ability to model both building services in construction and operations within the built environment are well known and have been well utilised throughout the industry for some time. In order to clarify what can be offered as a further benefit by "Digital Twin" (DT) the following definition is stated:

"A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making."

In simple terms, this means creating a highly complex virtual model that is the exact counterpart (or twin) of a physical entity. The 'entity' could be a plane, a building, a bridge, or a jet engine. Connected sensors on the physical asset collect data that can be mapped onto the virtual model. Anyone looking at the DT can analyse crucial information about how the physical entity is doing out there in the real world.

UoL is currently undertaking a pilot scheme, in association with the Virtual Engineering Centre (VEC), which initially looks to develop a DT in 3 areas. The main campus Energy Centre, the Mechanical and Electrical Key Infrastructure and 4 buildings. These DT's will have the capability of being more accurate at reproducing building zones and spaces than existing systems. To create these models, data will need collecting and more detailed information for the buildings.

The University, therefore seeks to further expand these highly complex DT's on a number of the building assets within the campus, to collect data that can be mapped onto a virtual model developed by VEC. Anyone looking at the virtual model can then evaluate crucial information about how the physical assets would perform in the real world.

The scope for inclusion in the DT; occupancy for bookable teaching spaces and energy modelling for reduced cost and CO2 impact.

Principal areas to be include:

- Energy (BMS) and Carbon
- Occupancy (wireless heat maps, digital signage, people ‘flow’)
- Access Control
- AV monitoring
- CCTV
- Car Parking

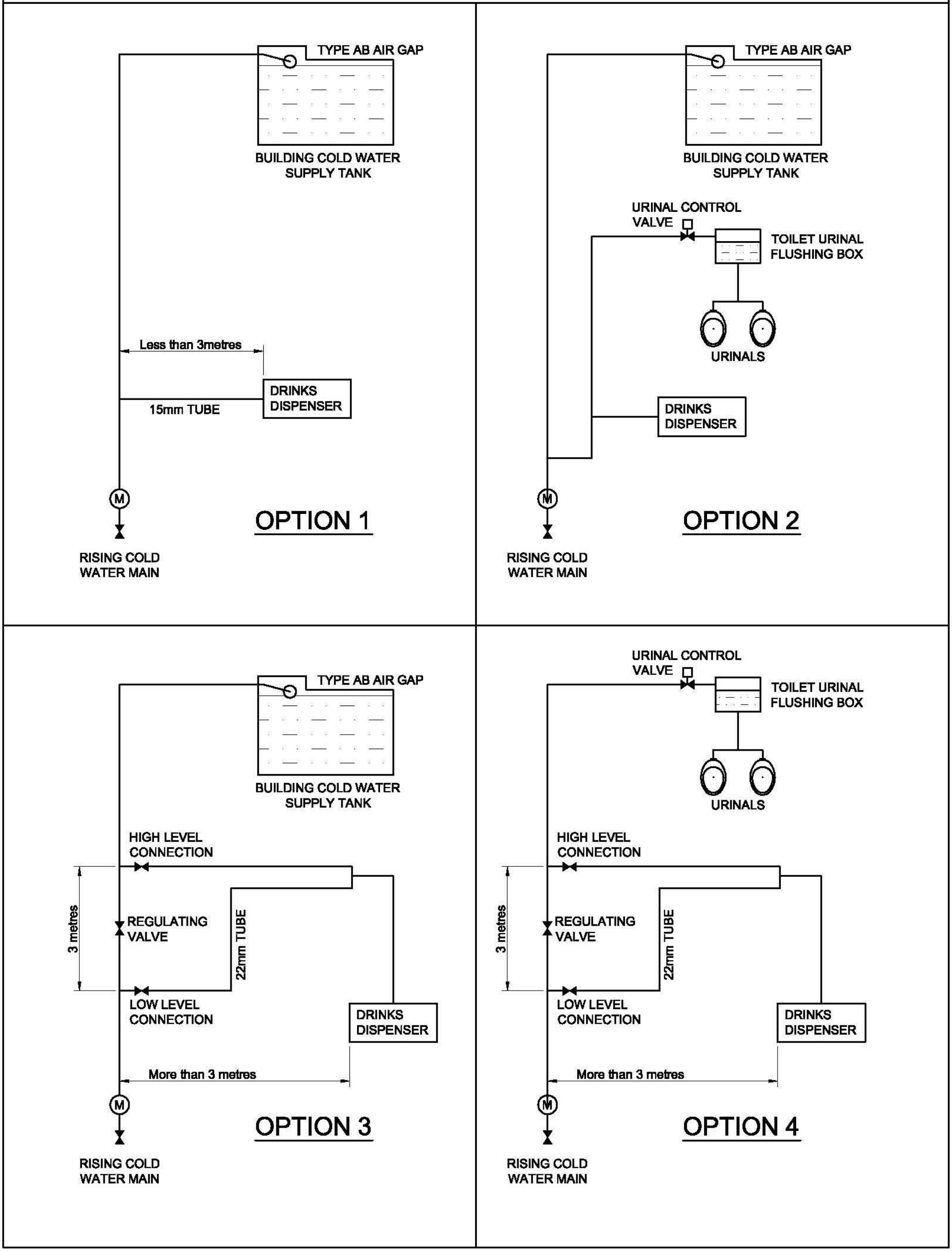
All areas to be available in the DT should include, but not limited to:

- Floor plans
- Number of floors
- Building use across all spaces
- Occupancy patterns
- Room types
- Building and Fabric
    - Glazing, U and G values
    - Wall and roof system insulation
    - Airtightness
- Laboratory LEV
- Mechanical and or natural ventilation
- Cooling plant
- Predicted weather patterns,
- Temperature impacts on tertiary circuits
- Electrical loads, lighting and power
- BMS integration, temperature sensors, Co2 etc.
- Lighting control

This will allow for an effective DT to be developed and the true impact of any ECM’s on energy/carbon reduction techniques to be modelled effectively.

Appendix 1

UNIVERSITY PERMITTED DRINKING WATER CONNECTION ARRANGEMENTS



Appendix 2 - Approved Equipment Manufacturers List - Mechanical

Plant Description	Supplier 1	Supplier 2	Supplier 3
Air & Dirt Separators/Deaerators	Spirotech		
Air Vents	Spirotop (Spirotech)	Winns	
Sidestream Filtration & Treatment	Enwa (EnwaMatic)		
Safety Valves	NABIC		
LPHW Boilers	Remeha	Viessmann	Hamworthy
Flue (Gas) Systems	A1 Flue Systems	Selkirk	Sigram
Radiators	Stelrad	Myson	Hudevad
Radiators Valves	Danfoss		
Isolating Valves, NRV etc.	Crane	Hattersley	
PICV			Via review at Design Stage (RIBA 3-4)
LPHW DRV & Commissioning Valves	Crane		
LPHW Heating Pumps	Grundfos	Armstrong	Wilo
Pressurisation Units	Aquatech Pressmain	Mikrofill	
Heat Meters	Endress & Hauser		
DHW – LPHW heat source	Stokvis Ltd	Ormandy Ryecroft	
DHW – Gas fired	AO Smith	Andrews	Hamworthy
DHW – Electric (storage)	MegaFlo	Heatrae Sadia	Viessmann
DHW – Electric (undersink)	Heatrae Sadia	Santon	
Water Boilers (Drinks)	Zip		
TCV (DHW Temperature Control Valves)	Crane	Pegler	Reliance
TMV (DHW Temperature Mixing Valves)	Reliance	Pegler	Crane
SanitaryWare	Armitage	Twyfords	
Brassware (Taps)	Armitage	Twyfords	Rada/Mira
Showers	Mira	Horne	
Water Tanks	Dewey	Nicholson	
CWS Booster Pump Sets	Grundfos	Pressmain	EfaFlu (PumpLogic)
Controls – BMS System	Tridium Jace with Tridium Niagra N4 Supervisor Refer to the UoL BEMS Specification		
Control – General BMS I/O Modules	Tridium	ISMA	Danfoss
Control – Critical BMS I/O Modules	American Automatrix		
LPHW Control Valves	Belimo	Danfoss	Siemens
Control Valve & Damper Actuators	Belimo	Danfoss	Siemens
Sensors inc. Pressure Transducers	Sontay	B&K	
Inverters	Danfoss	ABB	
Controls – BMS System Installers	Impact Controls Systems Ltd		
Air Handling Units	AHE - Air Handling Equipment Ltd	DalAir	Via review at Early Design Stage (RIBA 2-3)
Grilles/Diffusers/Louvres Equipment	Waterloo Air Management	Gilberts Ltd	GDL Ltd
Air Flow Control Dampers	ActionAir	Gilberts	BSB
Fire and Fire&Smoke Dampers	ActionAir	BSB	
Fume Cupboards	CleanAir	TCS Ltd	PF&F Ltd
Fume Cupboard Extract Fans	Central Fans - Colasit		
Fume Extract VAV Control Systems	TEL	CMR	
MVHRU & Toilet Extract Fans	NuAire	Vent Axia	Lossnay
Window Extract Fans	Vent Axia		
Smoke Extract Systems	Colt	SE Controls	
Gas Alarms – Laboratories			Via review at Design Stage (RIBA 3-4)

Gas Alarms – Kitchens			Via review at Design Stage (RIBA 3-4)
Gas Alarms – Plantrooms			Via review at Design Stage (RIBA 3-4)
Air Conditioning (split/VRV/DX ACCU)	Mitsubishi		
Cassette Condensate Pumps	Little Giant	Aspen	
Chillers	Airedale	Carrier	Trane
CHP units	Jenbacher		Via review at Design Stage (RIBA 3-4)
District Heating – Pipework & Valves	Logstor		Via review at Design Stage (RIBA 3-4)
District Heating – Installation	Vital Energi		Via review at Design Stage (RIBA 3-4)
District Heating – PHE	Vital Energi		Via review at Design Stage (RIBA 3-4)
Lab Gas Installations	Medical Pipeline Services	RGE Ltd	
Scaffolding	Merseyside Scaffolding Ltd		

	Required Supplier

Required supplier (as indicated by the shading) are to be used until otherwise agreed in writing.
Where there are several names in none shaded areas then any of those listed can be used.
Where there is one name shaded and others in un-shaded this indicates that the shaded one should be used but **IF** this is relaxed then the unshaded may be acceptable.

This does not however mean that alternatives cannot be submitted for consideration. It gives the basis for plant design, selection and costings until alternatives are agreed and confirmed in writing. If there is a better or more suitable providers, or concerns over the manufacturers listed, then this should be raised and changes will be considered. Details need to be provided to UoL by whoever is proposing the change with outline details of the implications including what, why, product details and any cost or programme implications. However, until the change is confirmed in writing by the UoL PM then the basis is to be as per the list above.

There are various items of specialist plant, equipment or systems where the manufacturer or system specialist either needs to be assessed and agreed for that project. This can either be as there are differing existing systems in certain buildings that need to be matched and integrated, there is an agreed transition policy or that the application is specialised and complex and warrants a full assessment over requirements (i.e. large CHP). These generally need to be discussed and agreed at the appropriate design stage as noted.