Estates Standards

Employer's Requirements and Design Standards for Mechanical, Electrical and Public Health Services

Version 9.0

October 2022 Final Issue

Version Number	Description	Date
1.0	1st Issue of Document	Sept 2005
2.0	Contact directory updated, M&E general revisions, and vertical transportation substantially revised.	August 2009
3.0	Contact directory updated, revisions to M& E sections	February 2011
4.0	Revised to reflect updates to all sections	May 2013
5.0	Revised to reflect comments from Deputy Head of Engineering	Sept 2013
6.0	General Revisions to adopt new policies, industry changes and align with other standards.	May 2017
7.0	Revised to reflect previous comments. Copy issued for further review (not formally issued).	May 2022
8.0	Final Draft Issue (not formally issued).	August 2022
8.1	Amended Final Draft Issue (not formally issued).	Sept 2022
9.0	Final Issue	Oct 2022

CONTENTS

INTRODUCTION AND GLOSSARY 7

A.1 EXECUTIVE SUMMARY 7

A.2 INTRODUCTION AND GLOSSARY 7

A.2.1 Employer's Requirements and Design Standards for Mechanical, Electrical And Public Health Services 7

A.2.2 Best Value 8

A.2.3 Objectives 8

A.2.4 Consultant Appointment 9

A.2.5 Responsibilities for design and information production 9

A.2.6 Glossary of terms 10

A.3 PROJECT GOVERNANCE 12

A.4 CONSULTATION AND ENGAGEMENT 12

A.4.1 Stakeholder Engagement 12

A.4.2 Background on UCL's Support structure 13

A.5 DESIGN STANDARDS 13

A.6 STAGE GATE APPROVALS 14

A.7 WORK ON EXISTING BUILDINGS 14

A.8 ENERGY CONSERVATION CONSIDERATIONS 16

A.8.1 Energy efficiency measures to be included in the Project 16

A.8.2 Regulatory Considerations 17

A.8.3 Passive Design – Minimising Services Requirements 18

A.8.4 Building Fabric 19

A.8.5 Natural Ventilation 19

A.8.6 Mechanical Ventilation 20

A.8.7 Space Heating 21

A.8.8 Water Heating 23

A.8.9 Electrical Services 23

A.8.10 Water Conservation 24

A.8.11 Cooling 24

A.9 PLANT LOCATION, ACCESS FOR MAINTENANCE, OPERATION AND REPLACEMENT 27

A.10 METERING STRATEGY 28

A.11 BUILDING MANAGEMENT SYSTEM 28

A.12 BUILDING USER GUIDE 29

A.13 COMMISSIONING AND TESTING 30

A.14 OPERATING AND MAINTENANCE MANUALS 34

A.14.1 General Requirements of the O&M's 35
A.14.2 Content and layout 36
A.14.3 Checking of Drafts 36
A.14.4 Final documentation 36
A.14.5 Copyright 37
A.15 RECORD DRAWINGS 37
A.16 PLANT AND SWITCHROOM DRAWINGS, SCHEDULES AND SCHEMATICS 38
A.17 BUILDING LOG BOOKS 39
A.18 HANDOVER 39
A.19 DEFECTS PERIODS NAMED MATERIALS/SPECIALISTS 40
A.20 LIFE CYCLE CARBON ASSESSMENT 41
A.21 WORKING WITH ASBESTOS 41
A.22 NAMED MATERIALS/SPECIALISTS 42
A.23 OTHER APPLICABLE UCL TECHNICAL DOCUMENTATION 42
A.24 HEALTH AND SAFETY 42
A.25 DESIGNING FOR THOSE REQUIRING SUPPORT AND ASSISTANCE (INCLUSIVITY) 42
ELECTRICAL SERVICES 46
B.1 ELECTRICAL DESIGN CRITERIA 46
B.1.1 HV Electrical System 46
B.1.2 LV Electrical Supplies 47
B.1.3 Electricity Generating Plant 47
B.1.4 General Lighting Systems 48
B.1.5 Emergency Lighting Systems 49
B.1.6 Power Systems 50
B.1.7 Fire Alarms, Detection and Suppression Systems 50
B.1.8 Mechanical Wiring 51
B.1.9 Lightning Protection System 51
B.1.10 Earthing Systems 51
B.2 GENERAL REQUIREMENTS 52
B.2.1 Decommissioning of Systems (applicable to existing buildings only) 52
B.2.2 HV Systems 53
B.2.3 Electrical Substations 54
B.2.4 LV Switchgear 54
B.2.5 Residual Current Devices and Arc Protection 57
B.2.6 Fuses and Disconnecting Links 58
B.2.7 Distribution Boards 58
B.2.8 Busbar Systems 59
B.2.9 Uninterruptable Power Supply units 60

B.2.10 Transient Voltage Surge Suppression 62
B.2.11 Harmonic Conditioners 62
B.2.12 Power Factor Correction Units 62
B.2.13 Electricity Metering 62
B.2.14 Earthing Systems 63
B.2.15 Small Power Services 64
B.2.16 Wiring Containment 65
B.2.17 Cable Types & Colours 66
B.2.18 Interior Lighting Levels and Zoning 66
B.2.19 Exterior Lighting 68
B.2.20 LED Colour Temperature Guide 70
B.2.21 Lamps and Ballast preference 70
B.2.22 Lighting Control Systems 71
B.2.23 Specialist Lighting 72
B.2.24 Emergency Lighting 72
B.2.25 Emergency Lighting Testing Systems 73
B.2.26 Fire Alarms and Detection System 74
B.2.27 Alarms & Services for those requiring Support and Assistance 76
B.2.28 Electrical Vehicles and Scooters Charging System 76
B.2.29 Induction Loops 76
B.2.230 Ancillary Alarms 77
B.2.31 Intruder & Panic Alarms 77
B.2.32 Access Control & CCTV Security Systems 77
B.2.33 Communication Systems 77
B.2.34 Media Systems 77
B.2.35 Labelling of Services 77
MECHANICAL SERVICES 80
C.1 MECHANICAL DESIGN CRITERIA 80
C.1.1 Environmental criteria, External Conditions 80
C.1.2 Environmental Criteria, Internal Conditions 80
C.1.3 Ventilation Requirements 81
C.1.4 Filtration Standards 81
C.1.5 Internal Heat Loads 82
C.1.6 Water Services 82
C.1.7 Noise Criteria 82
C.1.8 External noise arising from installed plant and equipment 84
C2 GENERAL REQUIREMENTS 87
C.2.1 Utilities and Infrastructure 87
C.2.2 Pipework Systems 88

C.2.3 Heating, Boilers & Humidification 90
C.2.4 Cold Water Services 93
C.2.5 Hot Water Services 95
C.2.6 Above Ground Drainage 97
C.2.7 Chilled Water & Cooling Systems 98
C.2.8 Expansion and Contraction 101
C.2.9 Isolating Valves 101
C.2.10 Equipment Cooling 101
C.2.11 Mechanical Ventilation 101
C.2.12 Cooling Towers and Dry Coolers 104
C.2.13 Biological Services Units (BSUs) 105
C.2.14 Controls 106
C.2.15 Continuous and Out-of-Hours Operation of Plant 106
C.2.16 Fume Cupboards (FCs) 106
C.2.17 Microbiological safety cabinets (MSC's) 112
C.2.18 Microbiological laboratories 113
C.2.19 Containment level 3 (CL3) Laboratories 113
C.2.20 Plant Maintenance 115
C.2.21 Water hygiene risk assessments/method statements 115
C.2.22 Plant and services adjacent to project site 115
C.2.23 Pressure gauges and thermometers 116
C.2.24 Electrical power supplies to pumps 116
APPENDIX A – MEP STAGE GATE DELIVERABLES / ROLES & RESPONSIBILITIES .. 117
APPENDIX B – UCL MEP PREFERRED MANUFACTURERS AND SUPPLIERS 121
APPENDIX C – RELEVANT UCL EMPLOYER'S REQUIREMENTS PAGES 122
APPENDIX D – BMS SPECIFICATION 123
APPENDIX E – UCL MANAGEMENT OF INCUMBENTS 124
APPENDIX F – PIPEWORK AND LAGGING INSULATION GUIDELINES 125
APPENDIX G – STUDENT RESIDENCES SPECIFIC REQUIREMENTS 126

A.1 EXECUTIVE SUMMARY

These Engineering Services guidelines have been prepared to communicate UCL's MEP engineering services requirements. They are intended to guide and inform the Building Services Designers (as defined in the glossary) and UCL Operations and Maintenance staff in the development of engineering solutions for all UCL projects for new build and refurbishment installations.

A.2 INTRODUCTION AND GLOSSARY

A.2.1 Employer's Requirements and Design Standards for Mechanical, Electrical And Public Health Services

This guidance is for information only, UCL accepts no liability for any loss, damage or inconvenience caused as a result of reliance on this information.

Before signing agreements for any design work, appropriate legal and engineering professionals must be consulted.

UCL will strive to ensure that the highest standard of engineering services installation and operations are achieved throughout the entire property portfolio.

The use of this design guide is not intended to take the place of, or remove any professional responsibility from the Consultants Designers to fully comply with the requirements of a project brief. It would be impracticable to cover all eventualities given the diverse nature of UCL projects.

Complementing this is UCL's Information for Contractors and Designers suite of documents which can be downloaded from UCL's website. Where deviation from these guidelines is considered appropriate, these are subject to approval in writing by the UCL Operations and Infrastructure Teams.

The following sections give guidance on the required criteria for common installations.

The Building Services Consultants Designers are required to comply with the specific project requirements as laid down in the project brief or otherwise indicated in writing by the UCL Project Officer.

It is the intention of UCL to ensure that all works are provided to a uniform and high standard. This must be applied to the following:

- Compliance with the project brief, workmanship, quality and appearance
- Environmental control and energy consumption
- Reliability and quality of materials
- Maintainability and resilience of systems
- Change Possible: Strategy for a Sustainable UCL
- Sustainable Building Standard.

The technical standards and deliverables referred to within these guidelines are the responsibility of the Operations and Infrastructure Teams. They may not be varied without written approval of the UCL Operations and Infrastructure Teams.

These guidelines are a statement of the minimum standards of engineering services to be applied throughout the estate. They are not intended to stifle innovation and technical advances. UCL has adopted a long-term view with regard to longevity of equipment, cost effective energy saving measures and environmental issues.

A.2.2 Best Value

The Building Services Designer must work both as a member of the team and individually in the spirit of trust, fairness and mutual co-operation for the benefit of the project to achieve transparent and co-operative exchange of information in order to obtain best value for UCL, with due regard for life cycle costs and benefits.

The Building Services Designer must promote sustainability objectives that deliver a high standard of design and installation, whilst meeting the economic needs of UCL. They must work in conjunction with the Sustainability Consultant, where appointed, or Sustainable UCL to develop an environmental strategy, specific to each project.

The Building Services Designer must assist in improving the image of UCL by raising standards within the UCL Built Environment whilst providing best value for money.

A.2.3 Objectives

These Employers Requirements and Design Standards have been compiled to achieve the following objectives, as a minimum standard:

- To provide a minimum standard on design strategies in order to achieve standard engineering solutions whilst promoting energy efficiency and innovative designs.
- To harmonise building and site wide systems to facilitate cost effective and efficient operations, maintenance functions and standardisation.
- To standardise the building services engineering systems, so the estate will be operated and maintained more efficiently/economically with reduced life cycle operation and maintenance costs.
- To standardise the use of building services engineering systems to facilitate best value solutions with manufacturers and specialists with respect to prolonged equipment and system warranties which will reduce life cycle operation and maintenance costs.
- To reduce the energy consumption of UCL's estate and meet sustainability objectives as set out in UCL's sustainability strategy. It encourages the use of organisations with recognised energy, sustainability and environment certification and approval standards, including but not limited to, ISO 14001, Eurovent, Energy Technology List (ETL), BREEAM, LEED, SKA etc.
- To provide a preferred list of manufacturers and suppliers for use on UCL projects as appropriate. Alternative systems and suppliers not on this list must be formally submitted including justification for change to UCL Operations & Infrastructure for consideration. Purchase of alternative suppliers' equipment must not proceed unless agreed in writing with the UCL Operations & Infrastructure Team.

- To facilitate and improve site records and site engineering data by utilising and updating live data systems currently being implemented across the UCL Estate.

- To maintain updated UCL site wide master and live utility services records, i.e. BMS topography, metering, MTHW, steam and condensate, water, gas, LV and HV distribution and communications, etc.

- To maintain updated individual UCL building master and live schematic records for LTHW, CHW, domestic services, small power, lighting, fire alarms and security etc.

A.2.4 Consultant Appointment

All Consultants must carry out their duties in accordance with their UCL Framework Agreement as referenced in the project specific Deed of Instruction (where applicable).

Traditional appointments will be identified during the tender process for the consultancy team and opportunity to update costs and duties will need to be captured within tender submissions (where applicable).

All Designers working on UCL Projects shall be deemed as “Competent”.

Where no formal environmental / energy advisor(s) have been appointed, the Building Services Designer may be asked to act as the environmental lead or champion.

All Building Services Designers will require a valid CSCS card to the appropriate level when visiting any UCL site during either construction or carrying out survey works.

For BSU Facilities, prior vetting will be required for all individuals entering the facility.

A.2.5 Responsibilities for design and information production

The Building Services Designer must take responsibility for the complete design of the works including developing the conceptual design into a fully co-ordinated detailed design.

Throughout the design stages they will be actively involved with the UCL design/project team, UCL Sustainability Team and Operations and Infrastructure Teams, and be responsible for undertaking and preparing any such design sketches, details or information required by other design team members to enable their element of the work to be detailed.

During the design and information production stages the UCL Project Officer and UCL Operations and Infrastructure Teams will monitor the development of the design and the production of the detailed and co-ordinated design.

A.2.6 Glossary of terms

Where used in this guide, the following definitions apply:

Building Services Designer
Building Services Designers are responsible for the design, installation, operation and monitoring of the technical services in buildings (including mechanical and electrical services, also known as MEP), in order to ensure their safe, comfortable and environmentally friendly operation.

Commissioning
The advancement of an installation from the stage of static completion to working order and to the specified requirements.

Competent
Having the necessary ability, knowledge and skills to do something successfully. This is including, but not limited to, the Designer holding Building Services related degrees, HNDs, HNCs, membership to CIBSE, membership to IET etc. and having had considerable experience within the industry.

Consultant
A person who provides expert advice professionally.

Environmental testing
The measurement and recording of internal temperatures during commissioning.

Fine-tuning
The adjustment of the system where usage and system proving has shown such a need. This may include the re-assessment of design values and control set points to achieve the required system performance.

Regulation
The process of adjusting the rates of fluid flow in a distribution system to achieve specified values

Setting to work
The process of setting a static system in motion

Specialist
A person who concentrates primarily on a particular subject or activity; a person highly skilled in a specific and restricted field.

System demonstration
Demonstrating the capability of the installation to achieve and maintain the specified performance criteria

System proving
The measuring, recording, evaluating and reporting on the seasonal performance of the systems against their design values

Testing
The measurement and recording of specified quantifiable characteristics of an installation or parts thereof. This includes off site testing.

Commonly used abbreviations:

ABS	Acrylonitrile Butadiene Styrene (Plastic) Pipework
ACDP	Advisory Committee on Dangerous Pathogens
AHU	Air Handling Unit
BAFE	British Approvals For Fire Equipment
BEMS	Building Energy Management System
BMS	Building Management System
BRE	The Building Research Establishment
BSRIA	Building Services Research and Information Association
CAV	Constant Air Volume System
CDM	Construction (Design and Management) Regulations
CFD	Computational Fluid Dynamic
CHP	Combined Heat And Power
CIBSE	Chartered Institution of Building Services Engineers
CWS	Cold Water System
DNO	Distribution Network Operator
DPCV	Differential Pressure Control Valves
EMON	Energy Monitoring System
FC	Fume Cupboards
GA	General Arrangement Drawing
H & S	Health and Safety
HBN	Health Building Notes
HEPA	High Efficiency Particulate Air [Filter]
HTM	Health Technical Memoranda
HVAC	Heating, Ventilation, and Air Conditioning
ICEL	Industry Committee for Emergency Lighting
IET	Institution of Engineering and Technology
IGEM	Institution of Gas Engineers & Managers
ISD	UCL Information Services Division
ISO	International Organization for Standardization
LED	Light-Emitting Diode
LTHW	Low Temperature Hot Water
LPHW	Low Pressure Hot Water
MCB	Miniature Circuit Breaker
MEP	Mechanical, Electrical and Public Health
MTT	UCL Mobilisation and Transition Team
MSC	Microbiological Safety Cabinets
NRV	Non Return Valve
NSI	National Security Inspectorate
O & M	Operating and Maintenance Manual
PHE	Plate Heat Exchanger
PICV	Pressure Independent Control Valves
PIR	Passive Infrared Sensor
PME	Power Monitoring Expert (EMON)
RCBO	Residual Current Breaker with Over-Current
RIBA	Royal Institute of British Architects
TMV	Thermostatic Mixer Valve
TRV	Thermostatic Radiator Valves
UCL	University College London
UPO	University Project Officer
VAV	Variable Air Volume System

A.3 PROJECT GOVERNANCE

UCL Estates has adopted the following 7 stage lifecycle process for its projects. Each Stage has a stage gate:

1 – Need (RIBA Stage 0)
2 – Initiation (RIBA Stage 1-2)
3 – Development (RIBA Stage 3)
4 - Procurement, Planning and Budgeting (RIBA Stage 4)
5 – Implementation (RIBA Stage 5)
6 – Operations (RIBA Stage 6)
7 – Post Project (RIBA Stage 7)

These stage gates are based around the RIBA scope of duties and will be used by UCL to manage, control and deliver a successful property portfolio by providing a clear audit trail and robust sign off process. A project must not pass onto the next stage until the previous stage gate has been approved.

These design guidelines contain a summary of the MEP Stage Gate deliverables and roles & responsibilities which align the key Property Portfolio Services Stage Gates with the RIBA work stages and the GC Works Stages 1 to 5. The summary also identifies clearly the additional responsibility of the Building Services Designer to provide specific items of design at each stage and who will be responsible for signing them off.

Care has been taken to clearly identify throughout these Guidelines what deliverables are required and what form and content they must contain.

Further detail on how projects will be managed and UPO responsibilities can be found in the UCL Project Procedures documentation, which can be provided by UCL Project Officer on a case-by-case basis.

A.4 CONSULTATION AND ENGAGEMENT

A.4.1 Stakeholder Engagement

During the project briefing, design development, installation, commissioning and handover, engagement by the Building Services Designer with key stakeholders will be paramount. It will be the responsibility of the Building Services Designer in conjunction with the UCL Project Officer to communicate and engage with these stakeholders at each appropriate stage of the project.

Discuss outline scheme with:

- Local Planning Authority (if necessary)
- London Fire Brigade
- UCL Operations and Infrastructure Teams
- UCL Sustainability Team
- UCL CHP Team
- UCL Programme and Performance Team (P & PT)
- UCL Audio Visual Teams
- UCL Information Services Division (ISD)
- UCL End User Representatives
- UCL Students Representatives (Students Union)
- UCL Maintenance Operations Management
- UCL Mobilisation Management
- UCL Facilities Management

- UCL Asbestos Management
- UCL Fire Safety Management
- UCL Mobilisation and Transition Team
- UCL Inclusive Environments Team
- UCL Accommodation Team

Stakeholders to be engaged particularly early on systems, for example:

- Night cooling
- Green roofs
- Termodeck
- Heresay (for example Cruciform Building chilled water system)
- Solar PV installations.

A.4.2 Background on UCL's Support structure

The UCL Project Officer is responsible for coordinating sign off from all UCL key stakeholders and departments, direction will be provided to the Consultant team as required for input and possible attendance at meetings.

A.5 DESIGN STANDARDS

UCL requires that all engineering services installations are completed in full compliance of all statutory requirements and industry best practice guidelines. In addition, all standards, Codes of Practice, design guides and guidance notes issued by various bodies such as the British Standards Institution, Chartered Institute of Building Services Engineers, Health and Safety Executive etc. must be complied with. These may include, but are not limited to:

- CIBSE Guides and Technical Publications
- Current British Standards
- Current Legislation and Statutory Obligations
- Local Authority Regulations
- Home Office Guidelines
- BS 7671, IET Wiring Regulations, as amended.
- Building Regulations
- British Standards/ EN ISO
- UCL Sustainable Building Standard
- Health and Safety Executive guidance documentation
- Gas Safety (Management) Regulations, as amended.
- Gas Safety (Installation and use) Regulations, as amended.
- Water regulations, HSG 274, HSE ACOP L8, BS 806 and BS 8558, as amended.
- CDM Regulations, as amended
- Insurance Company
- Planning Authorities
- Building Control Officer
- Environmental Health Officer
- UCL Fire Safety Management Team
- UCL Fire Safety Technical Notes ('TNs')
- UCL Design Guidance for Vertical Transport Services
- UCL Inclusive Design Strategy

It is recognised that UCL, in some locations, partner with healthcare providers. In those situations, the relevant HTM and HBN guidance must be followed. It is the responsibility of the UCL design project manager to define where HTM and HBN guidance must be applied.

It is the Building Services Designer's responsibility to ensure that all relevant standards are current at the time of design, installation and completion.

As part of its Health and Safety regime; Operations and Infrastructure Teams have produced specific procedures and Permit to Work systems. These must be complied with.

A.6 STAGE GATE APPROVALS

The design deliverables and proposals identified at each stage gate will require the full approval and/or agreement of UCL and their designated representatives prior to commencing to the next stage of the project.

Design reports, construction specifications, drawing comments and approvals must be provided to ensure site works are not delayed, however it is the responsibility of the Building Services Designer and or Contractor to achieve the programme requirements.

The MEP Stage Gate deliverables / roles & responsibilities summary within Appendix A identify the key submissions and documentation required at each stage of the life cycle process. Each report, specification or set of drawings must be submitted to suit the individual programme of each project. A minimum design-review period of 2 weeks is required to allow UCL technical advisors and UCL stakeholders to review design packages at the end of each RIBA stage, including at the end of stage 4 on design and build projects.

A workshop with all appropriate stakeholders must be arranged to include a presentation of the entire scheme at stages 2 and 3 of design. The entire project team must be available but the workshop will be facilitated by the Building Services Designer and UCL Project Officer. The engagement is not limited, consultants should have further meetings with other UCL stakeholders as required.

The review of all reports and drawings will follow an A, B, C commenting/approval process as outlined below:

A. Designating drawing has no comments: proceed
B. Drawing has minor comments, integrate the comments and proceed
C. Drawing to be re-submitted integrating comments

Proceeding to the next design stage with anything other than 'A status' requires approval from the UCL Principal Engineers and/or the Deputy Director of Infrastructure, co-ordinated by the UCL Project Officer.

A.7 WORK ON EXISTING BUILDINGS

When starting a refurbishment or fit-out project the Building Services Designer must obtain all current and existing building and system information. UCL will provide O&Ms, record drawings, system schematics, asbestos records and water treatment, testing regime records and energy meter readings, where available.

Additional information must be obtained from the following sources:

- UCL Project Officer
- UCL Operations and Infrastructure Teams
- UCL Estates and FM Teams
- UCL ISD Department

- UCL Sustainability – for energy data
- UCL Transition & Mobilisation Team
- UCL Inclusive Environments Team

Must any relevant information not be available the Building Services Designer must undertake a detailed survey of the building and associated systems to produce system schematics of all Building Services systems associated with the entire building for which the works are proposed.

Opportunities for synergies with other current UCL projects, or opportunities for wider work within the building must also be identified, even where this would fall outside the scope and budget (e.g. more holistic work required to bring building fabric or services up to current standards). Every effort to be made to review and then integrate with existing systems where possible. Integrating with existing systems is preferred to adding standalone plant.

This exercise must be undertaken in conjunction with the UCL Operations and Infrastructure Teams and may require independent specialist contractors to be employed particularly where tracing and testing services and when intrusive surveys are required.

All surveys will require the standard UCL Data Collection sheet, to be completed and submitted to the Operations and Infrastructure Teams. All schematics and documentation produced must refer to the individual plant and equipment UCL Asset Management System references (EQ numbers).

The Building Services Designer will in accordance with the Project Handover Checklist, engage in a “Pre-Contract start” handover with UCL’s Operations and Infrastructure Teams to ensure allowance for a suitable transition of the existing assets and their management to the construction team.

All plant and equipment being de-commissioned as part of the proposed works, and all other existing redundant services on confirmation with Estates, must be removed as part of the contract. This must include, but not be limited to, the following associated components:

- Plant and equipment.
- Connecting ductwork, pipework and all associated ancillaries and supports.
- Power, wiring, controls and associated ancillaries and supports.
- Meters.

Assets being decommissioned must be offered back to UCL, for consideration for reuse elsewhere on its Estate. The design needs to carefully consider any alterations that impact building infrastructure systems and adjacent areas.

All relevant information to allow for the update of the UCL Asset Management System must be provided.

Any assets that are removed completely, or decommissioned and given back to UCL, need to be reported on the UCL Data Collection sheet, using their asset tag references (‘EQ numbers’). This updated asset list then needs to be returned to the Compliance and Performance Team.

UCL record documentation, including full schematics, to be updated prior to handover of the projects and provided to UCL Project Officer.

A.8 ENERGY CONSERVATION CONSIDERATIONS

The aim of these energy conservation guidelines is to identify and act upon the opportunities offered by all projects to improve the energy efficiency of the UCL estate.

It is not intended to be a design manual, but to provide guidance to Building Services Designers on UCL's requirements for the procurement of new buildings or the refurbishment of existing buildings.

All new build and refurbishment designs need to closely adhere to UCL's commitment to being a "Net Zero Carbon Institution by 2030" strategy. The Designer is to refer to UCL's Zero Carbon Plan and Sustainable Building Standard located online.

UCL emphasises that the requirements of this document are not meant to restrict Building Services Designers, but rather to prompt them to be innovative, and to go beyond the minimum requirements of building regulations. The initial cost of buildings is less important to UCL than their cost-in-use and their overall environmental impact.

This document must be read in conjunction with the relevant client brief, General Specification, Schedule of Works and all other UCL Employer's Requirements and Standards.

The onus is upon the Building Services Designer to ensure that all measures in this guide are considered. The Building Services Designer will ensure that a record is made of the approved derogations.

The Building Services Designer must work in conjunction with the Sustainability Consultant (where appointed), the Energy Manager and other team members in assessing the viability of all energy efficiency measures.

A.8.1 Energy efficiency measures to be included in the Project

All energy efficiency measures included in this guide, and the complementary UCL Sustainable Building Standard, will be considered for inclusion in the development, redevelopment and refurbishment of areas. Energy efficiency opportunities must be prioritised in accordance with the energy hierarchy (i.e. passive first approach).

Measures that are compulsory under the current revision of the Building Regulations or other legislative requirement must be included in the project.

Energy efficiency measures that are directly related to the Project Brief will be implemented.

Further possible energy efficiency opportunities that are not directly related to the project brief, must be outlined to UCL's sustainability team for consideration. These could form additional works that might be funded from an alternative source.

Connection to UCL's district heating and district cooling networks is an energy efficient measure and must be undertaken where possible (as per UCL's District Heating Connection Standard). Design approval for utilising these networks shall come from the Deputy Director of Campus Experience and Infrastructure.

Criteria for the return of investment in energy efficiency measures that are not directly related to the Project Brief are as follows:

- Energy saving measures must be considered cost effective providing that a simple payback period of fifteen years may be achieved. This payback may be calculated using UCL's current calculation tool (currently classified as Cost and Carbon Tool).

- The Building Services Designer will identify all energy efficient measures applicable to the refurbishment programme.

Legitimate reasons for excluding a measure must be given in writing to the UCL Operations and Infrastructure Teams and the UCL Sustainability team for their approval and could include the following:

- Not applicable to the works being carried out.

- Measure non-compulsory and payback period would be greater than 15 years.

Variation from this guide must be approved by the UCL Operations and Infrastructure Teams or key project stakeholders.

Where there is any contradiction between this document and any other contract documents, this will be brought to the attention of the UCL Project Officer and Operations and Infrastructure Teams.

The UCL Project Officer and Operations and Infrastructure Teams will be consulted with regard to interpretation of this energy conservation guidance or other documents it refers to. This will apply in particular when there is a need to make a professional judgement on what is acceptable and or affordable.

In addition to the energy efficiency requirements outlined above the Building Services Designer must account for all the relevant requirements in UCL's Sustainable Building Standard.

A.8.2 Regulatory Considerations

The energy performance of buildings is governed by the Building Regulations, Part L2A and L2B and all project carbon performance rating targets are bench marked against these regulations and clearly identified within UCL's Sustainable Buildings Standard.

The following Regulations must also be considered:

- Electricity Act and Electricity Regulations, as amended.
- Electricity Works Regulations, as amended.
- Energy Conservation Act, as amended.
- Gas and Electricity Regulations, as amended.
- Gas Act, as amended.
- Climate Change and Sustainability Energy Act, as amended.
- Energy Act, as amended.
- Renewable Energy Zone Order, as amended.
- Sustainable Energy Act, as amended.

Where the scheme is newbuild, the Building Services Designer is to include planning considerations in line with local planning requirements. Where the newbuild is within London, the Designer is to also consider planning requirements included within GLA's 'The London Plan 2021' energy policy.

A.8.3 Passive Design – Minimising Services Requirements

All projects must adopt an approach which seeks to minimise the requirements for new/ additional mechanical and electrical plant with due regard for operational requirements and user comfort, and with a view to minimising energy use intensity (EUI – kWh/m^2/year)

Wherever possible, the layout and orientation of buildings must be planned to maximise winter solar gains and natural day lighting and reduce summer overheating. These passive measures will be in place for the life of the building and will require minimal maintenance compared to active systems. The successful integration of passive features into building design demands early interaction between the architect, the Building Services Designer, planners and the structural engineer.

The optimum method of testing the comparative thermal performance of alternative designs is to use a dynamic thermal simulation program. A suitable program must be used to optimise the design of a new building. Where extensive use is to be made of natural ventilation, computational fluid dynamic (CFD) simulation must be used to test its effectiveness unless agreed otherwise with the Deputy Director of Campus Experience and Infrastructure.

The Design Team must take into account design considerations set out in the Sustainable Building Standard, for example:

- Carry out an analysis of the proposed building design/ development to identify opportunities for the implementation of passive design solutions that reduce demands for energy consuming building services. In particular, HVAC and lighting demand.

- Demonstrate how heat loss through the building envelope has been reduced below the requirements for regulatory compliance for all relevant aspects of the building envelope (target U-values are set out in the UCL Sustainable Building Standard and align to the UKGBC Net Zero Carbon Buildings Framework).). This applies to both new build and refurbishment; where works involve fit-out or refurbishment of part of a building, a whole-building approach to thermal improvements must be considered in order to identify potential synergies between different projects, and potentially with a view to securing separate funding.

- Where possible, use compact building forms optimised to maximise day lighting, maximise winter solar gain and minimise winter heat loss.

- Optimise thermal mass to help regulate internal temperatures, and vent unwanted heat to the atmosphere overnight through natural ventilation (for example, exposed surfaces, avoiding suspended ceilings etc which will also reduce material resource use).

- Use dynamic thermal simulation programs and, where appropriate, computational fluid dynamic (CFD) simulations to validate designs.

- Consider the use of green/brown roofs to reduce the effects of summer overheating.

- Ensure that equipment with high heat loads is not situated in rooms that require environmental control wherever possible.

A.8.4 Building Fabric

The design team must adopt an approach to building fabric performance which seeks to improve beyond the requirements of current Building Regulations wherever possible - as part of a whole building approach to energy efficiency, and in line with UCL's commitment to being a Net Zero Carbon Institution by 2030.

The design team must:

- View the current requirements of the Building Regulations as a minimum standard only.

- Seek to optimise the total energy performance of the building, to make maximum use of daylight and winter solar gains; and minimise summer overheating.

For new build and major refurbishment projects, the minimum number of energy credits for a BREEAM 'Excellent' rating must be targeted.

The design team must also consider the limitations of working in older buildings (e.g. moisture/condensation issues), and also take account of exemptions to requirements arising from the conservation or heritage status of a building. However, this must not be seen as a barrier to sympathetic and appropriate energy-efficiency improvements.

New insulation products must also achieve a minimum 'A' rating under the BRE Green Guide to Specification, as amended, including best practice performance levels with regard to global warming potential.

Where extensive window replacements or other changes to external building fabric are being undertaken, reference must be made to the use of external shading and the minimisation of solar gain. The consideration of secondary glazing systems may be appropriate where replacement glazing may not be either practical or economically viable.

Particular attention must be given to the potential for overheating in spaces where other internal heat gains are significant (e.g. equipment-related). Where fenestration will cause glare or lead to excessive internal space temperatures, options for internal blinds, glass replacement or retrofit window films must also be considered.

The position of all heating and ventilation sensors will be marked on a plan of the building by the Building Services Designer, prior to the design stage for the refurbishment of existing internal walls, or the installation of new ones.

A.8.5 Natural Ventilation

The successful use of natural ventilation depends on the geometry of the building, internal heat gains, building usage, local air quality and acoustic constraints. Designer should refer to the Sustainable Building Standard.

Adequate double-sided, cross-flow ventilation is difficult to achieve in buildings with widths greater than about 15 metres (offices 6 metres deep with openable windows on either side of a central 3 metre corridor). Buildings which rely on natural ventilation can have high summer ventilation rates with no energy penalty. Summer ventilation rates may need to be ten times greater than those achieved in winter to avoid overheating. There is some evidence that naturally ventilated buildings can be 'healthier' than some air-conditioned or mechanically ventilated buildings.

Buildings can be designed to use a mechanical ventilation system with heat recovery during the heating season, and natural ventilation from opening windows during summertime. During the heating season, the windows must be locked shut or have interlocking controls to avoid heating when the windows are open. This type of servicing arrangement is termed 'mixed-mode', and recent data from the Building Research Establishment has shown that office buildings with mixed-mode systems can use less energy than either continuously mechanically ventilated or air-conditioned buildings.

Natural ventilation can be provided from windows, ventilation slots in window frames, solar-driven stack-effect or from purpose-made controllable through-wall systems. Thermal comfort may also be influenced by the exposed thermal mass of the building: a lightweight building will respond rapidly to changes in external conditions, whereas with a heavyweight structure a noticeable damping effect on internal temperatures may occur. The use of suspended ceilings effectively removes the thermal mass of the floor slab from the thermal response of the building, allowing more rapid variations in temperature. Figures from the BRE suggest that for naturally ventilated offices with internal blinds overheating can be reduced to 10 days per year or less. Where external blinds are used, overheating would occur on average for only 3 days or less per year.

Areas to be naturally ventilated by means of trickle (or background) ventilation must meet the requirements of the current building regulations.

Areas to be naturally ventilated by means of openable windows must meet the requirements of CIBSE AM 10 Natural Ventilation in Non Domestic Buildings. Consideration to be made of air quality when natural ventilation being utilised. The Bloomsbury area in particular has a high air pollution rating on average (as per the London Air Quality Index (AQI).

The Building Services Designer must:

- Note that UCL expects to maximise the use of natural ventilation in all its buildings for both energy efficiency and user comfort.
- Ensure that the thermal mass of the building is optimised to minimise summer overheating.
- Where full natural ventilation is not feasible, prioritise the use of 'mixed-mode' ventilation systems with heat recovery.
- Consider the use of additional insulation and external solar shading to minimise summer overheating.
- Only provide air conditioning in line with the criteria set out in UCL's Heating & Cooling Policy

A.8.6 Mechanical Ventilation

The impact of the installation, removal or relocation of walls, doors, windows etc. upon ventilation requirements and provision must be carefully reviewed by the design team to ensure that all areas receive the appropriate air supply.

An appraisal of the existing natural and mechanical ventilation provision in the project area to be refurbished must be carried out.

Particular attention must be given to the impact of adding or removing fume cupboards or other local exhaust ventilation systems or safety equipment from project areas.

If the existing provision is determined to be either inadequate or excessive to meet the post-refurbishment needs of the space, the existing systems must be modified to meet the new ventilation requirements.

Where an existing mechanical ventilation system is being substantially altered, or new systems installed the specific fan power (SFP) must meet the minimum efficiencies and specific fan power levels as specified under Approved Document Part L. Additional energy efficient methods are to be included as appropriate e.g. heat recovery, inverter driven fans, occupancy/ CO_2 controls etc. This is not an exhaustive list and all avenues must be considered.

In relation to the natural ventilation first requirement outlined above, designers must propose plans to both use of natural ventilation when mechanical ventilation is utilised and ensure that mechanisms are in place to ramp down/turn off mechanical ventilation when windows are opened.

Where specialist processes require increased levels of filtration and heat recovery, higher SFPs may be appropriate and these must be specifically justified by the Building Services Designer.

The UCL Project Officer and Operations and Infrastructure Teams must be consulted with regard to all modifications to existing mechanical ventilation services as described within this guidance document. As part of the consultation with the “Operational Maintenance team within Operations and Infrastructure Teams, further consequential / performance improvements might be identified toward the overall reliable operation of the system. Where this is outside of the project brief scope, additional funding might be sort towards covering these works.

Ventilation systems will be designed to achieve the appropriate duties for the various activities as they take place in the project area.

Where existing suspended ceilings are being replaced, modified or new ones installed, the UCL Project Officer must be informed and consideration must be given to taking the opportunity to install lighting and HVAC control and communications cable or other energy saving systems that may need to be accommodated above the suspended ceiling.

A.8.7 Space Heating

Space heating strategy and proposal must be developed with the Operations and Infrastructure Teams Technical team.

Fuel sources must be evaluated with full prioritisation of life cycle cost/ payback; energy efficiency; and carbon emissions taking into account UCL’s commitment to achieving Net Zero Carbon Buildings. Wherever practical or economically feasible all buildings must be connected to the UCL district heat network and/or other district heating networks available to UCL, in agreement with the Deputy Director of Campus Experience and Infrastructure. Consultants should refer to Design Requirements for Connections to the UCL District Heating Network.

Otherwise, the feasibility of new low or zero carbon heating options must be evaluated. Local efficient gas boiler facilities must only be provided where other lower carbon options are not possible. The successful application depends on the type of heating system to be used: condensing boilers are effective with under floor heating, and weather compensated variable temperature circuits.

The Building Services Designer must:

- Consider the use of low or zero carbon heating options, preferably as the principal heating source.
- Minimise the specification of new heating systems which rely on fossil fuels. Where these cannot be avoided, prioritise efficiency with full consideration of life cycle costs.
- UCL is over time moving its district heating system to lower temperatures designers must therefore design systems with low water return temperatures such as under floor heating to maximise system efficiency.
- Use weather compensation of flow temperature if radiator systems are used.
- Size new heat-emitting plant carefully: oversized plant will be less efficient. For example smaller modular boilers must be considered, which will provide greater resilience and maximise efficiency. Historic heat/gas data, where available, must be obtained and factored into the sizing assessment for refurbishment projects, alongside any change of use of occupancy. The Maintenance Operations Manager and CHP Team Supervisor must be given the opportunity to review all historic gas data prior to design being approved.
- The size and location of heat emitters in any given space must take account of the heat loss and ventilation requirements of that space. Zone controls must be implemented in the designs and must be appropriate for the planned usage of the spaces – for example offices and labs must be part of the same zone.
- BMS Control systems must be included to fully control all heating installations. Designers to confirm with Sustainability and Operations Team proposals on any design.

Where the works involve the installation, removal or relocation of partition walls, the Building Services Designer must:

- Review heat losses from the areas affected by the works.
- Review heat emitter capacities in relation to the new heat loss.
- Review air movement within the space to ensure that newly enclosed office areas have an appropriate heat source and are neither over-heated nor under-heated, taking account of changes in heat load caused by a change in the rate of supply of fresh air.
- Review controls to ensure correct operation for newly configured space.

As a result of the above reviews the following actions may be required:

- Heat emitters must either be removed, or new ones installed.
- The heating system must be rebalanced to enable the new heating requirements to be satisfied.
- Local controls (such as thermostatic radiator valves) must be installed to limit the heat output of heat emitters in areas from which heat loss has been significantly

reduced. These controls must be locked off at 21degC. The UCL Operations and Infrastructure Teams will identify suitable new positions for control equipment in the space affected.

The provision of electric heating must be approved by the Deputy Director of Engineering and Infrastructure and in line with UCL's "Net Zero Carbon Institution by 2030" strategy. Where electric heating is installed, it must be provided with tamperproof temperature and time programme controls. Electric heating in cellular offices or areas of intermittent occupancy must be fitted with automatic absence sensing controls or run back timer. All efforts to be made to not use direct acting heaters and consideration must be given to storage heaters that can provide latent heat. Careful consideration of electrical load capacity required.

New pipe work, vessels and other items for space heating systems must be insulated in compliance with the British Standards.

A.8.8 Water Heating

Hot water strategy and proposal must be developed with the Technical team.

Summer standing losses from operation of main boiler plant to heat hot water storage calorifiers for the provision of small quantities of hot water will be very inefficient.

Hot water must be provided from the local district heating main, or where this is not available from direct gas-fired storage water heaters.

Condensing direct gas-fired storage heaters are available, and the economics of their use must be appraised. Where hot water use is expected to be low, the use of electric instantaneous heaters (point of use water heaters), or low volume electric storage heaters for localised supply where usage is expected to be low such as office areas where water will be used for infrequent hand washing only.

A.8.9 Electrical Services

The use of natural daylight introduced into the space by windows, skylights and other sources must be prioritised with a view to minimising artificial lighting requirements wherever possible. Where appropriate, means of increasing natural light into existing areas must be implemented.

Artificial lighting must be LED products where this does not compromise the operational functionality of the environment. $6W/m^2$ is the target for standard lighting installations, but should not exceed $7W/m^{2,}$ in line with SKA requirements. Where LEDs are not practical approval must be sought from the Deputy Director of Engineering and Infrastructure. Please note that in some environments LED products will not be suitable, for example a traditional dark room. The Building Services Designer must obtain confirmation from Operations and Infrastructure Teams to specify non-LED products.

Lighting systems must make effective use of the natural light available via the use of day lighting control systems (e.g. daylight dimming, timer switches, as appropriate). Absence detection must be the primary consideration.

However, a background light level in accordance with the 'electrical services' (B clauses) section of this guide must be provided as a minimum by means of artificial lighting.

Where higher light levels are required, such as on laboratory bench tops, the Building Services Designer must ensure that this requirement is met by task lighting. Socket outlets or fused spurs must be positioned to facilitate this. LED lamps must be used in all desk/ task lamps.

A.8.10 Water Conservation

UCL is conscious of its environmental responsibility with respect to water conservation.

Building Services Designers must:

- Use electronic sensor taps or timed turn-off taps in toilets.
- Use 'water-saver' showerheads (8litres/min or less up to a pressure of 5 bar (+/- 0.2 bar) and flow controller fittings meet the Water Technology List criteria (WTL)).
- Use occupancy sensing flush controllers for urinals, and consider interlocking occupancy sensing to toilet lights.
- Use dual-flush WC suites (with effective flush volume of 4.5 litres or less and the model is listed on the Water Technology List (WTL)).
- Only use water equipment that has a WRAS approval number. This must form part of the asset register.
- Consider the use of 'grey water' recycling for toilet flushing. Special consideration must be given to the recycling of waste water from reverse osmosis water plant or once through cooling equipment. Designs need to be approved by UCL Sustainability Team and Deputy Director of Campus Experience and Infrastructure.
- Consider the use of rainwater collection and storage systems for irrigation and toilet flushing.
- Ensure recirculating chillers are used for process cooling demands within the project area to prevent the use of 'mains water to drain' wastage.
- **All sanitaryware must comply with the requirements in the UCL Washroom Standard**

A.8.11 Cooling

The UCL Heating & Cooling policy requires the installation of comfort cooling or air conditioning to be only considered where absolutely necessary.

Where there is an equipment, process or scientific need for a controlled temperature environment of either less than 22ºC or to within a control band of +/– 2ºC from a specified temperature, the provision of cooling must be considered. All project-specific technical options appraisals are to be agreed between the Designer and UCL's Principal Mechanical Engineer to inform the design.

Designs shall be informed by the ASHRAE regulations, as amended.

Any specialist equipment requirements (as recommended by the manufacturer) must be reviewed with UCL's Principal Mechanical Engineer and the End Users and included within the design e.g.:

- Comms Room/Data Centre cooling

- Scientific cooling
    - Where the equipment electrical loads requested by the 'Client Department' for a laboratory space will lead to elevated space temperatures the following actions will be taken:

- The client department must be requested to reduce or relocate a number of pieces of equipment with high heat dissipation from their brief. Options to locate high heat emitting equipment in unoccupied areas, or areas which are easier to cool, must be considered.

- The client department must review the energy efficiency of the equipment intended for the space with the assistance of the Building Services Designer, with a view to decreasing equipment heat dissipation into the space. This must include specification of technologies such as flat screen PC monitors, shared printers, high efficiency fridges/freezers and dedicated photocopier rooms.

- Natural ventilation provision to the space must be reviewed.

- On approval by the UCL Operations and Infrastructure Teams and sustainability team direct equipment ventilation or cooling must be considered to reduce or eliminate heat dissipation into the occupied space and hence remove the requirement for space cooling.

- Mechanical ventilation provision to the space must be reviewed, taking account of potential for free cooling.

If internal space temperatures are still likely to be excessive, the design team must advise the Head of the Client Department. Cooling must only be considered on written request from the Head of the Client Department to the UCL Operations and Infrastructure Teams.

Where the UCL Operations and Infrastructure Teams approves cooling, it must be achieved in accordance with the cooling strategy for the building in which the works are taking place.

For each building being worked upon a review of all existing installations (even beyond the area/scope of works) must be carried out in respect to the decommissioning of ozone depleting refrigerant gases and recommendations presented to the UCL Operations and Infrastructure Teams for any plant replacement and/or modification to accept a new gas type.

All specified refrigeration systems must have minimal or zero global warming potential (GWP). The Building Services Designer must when selecting cooling/chiller plant take due consideration of the F-Gas Regulations and HFC phase down.

Where modifications are made to existing space cooling systems they will result in compliance with the minimum Building Regulations Part L efficiencies.

The Building Services Designer must:

- Design air flow rates to be large enough to enable the air supply to meet the space cooling loads when used as a cooling medium.
- Ensure only areas that are authorised for the provision of cooling are served by the air supply to be cooled (consider appropriate door controls/ partitions etc).
- Where available ensure chilled water is used to cool the air supply. If the project is altering or extending from existing systems, the full system recommissioning must be carried out. The approach must be agreed with Mobilisation and Transition Team and Operational team.
- Always prioritise the inclusion of heat recovery where feasible.
- Hybrid cooling systems must always be considered and used in the first instance. Pure DX systems must only be considered where a hybrid cooling system is not practicable. Designers must get approval from UCL's Principal Mechanical Engineer on any proposal.
- In order to achieve the benefits of energy saving, low maintenance and occupier comfort, inverter controlled compressor systems must be specified for DX cooling systems.
- Time control, seven day and run back timers to limit the unnecessary use of cooling out of hours must be employed.
- Any cooling systems installed must be connected to the Building Management System, or where one is not present, an interlock with the heating controls provided to prevent simultaneous heating and cooling.
- Cooling system interlocks to be included with windows in areas where natural ventilation is being utilised. The design for these interlocks to be approved by UCL's Principal Mechanical Engineer.
- Building Services Designer to review the total impact on the building and report residual risk.
- In line with the UCL Heating, Cooling and Ventilation Policy comfort cooling must be set to a minimum temperature of 22°C.
- Use of portable evaporative cooling is not permitted.

The UCL Operations and Infrastructure Teams must be consulted with regard to the locations available for condenser units for 'split' cooling systems.

Consideration must be given to fire risk, obstruction of fire escape routes, noise nuisance, vibration noise nuisance, visual intrusion and structural strength of the building fabric at proposed locations for condenser units. Consideration must be made for discharge from mechanical ventilation systems and impact on naturally ventilated spaces and any other air intake.

A.9 PLANT LOCATION, ACCESS FOR MAINTENANCE, OPERATION AND REPLACEMENT

All plant and equipment must be located wherever possible outside of teaching areas. This is particularly important for laboratory areas where fixed furniture and equipment may impede on safe access for maintenance.

Attention must be given to the location of lighting and other ceiling mounted plant in terms of working at height and regular maintenance requirements.

The isolation of pipework systems must be considered within the design to avoid the need for large system drain downs.

The design of all systems must demonstrate that all plant and equipment incorporated into the Works can be safely and easily maintained in full compliance with Health and Safety legislation, CDM requirements, British Standards and (where applicable) Health Technical Memoranda.

Ensure that all access panels/doors are unobstructed and that adequate space is provided for future replacement of plant or parts.

Access panels must be large enough to allow maintenance tasks to be undertaken. They must be fixed to the structure rather than dropped ceilings and/or partition walls to ensure they maintain their structural integrity must leaks occur.

Identify all access platforms, access covers, gratings, ladders, stairs, rails and protecting elements required for future maintenance and operation of the Works.

All walkways and stairways must be designed in accordance with all relevant and current British Standards and safety codes and guidance and must include all toe plates, railings, guards and in fills necessary to ensure a safe installation. Where the design provisions will not comply with the British Standards and safety culture practice these must get prior approval from UCL Operations and Infrastructure Teams.

All external and plant room installations must be of the open mesh type fabricated from mild steel sections hot dip galvanised after manufacture in accordance with British Standards. Suitable access and walkways must be part of the external plant access systems.

External installations must be finished with a polyester powder coating in a BS or RAL colour advised by the Architect.

It is a requirement that a clearance of 450mm be maintained below any item of plant, pipework or ductwork running on or across roof finishes. This is to enable roof maintenance to be carried out without the need to remove or raise services. This does not apply to plant mounted on concrete bases.

Where services are boxed in or concealed within the building fabric or building finishes such as floors and ceilings, safe and suitable access must be provided and identification of concealed services provided post completion of works. Any equipment which needs to be serviced must not be located above fixed room furniture.

All plant and equipment serving hazardous and restricted access areas such as BSU rooms, containment rooms, etc., shall be designed and installed such that they can be totally maintained from outside of the actual area.

The Building Services Designer must work with the support of the UCL Operations and Infrastructure Teams to ensure that these measures are incorporated.

The Building Services Designer must produce at Stage 3 a detailed Plant Replacement Strategy. This independent document must be presented to the UCL Operations and Infrastructure Teams for comment and approval prior to the commencement of detailed design. The report format must be flexible but cover through descriptive text and supporting sketches the provision for safe and practical plant installation, maintenance and replacement. The document must not only consider the existing and proposed works but any known future master plan works associated with adjacent and surrounding buildings or public realm areas.

On projects incorporating a BIM model, the Plant Replacement Strategy will be contained within the BIM Implementation Strategy and BIM Model. Full details of UCL's Employer's Requirements for BIM Models are available on their website.

Once approved the Building Services Designer must maintain this document throughout detailed design and ensure that it is adopted by the contractor during the works and presented within the final O&M's.

All relevant information to allow for the update of the UCL Asset Management System.

A.10 METERING STRATEGY

At Stage 3 the Building Services Designer must produce an Energy Metering Strategy that must be in accordance with UCL's Metering Specification, compliant with Building Regulations, CIBSE TM39 and, as relevant, BREEAM or Ska requirements, as amended.

This document must be presented to the UCL Operations and Infrastructure Teams and Sustainability teams for comment and approval prior to proceeding to detailed design. It must remain the responsibility of the Building Services Designer to maintain this document through detailed design to handover.

Under a Design and Build contract the contractor must become responsible for this strategy with the Building Services Designer responsible for the review and approval of the strategy at production information and construction stage.

All sub-metering must be agreed with the UCL Operations and Infrastructure Teams and Sustainability teams with all meters to be UCL Energy Monitoring System / network compatible for central energy monitoring purposes as detailed in UCL's Metering Specification.

The Building Services Designer shall engage the metering specialist identified in the Metering Specification to develop the Metering Strategy.

Individual monitoring required for lighting (per floor), end user small power (per floor), centralise mechanical loads, single connected loads over 50kw, lifts, heat, gas, water, chilled water, steam and electrical loads.

A.11 BUILDING MANAGEMENT SYSTEM

The UCL Estate currently operates both Trend and Schneider control systems. All new buildings or major refurbishments must be specified with Schneider EcoStruxure platform

controls. Minor refurbishments may retain their Trend controls if appropriate. If above 40% of the building is being refurbished, the system must be migrated to Schneider EcoStruxure platform.

The Building Services Designer must provide a detailed description of the building and system controls whilst adhering to UCL BMS Standard Specification. Full BMS Specification included as Appendix D of this document.

All new plant and equipment must be compatible with the UCL BEMS system and must have remote control and monitoring functionality back to the UCL headend server.

Monitoring of the electrical and mechanical sub metering of plant and lifts must be provided for energy monitoring and preventative and reactive maintenance the data for which will be ultimately linked back to the UCL Energy Monitoring (EMON) System. Electrical meters to be connected to the PME (EMON) system and mechanical meters to the BMS where this exists.

All BMS devices need to communicate over UCL IP Ethernet network, with IP in '10.4' range and patched to VLAN 720 (these is one VLAN for all BMS systems).

Panel network switches are prohibited, so Designer will ensure there are always enough data ports installed to accommodate require BMS controllers' connections.

Fully programmable BMS controllers are to be provided on all main plant controllers (i.e. packaged controllers are not acceptable).

Packaged controls of Air Handling Units, Multi Service Chilled Beams, Fan Coil Units, etc. are not acceptable.

Refer to UCL's Metering Specification and BMS design specification (Appendix D) for further information.

For all newly acquired buildings to the UCL Estate a review of the existing BMS system must be undertaken and an appropriate design solution agreed with the UCL Operations and Infrastructure Teams.

The Building Services Designer shall engage the Operational Maintenance team and the Termed BMS contractor in the development of the BMS proposals, particularly on Refurbishment projects.

A.12 BUILDING USER GUIDE

For larger projects (generally >£10m, but as agreed depending on project scope) a Building User Guide must be developed prior to handover and made available to UCL Estates for distribution to the building users and in a format suitable for publication on relevant UCL web pages. A blank Building User Guide template is provided on the UCL website and is to be used for this purpose. This template prompts all potential information that would need to be included.

Smaller projects must also develop a guide where suggested by the nature of operational requirements (e.g. AV, lighting, heating, cooling instructions).

The Building Services Designer must contribute relevant content for the Building User Guide (where required by the project) including, but not limited to, the following information which must be prepared and issued to UCL for comment prior to Practical Completion (PC).

- Building services information
- Emergency information
- Energy and environmental strategy
- Water use
- Materials & waste management
- Transport facilities
- Catering
- Refit / re-arrangement considerations
- Reporting provision
- Training
- Links and references (must this be electronic)
- Log book and O&M's

NOTE: the Building User Guide is intended to be a non-technical guide for facilities management and general building users. For larger projects, it needs to be provided separately from the O&M manual and Building Log Book.

A.13 COMMISSIONING AND TESTING

For all projects a Soft Landings Champion must be appointed. The role of the Soft Landings Champion is to ensure that all systems and components of a building or industrial plant are designed, installed, tested, operated, and maintained according to the operational requirements of the owner or final client. Therefore, a Soft Landings Champion must be nominated during the design stage of a project. For full details of UCL's Soft Landings Procedure please refer to their UCL Soft Landings Framework document.

Refer to the UCL Seasonal Commissioning Employers Requirement for full details on the requirements for seasonal commissioning.

The role is to ensure that commissioning is carried out in line with current building regulations, BSRIA and CIBSE guidelines. The following lists the responsibilities of the specialist commissioning manager;

- Design input – reviews of the project, its design and ease of commissioning. A detailed examination of the design specification and drawings, supplemented by site inspections would be undertaken. Confirmation/recommendations would be provided concerning the capability of the system in a safe and proper manner.

- Programming – to review and contribute management input into the construction programme. Working with the contractors' commissioning team to ensure practical solutions were achieved in the shortest time possible and monitoring changes to the design scheme to ensure effective commissioning facilities are provided at all times.

- Installation stage – to review and advise during this stage to ensure the proper development of the commissioning process. Undertake initial tests and pre-commissioning as systems are complete. Ensuring systems are protected to avoid damage during commissioning and early installation stages.

- Management – at the following stages of commissioning, performance, testing and handover/post-handover. Ensuring the proper provision of contractors' method statements, test and commissioning certificates and O&M's.

Throughout the project the commissioning manager will review and develop with the contractor, the commissioning programme to ensure compliance is met at each stage.

The UCL Post Project Review Guidelines are to be followed.

All capital projects that include mechanical and/or electrical installations within their scope of works must complete the seasonal commissioning process detailed in UCL's Seasonal Commissioning Employer's Requirements within 12 months of substantial building occupation. The purpose of seasonal commissioning is to assess the operational performance of newly installed mechanical, electrical and renewable energy systems. Throughout the seasons typically these systems are affected by changes in climate, and we assess them to ensure these perform as they were designed to. Seasonal commissioning is a separate, but complementary process to the normal commissioning of building services.

Testing of all the services under full load conditions and under part load conditions may be undertaken (i.e. throughout the 4 seasons). Interviews with building occupants and the Operational maintenance team must be undertaken to identify problems or concerns regarding the effectiveness of the system. Re-commissioning of systems must be undertaken as identified to serve revised loads.

The commissioning manager ensures that installations operate as designed and helps ensure the building is ready to operate as intended on handover. Post Occupancy Reviews must be undertaken in accordance with UCL Post Project Review procedures to ensure that systems are as intended throughout the seasonal year and provide critical information to the building user/owner to identify any short comings within the project to ensure such problems are not replicated in future.

All commissioning and testing must be undertaken in line with Part L, CIBSE and UCL Soft Landings Framework.

When compiling the contract documentation, the Building Services Designer must ensure that the following is communicated and policed throughout the installation stage of the project:

- Notify the Soft Landings Champion when the Works or parts thereof are ready for testing and commissioning.

- Provide all necessary facilities to enable tests to be witnessed and inspections carried out including all necessary instruments and recorders to monitor systems during commissioning system proving and environmental testing.

- Appoint a "competent person" to supervise the whole of the testing, commissioning, system proving, system demonstration and instruction of the employer's staff. This must be from an approved UCL Independent Commissioning Manager supply chain.

- Co-ordinate the activities of all specialised personnel, including manufacturer's representatives, together with providing any attendance required.

- Indicate on drawings where access is required into ceiling voids, service risers etc and ensure these points are not closed up until the commissioning and testing is complete.

- The Building Services Designer and or UCL representative must be given the opportunity to examine, subsequent to setting to work and regulation of the Works the results of the commissioning and the documentary records thereof.

- Ensure all requirements such as cleanliness, protection from harmful external and internal elements are provided prior to commencement of commissioning.

The object of the witnessing stage is to enable the Building Services Designer and or UCL representative to establish a level of confidence in the commissioning results being presented. The extent and proportion of results to be witnessed by the Building Services Designer and or UCL representative must be at the discretion of Building Services Designer and UCL.

The Building Services Designer and or UCL representative must only witness test the completed systems proceeding the receipt of recorded results from the commissioning and must determine if the specified requirements have been satisfied.

Must the tests fail to demonstrate that the plant and equipment are properly installed and functioning correctly, the cause of the failure must be investigated. Must the failure be due to incorrect or faulty work then without delay, carry out such remedial measures and adjustments as may be necessary and repeat the commissioning and testing procedure to the satisfaction of the Building Services Designer and or UCL representative.

Where it is not possible at the particular time of commissioning and testing for full load conditions to be obtained or simulated, undertake to repeat such operations of full load or a simulation thereof at a time when this can be achieved.

The Works must be fully tested, commissioned and be fully operational prior to witnessing and inspection by the Building Services Designer and or UCL representative.

Where portions of the Works are required to be commissioned and tested separately, then upon final completion, the Contractor must demonstrate to the Building Services Designer and or UCL representative that all of the portions are capable of proper simultaneous operation in accordance with the requirements of the specification.

In cases where the construction programme is such that the commissioning, testing, balancing and adjustment needs to be undertaken in an area of the building taken over and occupied by UCL. The Contractor must take all necessary precautions against and be responsible for any damage and remedial works required as a result of the commissioning, testing, balancing or adjustment.

The Contractor must provide all certification documents to the Building Services Designer and or UCL representative for examination before any system is offered for final acceptance.

The Contractor must provide a written statement to the Building Services Designer and or UCL representative confirming that each installation has been correctly tested and commissioned and that the performance requirements can be achieved.

In addition the Contractor must undertake the following:

- Test, commission, regulate and set to work the Works.
  Prepare comprehensive programmes, commissioning plans, schedules and method statements and procedures supported by risk assessments for the pre-commissioning checks, setting to work, commissioning, system proving for a minimum period of 2 weeks, and environmental testing of the Works.
- Comply with the requirements of the Building Regulations (Approved Document Part L2) for the inspection and commissioning of the building services systems. Prepare all necessary submittals including commissioning plans and reports. Obtain all compliance approvals from the building control bodies.
- Provide all specialist personnel including manufacturer's representatives and coordinate their activities, together with providing any attendance required.
- Provide and submit standard proforma for the various requirements for commissioning records and certification for agreement with the Engineer prior to commencement of the works.
- Monitor progress against the programme of works and provide weekly reports detailing progress of testing and commissioning activities.
- Maintain a diary/log of significant commissioning and testing activities
- Measure and reconcile noise levels at agreed locations to verify compliance with design criteria if requested.
- Submit to the Building Services Designer and or UCL representative all certification documents for any system being offered for final acceptance.
- Confirm in writing to the Building Services Designer and or UCL representative that each installation has been correctly tested and commissioned and that the performance requirements can be achieved.
- Ensure all certification is attained and witnessed as necessary for inclusion in the record documentation.
- Provide and submit a report for every test, demonstration, balance or commissioning activity witnessed, together with an engineering appraisal on the performance, either on or off-site.
- As necessary co-ordinate and liaise with the Building Services Designer and or UCL representative.
- Maintain on site at all times full records of all testing, commissioning and performance testing. Performance testing, system demonstration, system proving for a minimum period of 2 weeks, environmental testing, until commissioning of the system is completed to the satisfaction of the Building Services Designer and or UCL representative.
- System proving data will be reviewed against existing documentation and reviewed with UCL Project Officer.

Submit to the Building Services Designer and or UCL representative written reports signed by a "competent person" to confirm that:

- Prior installation - all system designs can be commissioned
- Post installation - installations complete and ready for commissioning
- System cleanliness - specified cleanliness has been achieved
- Pre-commissioning checks – completion of pre-commissioning checks
- Commissioning and testing – demonstrate compliance with specified requirements and confirm that each installation has been correctly tested and commissioned and achieving the specified performance. During the 12 months after practical completion as deemed necessary by the Main Contractor (MC) or must the system not be performing to the required design parameters, undertake:
- Assess the need for fine tuning of the installations
- Ensure the requirements for fine tuning are incorporated in the commissioning specification

- Ensure that fine tuning activities are programmed, planned in advance and agreed with the MC and employer prior to commencement
- Arrange that the relevant parties are retained and appointed to provide input to fine tuning activities
- Ensure that fine tuning activities are planned with regard to the health and safety of occupants and such that any disturbance to them is minimised
- Provide a mechanism by which the employer can provide feedback on the performance of the building both before and after fine tuning
- Attended meetings as requested by the Building Services Designer and or UCL representative to deal with issues arising from fine-tuning of the Works. Costs for fine-tuning and adjustment of the Works during the 12 months after practical completion must be included in the contract price.

Allow as necessary visits during the 12 months after practical completion including the requirements to complete all actions associated with BREEAM and or Seasonal commissioning requirements.

A.14 OPERATING AND MAINTENANCE MANUALS

The Contractor shall prepare operation and maintenance manuals in accordance with the requirements of the UCL Health & Safety (H&S) File and Operation & Maintenance (O&M) Manual formats.

Health & Safety Files and Operating and Maintenance Manuals (O&M) must be provided to UCL Estates, Facilities & Infrastructure team in electronic format.

Full details of Health & Safety (H&S) File and Operating & Maintenance (O&M) Manuals procedure and formatting requirements are available on UCL Employer's Requirements website.

Two weeks before the contracts practical completion date, a draft copy of the operating and maintenance manual(s) must be issued to Operations and Infrastructure Teams. The draft copy shall be a complete copy of all the manual(s) for review, with all information provided to be reviewed. Providing draft manual(s) with missing sections/information is not acceptable.

The Health & Safety Files & O&M Manuals must be fully reviewed and commented on by the Principal Designer, the professional design team and professional advisors ahead of draft presentation to UCL. The draft manuals are then to be reviewed at a Health and Safety File Review Meeting. This meeting is to be coordinated and chaired by the University Project Officer (UPO) / Project Manager and attended by the Principal Designer / Contractor, representatives from the UCL Mobilisation & Transition Team (MTT) and Operations and Infrastructure Teams, including the Maintenance Manager (DLO Manager), the design team and other professional advisors.

All comments made from this meeting shall be incorporated ahead of the documents being formally issued to UCL. All Health & Safety Files & O&M Manuals must be provided prior to Practical Completion. Final issue to UCL shall be to the MTT, who will then final check and cascade accordingly.

The UCL Programmes & Performance Team are the custodians of all final Health & Safety Files & O&M Manuals, who must arrange for inclusion onto the UCL H&S and O&M Digital Manuals Database within 4 weeks.

The draft and final O&M's must include a full schedule of plant and equipment referenced in line with the UCL Asset Management System. The Operations and Infrastructure Teams will appoint for each project, a nominated person whose responsibility will be to update the Asset Management System with the final record information. The Building Services Designer must check and verify that this has been carried out prior to Practical Completion.

All O&M's must be produced in an electronic format that is compatible with the UCL central database.

The O&M's must contain the approved Plant Replacement Strategy developed and maintained as part of the design.

The Contractor shall retain a copy of all the delivered record documentation for at least one year after practical completion. If requested by UCL during this period, they must provide additional copies subject to a charge.

The Contractor is responsible for the correction of any errors or omissions in the manual.

A.14.1 General Requirements of the O&M's

All documentation must be in English as spoken and written in the United Kingdom.

All units of measurement must be metric, conforming to the SI system.

The text of descriptive sections must be concise and complete avoiding possible ambiguity or misunderstanding. All information must be pertinent to the specific installations.

Irrelevant material or material of a general nature must not be included. Where generic standard clauses are used as the basis for certain parts of the manual, they must be edited to ensure that all text is relevant to the Works.

Jargon must be avoided. All new terms must be defined when first introduced. Abbreviations must only be used if they have been defined or their meaning is clear from the text.

The imperative mode must be used for instructions regarding operation, maintenance, disassembly etc.

Illustrations, drawings and diagrams incorporated into the manual must be easily read in conjunction with the relevant text and checked for accuracy prior to Handover.

All aspects of the manual must comply with relevant requirements of the CDM Regulations for the provision of information for the Health and Safety File.

Where appropriate, the maintenance procedures and frequencies detailed in the manual must be in accordance with details provided by the manufacturer for specific items of equipment. Where specific requirements are not pertinent, the procedures and frequencies must be as recommended in SFG 20 Standard Maintenance Specifications for Services in Buildings.

Care must be exercised to ensure that maintenance procedures and frequencies described in manufacturers' printed details are accurately reflected in the text of the manual.

The Contractor must identify, from the Operations and Infrastructure Teams, the intended maintenance strategy for the Works and the level of technical competence and user ability of the personnel likely to be employed. The manual must be written in a style to suit the abilities of all users. Where necessary, separate sections must be prepared to suit the following levels of competence:

a) Non-technical – e.g. building manager or caretaker requiring simple directions for basic operations.
b) General technical – with broad-based maintenance skills required for routine maintenance, inspections etc and detailed analysis of system operation.
c) Specialist – in individual fields and with respect to particular items of equipment.

The manual must have an alphabetical index or indexes. The indexing and cross-referencing in other parts of the manual must be arranged to provide easy access to required information.

UCL space location information to align with the UCL Asset Management System.

A.14.2 Content and layout

The manual must be formatted using the Health & Safety (H&S) File and Operating & Maintenance (O&M) Manuals procedure and formatting requirements which are available on UCL Employer's Requirements website.

Document to be provided as an electronic version. The method of electronic document issue to be agreed with UCL Project Officer (e.g. WeTransfer, Microsoft SharePoint/Teams, DropBox, or similar).

A.14.3 Checking of Drafts

The Health & Safety Files & O&M Manuals must be fully reviewed and commented on by the Principal Designer, the professional design team and professional advisors ahead of draft presentation to UCL. The draft manuals are then to be reviewed at a Health and Safety File Review Meeting. This meeting is to be coordinated and chaired by the University Project Officer (UPO) / Project Manager and attended by the Principal Designer / Contractor, representatives from the UCL Mobilisation & Transition Team (MTT) and Operations And Infrastructure Teams, including the Maintenance Manager (DLO Manager), the design team and other professional advisors.

The draft copy of the manual must conform to the required format of the final document, with the exception of any information not available at that time (such as commissioning results).

Draft versions of the manual must clearly display the word "DRAFT".

A.14.4 Final documentation

Once approved a final draft must be provided to the employer prior to instructing the employer's staff in the operation and use of the services installations. This copy must contain all testing and commissioning data and test results, actual control set points etc. in draft form.

The electronic documentation shall include:

a) The complete O&M Manual as a single PDF file in .pdf format
b) All drawings in latest Autodesk AutoCAD .dwg format (and where applicable)
c) BIM data and Model in latest Autodesk REVIT.rvt format (and where applicable)

Documents must apply version number system to manage version control where necessary.

A.14.5 Copyright

UCL must have sole copyright to all documents produced specifically for the manual. UCL must be entitled to produce copies of all parts of the manual for its own use.

If the Employer transfers ownership or responsibility of the installations he must be entitled to transfer his copyright of documents included in the manual. Any intellectual property procured by UCL to be vested within UCL.

A.15 RECORD DRAWINGS

Record drawings of the complete Works must be provided before practical completion.

Record drawings of the final “construction record (CR) ”/"as installed"/ “as built (AB)” layouts must be issued in draft form to the Building Services Designer and UCL Operations and Infrastructure Teams for examination 4 weeks prior to the testing and commissioning period to allow checking for accuracy.

Record drawings must be prepared and provided using the current version of Autodesk AutoCAD in .dwg format. Drawings are also required to be provided in single .pdf format as agreed with the Building Services Designer and or UCL Project Officer prior to production of the drawings.

DWGs provided must have bound GAs (where appropriate) within the DWG files.

All drawings must be suitably layered, with different services on each layer. A detailed list of layers, external references or equivalent (if used) and list of files must be provided. If the drawings were produced from CAD drawings provided by the Building Services Designer the same layering system must be used.

Full schematics and layouts of as-built services are required for all projects, showing clearly where connection is made to existing services. Where intrusive investigative surveys have been undertaken, these drawings are to be included in full package of record information (i.e. below ground drainage surveys).

Drawings are required for building services (MEP), structural works if applicable, and architectural drawings.

The drawings must be produced in metric units.

Once approved the complete set of electronic record drawings must be revised as necessary to incorporate testing and commissioning data where applicable, and the final set(s) of record drawings must be handed over at practical completion.

Issue at practical completion the complete approved package of record drawings in an electronic format consisting of PDF and DWG.

Valve charts, electrical distribution charts in panels and the like, must be issued for examination at agreed dates to allow adequate time for manufacture and installation prior to practical completion.

Where portions of the work are to be concealed, draft copies of record drawings must be supplied to the Building Services Designer before the work is concealed in order to facilitate checking and examination.

The record documents must be correlated so that the terminology and the numerical and/or other references used therein are consistent with and similar to those used in the physical identification of component parts of the Works.

Each record drawing must show the following information:

a) The name of the contract and, where appropriate, the zone or floor designation.
b) Name and location of the project.
c) Description of drawing, drawing reference and scale.
d) Name and address of the contractor and the consulting engineer.

The completed drawings must be signed as record drawings.

Each record drawing must be endorsed with the words 'Record Drawing' in the bottom right hand corner adjacent to the title block.

Changes to the layout of existing floor plans are to be reflected in DWG format drawings.

FAILURE TO UNDERTAKE THE ABOVE PROCEDURE FOR THE PREPARATION OF RECORD DRAWINGS, O&MS AND SYSTEM COMMISSIONING/TESTING RESULTS AND LEAVING THE PRODUCTION OF SUCH DRAWINGS /DOCUMENTS TOO LATE IN THE CONSTRUCTION/COMMISSIONING PERIOD WILL RESULT IN HANDOVER NOT BEING ACCEPTED BY THE BUILDING SERVICES DESIGNER AND OR UCL REPRESENTATIVE.

For full details of UCL's BIM Model/Revit/COBie requirements please refer to the BIM – Employer's Information Requirements document.

A.16 PLANT AND SWITCHROOM DRAWINGS, SCHEDULES AND SCHEMATICS

The Contractor must provide good quality plant and switch room drawings, schedules, schematics and instructions and hang them in the respective plant room or any other appropriate location, or where directed by the Building Services Designer and or UCL representative. Drawings and schematics to be at A1 size wherever possible. If not practicable, A2 size to be agreed with UCL Project Officer.

The surfaces of such information shall be protected by pressure lamination and hung using suitable fixings and the provision of backboards if necessary.

A sample must be submitted for approval by the Building Services Designer prior to commencing production.

Provide information as stated elsewhere and include:

a) All information required under statutory or other regulations
b) Location of all incoming service isolating and metering facilities

c) Emergency operating procedures including details for emergency call out service
d) First aid instructions for treatment of persons after electrical shock
e) Schematic drawings of installations showing identification and duties of equipment for all services.
f) Controls schematics.
g) Valve schedules showing reference, type, location, application/service and normal operating position.
h) Asset management System references.

Prior to being fixed, plant and switch room drawings, schedules, schematics and instructions must be submitted for review by the Building Services Designer. The review procedure must be as for record drawings as stated elsewhere and all items must be fixed prior to practical completion.

A.17 BUILDING LOG BOOKS

Building Log Books are required in accordance with the Building Regulations Approved Document L2.

The Log Book must be in the format of CIBSE TM31: "Building Log Books and Standard Templates" and must be provided in electronic format.

The Contract specification must require the contractor to produce the log book but the Building Services Designer must provide the contractor with all necessary design information necessary for the contractor to produce a comprehensive document.

This information must be collated and included within the Health and Safety File.

HANDOVER WILL NOT BE RECEIVED IF THE REQUIRED INFORMATION IS NOT PROVIDED, WHICH COULD HAVE CONTRACTUAL IMPLICATIONS.

A.18 HANDOVER

This section outlines the requirements and procedures for completion and handover. UCL's Handover Checklist document must be completed and signed off for each system to the satisfaction of UCL Operations and Infrastructure Teams as a pre-requisite to Practical Completion.

The Building Services Designer must ensure that the Soft Landings Procedures are finalised at Handover. Full Employer's Requirements are included on the UCL website.

The Building Services Design must provide the UCL Project Officer with any information they require to complete the CH3 form.

The contractor must demonstrate the full extent of the contract works, including all variations or part thereof, to the satisfaction of the Building Services Consultant and or UCL representative that:

a) All the contract works are complete. With the exception of minor snags or limited defects as agreed with the Building Services Designer and or UCL representative that could be reasonably completed within an agreed programme without causing disruption to UCL's use of the building or part thereof.

b) All spares, keys, tools and other consumables as stated elsewhere have been supplied and handed over to UCL.
c) The instruction of UCL's staff in the use and correct operation of the installation has been completed satisfactorily. In particular, the demonstration of safety devices and controls.
d) All commissioning and testing completed including the issue of final commissioning reports signed by the UCL approved Commissioning Specialist, Building Services Consultant and or UCL representative.
e) A complete demonstration of the contract works including fully functional operational controls tests undertaken in the presence and to the satisfaction of the Building Services Designer and or UCL representative.
f) All necessary certification by UCL's insurers has been completed (if required).
g) All approved record documentation including record drawings, operation and maintenance manuals, etc. is received and approved. This must cover the requirements of BREEAM, Ska or other relevant environmental assessment, as relevant.
h) All information required for the health and safety file is issued to the satisfaction of the Planning Supervisor.
i) All necessary Statutory Authority approvals have been obtained and written confirmation received.
j) Completion and issue of full Health and Safety File, including building log book information, in accordance with Building Regulations.

MUST ADEQUATE RECORD DOCUMENTATION NOT BE AVAILABLE PRACTICAL COMPLETION WILL NOT BE GRANTED.

A.19 DEFECTS PERIODS NAMED MATERIALS/SPECIALISTS

During the defects period the contractor must price for addressing any issues arising with all systems covered under the works, including the entire system and not just a part of the system which may have been covered by the works.

The contractor must also price for a 12 month maintenance and servicing period of all works (including entire system) in order to maintain plant and equipment warranties. This will also allow for a 12 month seasonal commissioning programme.

Defects arising from failures arising out of improper operation by the Employer or fair wear and tear will not be liable for rectification under contract defects.

Carry out all planned preventative maintenance on all Engineering Services works during this period, including:

- Testing in compliance with statutory requirements
- Routine maintenance inspections in accordance with the O&M manuals
- Replacement of all 'consumables' at no additional expense to this contract
- Recording of all maintenance work carried out
- Monitoring and recording of all energy consumption through this period
- Interpretation of the energy consumption to demonstrate correct operation of the plant
- The requirements of the Building Regulations Approved Document Part L
- Seasonal commissioning

The Contractor will prepare and submit records of failures or malfunctions of any part of the works during the defects liability period, together with details of remedial action taken, subsequent re-testing and the results.

The Contractor will notify UCL of damage, failures or malfunctions to the works caused by incorrect operation of the installations, vandalism or other actions by a third party.

The Contractor will rectify all defects due to materials or workmanship or other faults that occur, including those notified by UCL, during the defects liability period with the minimum of delay and at no additional expense to this contract.

The Contractor will inform the Building Services Designer and or UCL representative in writing when all defects are finally rectified so that an inspection may be carried out prior to the issue of a final certificate.

All associated costs with this maintenance shall be detailed separately within the tender returns to allow Operations & Infrastructure Teams to review and confirm elements they wish to go forwards with.

A.20 LIFE CYCLE CARBON ASSESSMENT

A suitably qualified/competent person (e.g. CIBSE Low Carbon Consultant, or similar) must undertake a carbon appraisal for all plant and equipment whether it is to be retained or replaced as part of the proposed works. For smaller projects, this may be carried out using the UCL Cost and Carbon Tool, and must broadly consist of the following:

- Energy consumption in use
- Energy efficiency in use
- Carbon emissions in use
- Life cycle analysis
- Reliability
- Maintenance costs
- Controls
- Cost of carbon abatement

This appraisal must be undertaken and the resulting recommendations commented and approved by the UCL Project Officer, Operations and Infrastructure Teams and Sustainability teams prior to the project being presented to the Project Review Group.

All energy and water consuming plant, equipment and products must be selected in conjunction with the UCL Operations and Infrastructure Teams and Sustainability teams and in line with the approved technology lists and current BRE Green Guide to Specification.

A.21 WORKING WITH ASBESTOS

On all projects the aim is for the total removal of all and not the encapsulation of asbestos identified and must therefore form part of the works if identified. UCL Asbestos Management Team to be involved in projects from their earliest stages.

Please refer to the UCL Asbestos Management Plan for further information.

A.22 NAMED MATERIALS/SPECIALISTS

Where particular manufacturers/specialist suppliers are mentioned in this document within the appendices, this is to illustrate items/services that are proven to meet UCL requirements and to assist in minimizing stockholding of spares and specialist training of staff.

The Building Services Designer must ensure the suitability of such materials or specialists for the particular scheme and remain responsible for their integration into the design. In all cases, the Preferred Manufacturers List must be consulted in the first instance.

The Building Services Designer is at liberty to consider alternatives and to establish whether such alternatives are acceptable to UCL, particularly if the Building Services Designer has reservations about the use of such materials or specialists. The Building Services Designer must obtain approval in writing for any alternatives from Principal Mechanical or Principal Electrical Engineer.

Similar provision must be included in Building Services Designer specifications used for tendering purposes to clarify that such materials or specialists are not nominated and their performance under the contract remains the responsibility of the contractor.

Passive Fire protection relating to the integrity of fire compartments, are being actively managed at UCL, to comply with obligations under the Regulatory Reform (Fire Safety) order. The Building Services Designer must ensure compliance with the requirements set out in UCL Fire Technical Note.

A.23 OTHER APPLICABLE UCL TECHNICAL DOCUMENTATION

In the absence of specific information for particular systems being covered by this document, Building Services Designers must refer to suite of documents included on their Employer's Requirements website.

UCL Project Officers must also be consulted for any further information they may hold on UCL's private intranet system.

A.24 HEALTH AND SAFETY

Comply with the requirements of all relevant health and safety legislation and regulations including the Construction (Design & Management) Regulations (CDM) 2015, as amended.

The Building Services Designer must be responsible for incorporating Safety in their designs. As part of each stage gate approval process, Residual Risk Assessments must be provided.

A.25 DESIGNING FOR THOSE REQUIRING SUPPORT AND ASSISTANCE (INCLUSIVITY)

The Building Services Designer must adhere to Approved Document M and wherever possible look to achieve higher levels of sustainability than those prescribed by that document. The Designer must meet all requirements of UCL's Inclusive Design Standard (available via UCL's Employers Requirements website).

The following items are listed for further consideration and all items to be discussed with UCL's Access and Inclusion Manager before incorporating into designs. This list is not exhaustive.

Temperature Control

Balancing temperature preferences and needs across a wide spectrum of people should be reviewed and assessed.

Heat and humidity can exacerbate a proximation need for a greater distance between people and can be a distraction.

Sensitivity to cold temperatures can also be problematic for some groups, for instance, cold temperatures can exacerbate pain for people with fibromyalgia.

The provision of openable windows and fans should be taken into account, as well as the option, where practical, to have a choice of temperature and humidity settings in which to work.

Sensitivity to temperature, particularly heat, is commonly experienced across a range of disabilities and medical conditions, therefore having different working environments kept at different temperatures allows people to choose the most comfortable for them to work all or part of the time.

Acoustics and Noise Management

One of the biggest influences on wellbeing for people with sensory processing differences can be noise. Noise can have a negative physiological and psychological impact. Whilst most neurotypical people can adjust to a variation in noise levels, this can be much harder for individuals with a range of sensory processing differences. For example, hyper-sensitivity results in increased stress, anxiety and in the absence of any mitigating measures, sensory overload.

People with neurodegenerative conditions (such as dementia), and neurodivergent conditions (such as autism, ADHD) are very often sensitive to noise. Low frequency noise is generally found to be the most difficult to control, due to its ability to penetrate building structures (higher frequencies lack the sound energy to do this). However, mid and higher frequency sounds (particularly those associated with the human speech spectrum, i.e., 500-2000 Hz) can be more disturbing to thought processing and emotion.

Background Noise Reduction

Background noise in an internal environment can originate from a variety of sources, e.g., noise breaking in from external spaces, transmitted internally from other rooms or the noise generated inside a space by the ventilation and air-conditioning systems.

Background noise from ventilation and air-conditioning systems, which commonly includes significant low frequency components, should be minimized through the selection of appropriate low noise fans, in-duct attenuators, and acoustically insulated ductwork to minimize air transfer noise moving through the ductwork.

Unpredictable, sudden, loud sounds (high or low frequency) can be intimidating. Repetitive sounds, such as a ticking clock or whirring fan, often lead to concentration difficulties.

The following areas for background noise should be reviewed and assessed:

a) Direct Transmission

When sound is transmitted between areas, it can be reduced with sound insulation. This can involve increasing the mass of separating walls and floors and further measures might be needed, such as vibration-isolation (e.g., floating floors).

b) Absorption

The extent to which sound can be absorbed within the environment reducing reverberation; soft finishes are helpful and sound absorbing curtains and screens can adjust the room acoustics within a space during different activities. Absorptive materials can help reduce the sound pressure level within a space so reducing levels of background noise.

c) Flanking Sound Transmission

The extent to which building elements (e.g., walls, floors and ceilings, structure) permit noise transmission such as through gaps around doors, inadequate filling of mortar joints, or so-called “structure borne transmission” where elements are excited by sound and pass along the energy as vibration, to be re-radiated in another part of the building.

Lighting

People who experience sensory overload or migraines are particularly sensitive to lighting flicker, including many children. This flicker is often not visible or consciously perceived but can still cause discomfort, such as eye strain, headaches or migraine.

Flicker should be taken into account as a potential issue when:

a) fluorescent battens are installed.

b) residential quality LED lighting is used with a low-quality driver.

c) incompatible dimming controls are used with poor performance dimmable LEDs.

d) drivers and luminaires are incompatible.

With high frequency lighting often used in study and learning spaces, an appropriate choice of LED light sources and “constant current” driver technology should be used to achieve a successful system without flicker.

Flicker is most perceptible between the frequencies of 10 Hz to 25 Hz¬ (a 100 Hz flicker is not an issue for most people). Compact fluorescents operate at 20 000 Hz and are therefore not likely to produce a detectable flicker.

Dimming controls intended for incandescent tungsten lamps are not suitable for use with LED lamps and can result in flicker.

Light that is emitted directly from an LED source can be intense and cause visual discomfort for some neurodiverse individuals. Measures should be taken to subdue the intensity or direct viewing of the light source. Elements such as diffusers or recessed light sources with

reflector technologies should be used. The use of lens optics can assist to direct light to required areas and also limit light pollution or undue light spill onto adjacent areas.

Controls/Sockets/Switches etc.

All controls should not require the simultaneous use of two hands. Electrical socket outlets should be switched. Switches should indicate clearly whether they are on or off and should be positioned on the outside of the socket outlet.

Red and green should not be used as indicators of “ON” and “OFF” on switches and controls without clarification by text or pictogram, as they are the most commonly confused colours for people who are partially sighted or colour-blind.

Electrical wall socket outlets, telephone points, and television and data sockets should be located at least 400 mm but not more than 1000 mm above the floor. Socket outlets whose plugs are likely to be removed and replaced frequently should be located at the top of the range.

Switches for permanently wired appliances (e.g. fused spurs or reset switches for alarm calls) should be mounted within the range between 750 mm and 1200mm.

The maximum height of simple push button controls, including isolator switches and circuit breakers, that require limited dexterity should be 1200mm. Emergency “break glass” panels and door releases should be mounted between 1000mm and 1200mm from the floor.

Outlets, switches and controls should be at least 350 mm from room corners.

Entry Communication Systems

Entryphone systems should be sited for approach and use by all users, including wheelchair users, and should contain a light emitting diode (LED) display to enable people who are deaf and hard of hearing to use them. The means of indicating that the call is acknowledged and that the lock has been released (if permitted) should be both audible and visible.

The entry phone system should contrast visually with the background against which it is seen. Video entry phone systems provide additional benefits for the person answering the call, as well as for the person wishing to gain entry.

The cone of vision of any video entry phone system needs to be sufficiently wide to ensure that any visitor is in the line of sight.

The option to include hearing (induction) loops with entry phone panels is considered desirable; however, to achieve an acceptable signal the induction loop aerial (antenna) needs to extend beyond the casing of the entry phone panel to encompass the space adjacent to the entry phone or be mounted on the internal wall behind the panel. The signal is insufficient for a hearing aid user to pick up if the aerial is mounted within the entry phone panel, and it is advisable to seek expert guidance to ensure that the recommended performance of the induction loop is met. It is desirable for entry phone systems to incorporate a means of enabling a visitor with a speech impairment to communicate this to the person answering the call, e.g. a telephone number that can be used to receive text messages.

When designing such systems for vehicle entry points thought needs to be given to all of the above and that some users cannot get out of their cars to use these entry systems.

B.1 ELECTRICAL DESIGN CRITERIA

B.1.1 HV Electrical System

UCL manages HV equipment and systems in some areas of the Campus. These are largely concentrated on the Bloomsbury estate. Otherwise most of the connections serving buildings are as LV connections via the DNO network.

An HV ring exists on UCL's main campus site as part of a CHP system owned and operated UCL. The Authorised Person responsible for this system is the Maintenance Operations Manager, and UCL's CHP Management Team, who must be engaged on all proposed works affecting this system.

Any electrical alterations or upgrades that require connection to a substation / Main switchroom are to be carried out in accordance with the Electricity Safety Quality and Continuity Regulations (ESQCR), as amended), upon getting prior approval for this arrangement from the UCL Operations and Infrastructure Teams.

Where HV equipment and switchgear is to be incorporated in the UCL works, the design must comply with all relevant standards. The design must include the facility to isolate UCL systems either for maintenance or an emergency situation without the requirement to involve the Distribution Network Operator (DNO). The HV switch must earth the transformer and must be located on the part of the network that falls under the responsibility of UCL.

Consideration must be given at the design stage to limit over voltage when the transformer is partly loaded. The high voltage system must be designed to supply low voltage (230/400V) within the upper and lower limits as laid down in BS EN 50160, as amended.

All high voltage installation must incorporate an emergency power off button to enable the isolation of the high voltage system in the event of emergency without the attendance of a high voltage senior authorised person.

All high voltage installation must be securely segregated from other plant areas, to restrict access to authorised personnel only.

Where applicable the high voltage and low voltage protection system must be commissioned together by a specialist protection engineer to ensure the correct discrimination achieved in a fault condition.

All HV Switchgear and associated equipment shall be SF6 free.

Transformers shall be a low flammability type. Sizing to be based on AN rating with consideration to temperature monitoring and mechanical ventilation.

Transformer enclosures require Castell interlocking with upright hinged double doors, that a single operative can open/close.

Where tripping batteries are utilised, consideration must be undertaken for ventilation and maintenance.

B.1.2 LV Electrical Supplies

In accordance with the Electricity Safety, Quality and Continuity (ESQC) Regulations, as amended, the Building Services Designer, in so far as it is necessary, is required to liaise with the parties outlined within the said document, in relation to LV supply requirements.

Consultation to be carried out with the following when negotiating a new supply connection:

1. The Supply Authority
2. The metering company
3. UCL's Energy Manager
4. UCL's Property Manager {for lease agreement matters}

Any new supply is expected to be in accordance with The Distribution Code and specifically BS EN 50160 and G5/4.

The Building Services Designer must investigate and design for the following:

- Installed load for an existing facility (where applicable)
- The proposed additional loads
- Nature and characteristic of proposed loads or demand
- The capabilities of the existing electrical infrastructure
- Confirm/verify the characteristics of the existing or new supply
- The type, completeness and security of the existing or new protective earthing system.
- The load balancing of the existing system
- The discrimination study of existing and proposed protective devices and the settings (if applicable) on the complete system.

<table>
<tr><th>Specific Criteria</th><th></th></tr>
<tr><td>Voltage</td><td>400V AC, 3phase 50Hz / 230V AC, 1phase 50Hz</td></tr>
<tr><td>Volt drop tolerances
(i) Low voltage installations supplied directly from a public low voltage distribution system
(ii) Low voltage installation supplied from private LV supply</td><td><table><tr><td>Lighting</td><td>Other uses</td></tr><tr><td>3%</td><td>5%</td></tr><tr><td>6%</td><td>8%</td></tr></table></td></tr>
<tr><td>Power Factor Correction (pf)</td><td>>0.95</td></tr>
<tr><td>Total Harmonic Distortion</td><td>5% @ 400V and 4% @ 6.6,11 and 20KV.</td></tr>
<tr><td>Individual odd Harmonic Distortion (max)</td><td>4%@400V and 3% @ 6.6,11 and 20KV.</td></tr>
<tr><td>Individual even Harmonic Distortion (max)</td><td>1.6%@400V and 1.5% @ 6.6,11 and 20KV.</td></tr>
<tr><td>Earth impedance at earth electrode</td><td>< 1 ohm</td></tr>
</table>

B.1.3 Electricity Generating Plant

The private generation associated with the CHP system is for Base load support and has no allowance for exporting to the Grid. The system will not operate in island mode in the event of the imported Grid supply being totally lost.

Generating plant as standby generation must always be considered where essential services have been identified in a project proposal / brief.

Stand-by electrical generators must comply with BS 5514, as amended, and all designs parameters must be agreed with UCL Operations and Infrastructure Teams prior to completion of concept design Stage 3. The generator must comprise diesel/gas engines (UCL prefer diesel engines).

The system must be fully automatic and must function on a main fail basis. The main LV switchpanel must incorporate necessary mechanical and electrical interlock change over controls.

Consideration must be given to the location of fuel fill points and storage. Sufficient fuel storage to run the generator at full load for a period of minimum 18 hours must be provided. Fuel storage must be supplied with a meter, with capability for monitoring through the Building Management System. All fuel tanks must be within a bund area, capable of capturing the full capacity of the fuel storage tank. Run and standby (dual) fuel pumps are to be provided. Leak detection, together with double skinned pipework, to form part of the fuel delivery system.

The standby generator system must include appropriate weather proof acoustic enclosure (for external location), controls, silenced exhaust systems (max 75 dBA @ 1metre or to meet Planning Stipulations, whichever is less), electrical starting system and auxiliary power supplies.

Notwithstanding the financial boundaries, due consideration must be given to other means of achieving standby or alternative supply arrangement, and a cost projection plus life cycle cost analysis carried out and submitted to the Project manager for consideration.

For embedded private generation systems, proposed to work in parallel with the National Grid supply, these must conform to Engineering Recommendations P28, G98 and G99 for power quality and safety."

B.1.4 General Lighting Systems

Provide lighting that is suitable for the environment being served, anticipated tasks and any site constraints.

Fundamental Requirements:

- Design to meet recommendations outlined in CIBSE SLL Code for Lighting
- Equipment specified must be manufactured to current British Standards.
- Reliability and efficiency of operations is essential
- The systems must be flexible for alterations and development.
- All new general lighting systems (i.e. >20m^2 and 300-500 lux) shall be designed to achieve a maximum load of 7W/m^2.
- All new installations are to be automatically controlled for daylight and occupancy, as appropriate. Spaces with natural daylight must be provided with manual on/off switches and absence detectors.
- Where possible, consider including task lighting for specific lab activity as opposed to increasing lighting levels for the whole lab.
- In office spaces interface the lighting controls with the BMS where possible i.e. HVAC systems to be controlled by occupancy and using the lighting controls.
- In wellbeing and quiet contemplation spaces the lighting must be dimmable and possible to turn off.

Energy efficient designs are expected as a minimum, to be achieved by a dual approach in selecting efficient components and implementing efficient control measures.

B.1.5 Emergency Lighting Systems

Provide emergency lighting that is suitable for the environment being served, anticipated tasks and any site constraints.

Fundamental Requirements:

- Designed to BS 5266 and BS EN 62034 recommendations, as amended.
- Designed and installed by a BAFE accredited company.
- In accordance with UCL Standard Operating Procedure:
  Emergency Lighting Planned Preventative Maintenance document C015 found on UCL website.
- In accordance with UCL Fire Safety Technical Guide,
  TN 020 Emergency Lighting – UCL General Design Guidance. In accordance with UCL Fire Safety Technical Guide,
  TN 059 Specialist Fire Alarm / Emergency Lighting requirements for BSU's (where appropriate).
  Risk assessment to establish any specific requirements
- Luminaires are to be manufactured to BSEN 60598 Part 2.22, as amended.
- Maintained luminaire conversions in accordance with ICEL 1004 by ICEL registered companies
- Accessibility to luminaires must be considered particularly in relation to working height stipulations from the HSE.
- Emergency luminaire must be aesthetically pleasing with consistent symmetrical design layout that effectively illuminates the necessary areas.
- Emergency lighting system must be fully automatic for testing, monitoring and control.
- Designed to The Building Regulations 2010 'Access to and Use of Buildings, Approved Document M, Volume 1 (for Dwellings) and Volume 2 (Buildings Other Than Dwellings), as amended.

Specific Criteria	
Illumination levels on escape routes	1 lux minimum. Uniformity, Maximum to Minimum illuminance ratio to be 40:1.
Illumination levels on staircases	100 lux minimum at stair tread level. Uniformity, Maximum to Minimum illuminance ratio to be 40:1
Illumination levels open areas	1 lux minimum. Uniformity, Maximum to Minimum illuminance ratio to be 40:1
Illumination levels high risk areas	10% of General lighting Illuminance or Minimum 15 Lux, Uniformity <10:1
Illumination levels Lift Motor Rooms	10% of General lighting Illuminance or Minimum 15 Lux, Uniformity <10:1. With emergency Task Illumination directly at each winding
Duration of battery	3 hours minimum

B.1.6 Power Systems

- System design must be adequate plus allow 25% spare capacity
- System to be flexible to enable additions / omissions without major disruptions to others.
- Include measures to protect users and occupants from the possibilities of direct and indirect shock.
- Selected products to have proven reliability record.
- Proposed installation method to suit environmental requirements
- Where product selection and designs are stipulated as the responsibility of the contractor, stringent parameters must be detailed by the Building Services Designer to achieve best quality.

Containment systems associated with final circuit serving small power supplied must be suitable, durable and allowing future capacity for the proposed environment. Measures to mitigate EMF effects must be implemented in design with consideration of the proposed equipment to be installed.

B.1.7 Fire Alarms, Detection and Suppression Systems

- System must conform to BS 5839, as amended.
- Stipulation of Open Protocol system including panel software is essential. See UCL's Fire Safety Technical Guides
- Design must utilise products that must facilitate reliable operation and immunity to unwanted alarms.
- Implement UCL's general policy of protection of Life.
- Equipment manufacturers to be selected from approved list and registered with the Loss Prevention Certification board.
- UCL Fire Safety Technical Notes & Mandatory Instructions
- In accordance with UCL Fire Safety Technical Note,
  TN 059 Specialist Fire Alarm / Emergency Lighting requirements for BSU's (not available for download due to sensitive information, if this TN is required, please contact UCL Fire Team on E: fire@ucl.ac.uk).

The Building Services Designer must consult in with, Local councils, London Fire & Civil Defence Authority, UCL's Fire Safety Technical Guide, and liaise with user departments where applicable when developing the design and conducting the necessary risk assessment.

Fire risk assessment can also be required by UCL's property insurers as part of the strategy to safeguard valuable contents or parts of buildings. UCL's insurer's requirements must be obtained through the project manager.

In accordance with the Regulator Reform (Fire Safety) Order 2005, as amended, the complete fire safety strategy for the building must be considered by the Building Services Designer in all cases and all necessary works including such aspects as fire stopping and creating fire compartments must be allowed for. Where necessary works in this regard has been identified during the process of design, but is outside of the scope of the project remit, these must be brought to the attention of the UCL Fire Safety Team.

B.1.8 Mechanical Wiring

UCL's general policy is for the mechanical interconnecting and MCC wiring to be allowed for in mechanical engineering contract works. Primary electrical supplies to mechanical plant / equipment are to be part of the electrical engineering designs for installation by the electrical contractor.

The Mechanical Services Designer shall provide all relevant information in respect to loads, supplies and containment to the Building Services Designer, to allow the relevant elements to be included within the electrical design package. The Electrical Services Designer shall carry out due diligence on this information before inclusion.

B.1.9 Lightning Protection System

Lightning protection design must be in accordance with BS EN 62305, as amended, and incorporating all necessary bonding of exposed conductive parts and other systems as detailed therein.

The Building Services Designer is required to assess the necessity for lightning protection in relation to the surrounding and probability of lightning strike hitting the structure, with a bias towards safety at all times. Electronic Surge Protection (ESP) system must be provided as per the risk assessment.

Consideration to be given to the aesthetic impact, reaction to dissimilar metals and practicality of accessing testing points to be paramount in the application of design.

Where alteration to and existing system is proposed the suitable clamping and coupling accessories must be used and the system re-tested to confirm low impedance readings. Lightning protection system components to be in accordance with BS EN 50164, as amended.

Facilities for periodic testing and inspection must be allowed for the design.

B.1.10 Earthing Systems

Earthing and bonding of systems must be designed and installed to conform with the recommendation of BS 7671, BS 7430, BS EN 50310, all as amended, and electricity supply authority requirements.

All designs must employ as "best practice" segregation of sections of earthing system to achieve a "clean" and "dirty" system for electronic and motor loads respectively.

Allow for bonding all exposed conductive parts of the electrical installation and all such extraneous conductive parts associated with the structure as necessary.

The Building Services Designer shall assess any specialist earthing requirements that might be associated with research facilities and implement "Functional Earthing" in accordance with manufacturer's guidance and to the specific impedance levels.

B.2 GENERAL REQUIREMENTS

B.2.1 Decommissioning of Systems (applicable to existing buildings only)

The Building Services Designer must include specific clauses in the relevant sections of their specifications and if possible indicate on drawing decommissioning necessary for the following services.

- Fire Alarms and Detection Systems
- Emergency Lighting Systems
- UCL's Energy / Power monitoring Networked meters system
- Security Systems

The Building Services Designer must ensure that UCL has the opportunity to retain any redundant equipment (for use elsewhere) prior to decommissioning and provide relevant information to UCL Project Officer for inclusion within the CH3 Form.

The design needs to carefully consider any alterations that impact building infrastructure systems and adjacent areas. Design needs to carefully consider any controls affected by the works.

Fire Alarms and Detection Systems

These must be decommissioned by UCL's termed Maintenance contractor for Fire Alarms systems. As outlined in UCL's Fire Safety Technical Guides decommissioning must involve the conversion of the system to construction site requirements by replacing smoke detectors with heat detectors where these exist. Whilst liaising with UCL's Fire Safety Team, the Building Services Designer must conduct discussions on decommissioning works.

The replacement of smoke detector with heat detectors is only considered part of the requirement necessary for mitigating the possibilities of false alarms due to construction site pollutants whilst providing some fire coverage to the site area. Methods of restricting such pollutants from circulating to other parts of a building still in occupation must be addressed at design stage with the Electrical Design Engineer taking the lead on raising this at design meetings.

The existing system may be recommissioned as part of the refurbished space, or removed dependent on the final scheme design. If a new system is to be provided full removal of the decommissioned system shall be carried out.

Emergency Lighting Systems

Existing addressable Emergency systems must be decommissioned by UCL's termed Maintenance contactors employed under the contract works.

Where existing central battery systems exist, critical elements such as the cabling and battery system must not be decommissioned in an occupied building until replacement systems or alternative connection measures are in place.

For self contained emergency luminaires with traditional local controlled test key switches no special allowance for decommissioning required.

For self contained emergency luminaries complete with addressable testing modules and connected to a central addressable emergency panel, decommissioning must be carried out by the manufacturer or any termed contractor managing the system.

The Building Services Designer must familiarise themselves with existing systems and incorporate clause(s) within the specification for the decommissioning works ensuring this does not compromise coverage for the occupied areas outside of the contract site.

UCL's Energy Monitoring Networked (EMON) meters system

As a dual function of meeting Building Regulation part L and enabling better power / energy management at UCL, intelligent electricity, heat, gas and water check meters are installed linked back to a head-end server managed by Operations and Infrastructure Teams and or the BMS system, via a VLAN data network.

Decommissioning of any part of this network must be discussed and agreed with UCL's Principal Electrical Engineer and UCL's Energy Management Team at design stage.

NO PART OF THIS SYSTEM MUST BE DISCONNECTED, ALTERED, ADAPTED OR REMOVED WITHOUT APPROVAL FROM THE PRINCIPAL ELECTRICAL ENGINEER AND UCL'S ENERGY MANAGEMENT TEAM

Equipment becoming available as result of a decommissioning exercise must be offered back to the UCL Operations and Infrastructure Teams for taking back into storage in the first instance, where a decision will be made on the course of action.

The Building Services Designer must ensure the requirement to completely strip out and remove from site all redundant equipment and wiring, or where this is not possible, clearly define the extent of removal required. The Building Services Designer will also be responsible for verifying this has been carried out by the contractor in a safe manner, and to UCL's satisfaction.

Waste Disposal

The Contract documents must stipulate that contractors must comply with the Site Waste Management Plan (SWMP) Regulations 2008. They will be required to keep this up-to-date and provide detailed breakdown of tonnage disposal of all waste from site and the percentage that has been recycled/re-used. In particular WEEE Directive recycling must be applied as much as possible.

B.2.2 HV Systems

Close liaison with the supply Authority is important to determining the correct equipment and design configuration of any works associated with HV systems.

In the absence of specific requirements, the following guidelines must be implemented as best practice designs:

- Selected products must be suitable for the intended use and environmental conditions likely to be encountered.
- Substations to be a conventional brick structure or Glass Reinforced Plastic housing, depending on the location, as detailed in UKPN Energy's "Building Standard for Secondary Substations and Switchrooms"

- Internal dimensions and ventilation allowances must be sufficient for effective ambient temperature control within the substation, without the need for forced ventilation.
- Transformers must be as energy efficient as available.
- The option of Cast resin Transformers must be investigated as an alternative to standard Oil type transformers where these are a practical alternative due to weight and other factors.
- “Right of access” is required for all equipment and cabling associated with the supply authorities HV supply, and as such this must be allowed within any design.
- Levels of Electromagnet Interference are to be within the guidelines dictated by the National Radiological Board now covered under the Health Protection Agency.

B.2.3 Electrical Substations

To be designed in accordance with the guidance issued by Distribution Network Operator (DNO).

UK Power Networks
Metropolitan House
Darks Lane
Potters Bar
EN6 1AG

Or any other such Operator.

All UCL managed substations to be designed to DNO standards.

B.2.4 LV Switchgear

All switchgear shall be specified for Low Voltage installation to comply with all relevant standards.

The switchgear shall be designed to maximise the circulation of air for natural ventilation, measures must be taken to minimise possible contamination and ingress of dust, particles, damp and vermin. Hence the IP rating must be specified in relation to the environmental conditions likely to prevail.

Switchboards/switchpanels are to be ASTA BEAB or KEMA tested and certified with regards to the protective devices and systems employed.

Instrumentation shall be in accordance with ISO/IEC Guide 51, as amended, with controls conforming to BS EN 60947-4-1 and BS 6231, as amended.

All switchboards, control panels, Motor Control Centres, etc, shall be designed / specified as modularised, with all the necessary interconnections, switches on busbars, cables, connectors, such that their removal from the installation can be carried out with minimal disruption and continued operation of the installation, where safe to do so. All panels must conform to Form 4, with the classification of A/B and Type 1 – 7 to be agreed with the Principal Electrical Engineer.

All switchboard must be provided with minimum 25% spare capacity for future expansion. This will include a combination of a spare breaker, compartments for devices and energy

metering connections with all relevant internal wiring. Refer to circuit charts for further information.

The switchboard shall be complete a earthing facility to allow connection of new and existing supplies in accordance with BS 7671, as amended.

All switchboards shall be constructed as a minimum to Form 4 Type 2 or 6 with minimum short circuit rating of 50KA for 1 second, unless otherwise specified (to be determined by the UCL Principal Electrical Engineer) and supplied by one of the following preferred manufacturers:

1) AF. Switchgear Ltd.
2) Carville Switchgear Ltd.
3) Schneider Electric Ltd.
4) UEP Switchgear Ltd.
5) Prism Power Group Ltd.

All internal components shall be manufactured from the Schneider Electric range.

Existing buildings: Where modular switchboard options are not suitable, bespoke solutions must be designed particularly where space limitations and access complexities dictates.

New Buildings: Standard or bespoke switchboard solutions are acceptable as long as the full operational and safety criteria are met. The Building Services Designer however must ensure that sufficient space is allowed by the Architect to facilitate effective equipment operation and maintenance. Ventilation must be free air assisted by the overall volume and structural design of switchrooms.

To assist meeting the requirements of Building regulations Approved Document L2A & B, facilities to provide metering must be incorporated within the switchboard design as necessary. In addition, all other outgoing ways must be equipped with CT's, "CT shorts" and voltage connection points to enable the installation of future meters as and when necessary. Meters, associated equipment and wiring must be in accordance with UCL's requirements as detailed in UCL's Metering Specification.

Alternatively switchgear utilising the Schneider NSX MCCB breakers, incorporating onboard metering function, must have network cabling connected to all outgoing cubicle compartments including spare cubicles.

If requested by the Principal Electrical Engineer phase failure relays are to be included within the panel design. As panel requirements and location limitations will define the final panel design/layout, size and quantity of spare cubicles (and location) to be agreed with the Principal Electrical Engineer.

Switchboard requirement:

Paint finish / Casework	- powder coated finish.
Fire Systems supplies Cubicles	- door(s) colour Poppy Red
Factory Plinth	- As Panel Colour or Black
Fault Level Withstand	- 50kA for 1 sec (unless otherwise specified).
Integrity	- BS EN 60529 IP31 (minimum) , as amended.
Form of Separation	- BS EN 60439-1, as amended, Form 4 type 2 or 6
Construction	
Body	- 2mm (minimum) Zintec mild steel

Doors / Covers	- 5mm (minimum) Zintec mild Steel
Glandplates	- 4mm Aluminium
Access	- Front and Rear
Cable Entry	- Top and / or Bottom

Components:

ACBs	- Schneider
MCCBs	- Schneider
Multimeters	– Schneider ION meters (commissioned by Schneider)
TSS	- Furse or similar
C/Ts	- Rayleigh / Crompton or (as approved by meter supplier)
	- Power Factor Correction - Eaton JSP or as Panel Manufacturer
Ref C/T	- Moriarty or similar

Estimated weight to be suitable for floor construction.
Busbar Phase Identification In Brown (L1), Black (L2) Grey (L3) and Blue (N)(Neutral)
Neutral conductors – Full size or Double Neutral as harmonic assessment requires
Insulation of Live Parts – By Barriers or Enclosure
Busbar Size– To a capacity of at least 20% greater than Design Current
Busbar Supports – sufficient regularity to eliminate mains humming.
Type Tests – The following Certificates are required
Temperature rise limits
Dielectric properties
Short-circuit strength
Continuity of protective circuit
Clearance and creepage distance
Mechanical operation
Degree of protection
Short circuit withstand strength
Factory and on site test to be witnessed by the Building Services Designer and UCL Operations and Infrastructure Teams and offer made to the UCL Project Officer for a UCL representative to be present.

Current Transformers must be installed to meter manufacturer's recommendations on all incoming and outgoing ways wired to suitable terminal units with CT short links mounted on DIN rail, for both meters specified as part of the panel manufacture as well as for future additional meters.

Where necessary CT's must be installed on Neutral bars to afford full Power quality monitoring functionality of meters that so requires this.

Electricity meters (EMON) must be in accordance with UCL meter specification for UCL networked meters. Allowance must be made for the commissioning of the meter systems, constituting of a factory inspection and an on-site commissioning carried out by Schneider Electric. Meter types and network arrangement to be approved by UCL Operations and Infrastructure Teams. Panel must allow for the connection of the meters network back to UCL's VLAN intranet via RJ45 port and without the risk of exposure to live conductive parts after final install. The full commissioning of system must include the works required on the head-end Server.

Alternative supply terminal connections must be included in switchpanel design, down stream of the supply authority's electricity meter position and including means of isolation to

facilitate termination of generator or other secondary source. Controls for bringing this online must be through Castell interlocks (mechanically) and changeover switches.

Panels must be designed to enable, in as far as possible, the ability to conduct thermal imaging surveys.

A brief thermal image survey report must be carried out as part of the final submission once system is in operation with end user loads established.

Discrimination Requirements by Device Type

Device Type	Breaking capacity	Number of Poles	Comments
ACB (630 – 6300A)	50kA	4	Discrimination calc's and settings by Building Services Designer
MCCB (63 – 630A)	18kA min	3 & 4	Discrimination calc's and settings by Building Services Designer
MCB (6 – 100A)	10kA min	1, 2, & 3	Discrimination calculations by Building Services Designer
Fuse (6 – 630A)	As fuse rating	N/A	Discrimination calculations by Building Services Designer

The Building Services Designer must ensure devices selected are sufficient to withstand a potential short circuit fault at the points of implementation.

Outgoing protective devices must be plug-in type where this is possible. All outgoing circuit must be labelled as described in section B.2.33

B.2.5 Residual Current Devices and Arc Protection

All circuits shall be fitted with RCD protection in accordance with BS7671, as amended, but for the exception of circuits with loads or other equipment likely to cause unwanted tripping due to high earth leakage currents generated as part of their normal operation. Fridges, freezers and computers must be considered as such loads / equipment.

There is an exception to omit RCD protection where, other than for a dwelling, a documented risk assessment determines that RCD protection is not necessary. Therefore, the Building Services Designer must carry out a risk assessment to document the rationale to excluded circuits from RCD protection.

Permanent labels must be provided to the socket outlets which are not protected by RCD.

The RCD device must generally be incorporated within distribution boards as RCBO units or alternatively fitted local to the area being served, if the nature of use means tripping is likely, and resetting of devices can be managed by technical staff within the client department.

"S" – selective devices must be employed only where this is required to provide discrimination with another RCD device downstream.

The Building Services Designer must be responsible for ensuring at all times the ADS (automatic disconnection of supply) times are achieved in accordance with the BS 7671 wiring regulations, as amended, whilst employing RCBO and MCB/RCD systems.

Arc fault detection devices conforming to BS EN 62606, as amended, are recommended as a means of providing additional protection against fire caused by arc faults in AC final circuits. AFDDs shall comply with BS EN 62606, as amended. Coordination of AFDDs with overcurrent protective devices, if necessary, shall take account of the manufacturer's instructions. The use of such devices must be considered by the Building Services Designer.

B.2.6 Fuses and Disconnecting Links

All fuse links must be high breaking capacity conforming to BS 88, as amended, unless otherwise specified.

Fuse bridges and boxes must be of glazed porcelain/thermoplastic or other approved non-hygroscopic insulant construction. Disconnecting links being of hard-drawn high conductivity copper

B.2.7 Distribution Boards

All distribution boards shall be selected and designed to meet the following requirements:

Full compliance with BS EN IEC 61439-3, as amended.

The boards shall be meter ready where applicable and where used to serve lighting and power have split meters. Mechanical services are to be served from a separate board and supply.

Any outgoing way must have the capability to be converted to switch the neutral.

Boards are to be fully type tested conditional short circuit rating of 25kA to BS EN 61439-3, as amended.

High performance MCB 10kA BS EN 60898 15kA BS EN 60947-2 in B, C or D curve 1, 2, 3, 4 pole, BSs as amended.

Fitted with a minimum 125A busbar rating

Disconnection to BS EN 60947-3, as amended, ensuring unused outgoing ways are isolated

Option of switching outgoing neutral on all boards using distributed neutral kit

Terminal block for feeding up to 125A.

Have the facility to use a range of incomers: switch disconnectors, residual current devices, terminal blocks, MCCB

Full IP2X shrouding

Have a range of knockouts for cable gland and conduits.

Removable insulated pan assembly

Fully shrouded neutral and split neutral bars

Removable gland plates
Optional metering, dual supply and contactor on incoming

All distribution boards shall be generally as surface mounted units or where proposed as flush mounted, designed with adequate and suitable access for maintenance and rewiring.

All distribution boards must be provided with a means of being locked. This can be in the form of a key, or specialist tool..

Allowance shall be made for additional earth bar to be fitted in all boards to facilitate meeting the earthing requirements of BS 7671, as amended, and / or any clean earth connections necessary. Electronic Surge protection Device must be provided where necessary.

The neutral and earth bars must have provision for the same number of conductors as outgoing ways and corresponding labelling. i.e. connections to the earth and neutral bar is to be made in such a way that they correspond to the relevant phase.

Fuse boards must be complete with cartridge fuse links of the correct rating.

When selecting such equipment the Building Services Designer must obtain confirmation from manufacturers of their policy to support these products for a minimum of 10 years.

All necessary barriers to be fitted to enable safe working and prevent the possibility of direct contact.

UCL's preferred manufacturer for distribution board and fuse board is currently:

- Schneider Electric

B.2.8 Busbar Systems

All busbars shall be selected and meet the following requirements:

The busbar trunking system shall comply with IEC61439 1&6, be of low impedance and air insulated typed technology (available as feeder or plug-in). Non-flame propagation IEC60332-3, Material Resistance IEC60695-2, in case of fire the busbar system shall not release toxic gases.

Test Reports/Certificates by a recognised independent test laboratory (such as ASTA Certificate Services, ASEFA, KEMA) shall be available upon request. All components are halogen free.

Be constructed of galvanised sheet steel outer casing, which shall serve as an additional earth conductor when bonded to the protection earth conductor (PE is equal to 50%).

IP rating shall be IP55 to IEC60529.

IK08 Impact resistance (IK) shall be as define in standard IEC62262.

Live conductors shall be of hard drawn 99% purity [Aluminium/ Copper]. Conductors shall be supported on fibreglass reinforced polyester isolators. Conductors equipped with silver-plated aluminium/copper bi-metal contacts, electrically welded to junctions and tap off positions.

Neutral conductor to be (minimum) full size as phase conductor, and where significant harmonics is likely to be generated on the system double size neutrals to be allowed.

There shall be a mechanical and electrical joining system that ensures automatic and simultaneous joining of all live conductors and the continuity of the protective earth conductor, as well as it's connection with the casing. The joint unit also absorbs the difference in conductor and casing thermal expansion for each length.

Rated current at 35 degrees C (Inc) for standard circuit operation.

Rated Voltage (Ui) 500V Operating frequency - 50/60Hz 100-1000A (lower rating subject to approval)

Tap-off outlets shall be connected to the isolators to form a block, holding the bars. They shall have a shuttered outlet which is opened and closed automatically when tap-off units are plugged in or removed.

Tap-off outlets are spaced at 0.5 to 1 metre and available on both sides. Protection level of the tap off outlet shall be at least IP55 by construction.

To an end or centre feed unit; equipped with terminals made of tinned aluminium, this type of feed unit is designed for connection to copper or aluminium cables equipped with the necessary lugs. The feed unit is also equipped with an aluminium gland plate.

Must be manufactured from solid drawn or laminated copper representing the 3 phase, neutral supply and earth to comply with BS EN 60439-2, as amended.

Tap-off busbar systems live copper conductors must be fully enclosed and suitable rated for the prospected earth fault associated with that part of the system, assessing the following conditions:

1) Short-time withstand rating
2) Peak current withstand rating
3) Conditional short-circuit rating when protected by a short-circuit protective device.

UCL's requires standard busbar systems where new is being specified.

The Building Services Designer must be reminded of the need to assess volt drop on busbar systems, obtaining resistance and impedance values from the manufacturer as necessary.

B.2.9 Uninterruptable Power Supply units

UPS must only be installed where an uninterruptable power supply is absolutely essential. Specification of UPSs must be agreed with UCL's Principal Electrical Engineer. This must be approved by UCL's Environmental Sustainability team prior to design commencement.

System to comply with BS EN 50091-1, BS EN 50091-2, BS EN 62040-1 and BS EN 62040-3, as amended.

Static and Rotary UPS installation must be assessed on the merits for the installation proposed.

The UPS must be designed to operate continuously at an ambient temperature of 40°C, to guarantee outstanding reliability and allow continuity of load protection even in the event of air conditioning failures. Rotary type UPS units will need special consideration where higher ambient temperatures are more likely to occur for longer periods. Battery cooling can be considered, but must be agreed with the Principal Electrical Engineer.

The noise level must not exceed 57db at a load of 70%. The fans must have their speed of revolution indexed to the load level. Access may only be from the front, and connection may be made from the bottom.

The UPS must be anti-seismic, in accordance with the International Building Code BC2012 et CBC2013 at the SDS level = 2 g.

Essential requirements:

- EMC Suppression to IEC 1000 limits.
- Output voltages 380V – 415V, 3 phase at 50 HZ
- Frequency tolerance +1 %
- Power factor correction (min) 0.9
- Incorporation of full bypass system to enable extensive maintenance.
- Remote monitoring must be available as an option.
- UPS must be on-line device with 12 pulse rectifier as a minimum standard, but needs to be confirmed with the UCL Operations and Infrastructure Teams during design stage.

The battery charging voltage must be compensated according to the temperature variations. Battery charging time must be in accordance with the IEEE 485 standard. The battery must be protected by a circuit-breaker. The UPS must operate with lithium batteries as the preferred option.

The subassemblies of the inverter and the battery must be accessible. The inverter must be equipped with an automatic test function to verify the correct operation of the system and to identify the subsystem requiring repair in the event of a failure. The inverter must be serviceable by simply replacing a standard subassembly, without the need for adjustment. The UPS through a communication card can be connected with a remote maintenance system must be possible.

For maintenance purposes, the UPS system shall include an external, mechanical, manual bypass system with one-button operation, common to all Parallel Units UPS. For personnel safety during servicing or testing, this system shall be designed to isolate the UPS system while continuing to supply power to the load from the bypass AC source. The UPS shall also include a device making it possible to isolate the rectifier and the charger of each Parallel Unit UPS from the normal AC source.

There is a requirement for the use of synchronisation units where multiple UPS's are required or a UPS is required to work in conjunction with generator sets.

In relation to battery technology, an assessment must be undertaken to ensure the most efficient products are specified.

UCL's preferred supplier of UPS can be found within the Appendices.

B.2.10 Transient Voltage Surge Suppression

Consideration must be given to the likelihood and extent of electronic noise and their effects on the electrical system as an incumbent part of achieving an EMC compatible system.

The Building Services Designer must consider the full building application of suppression systems where full rewiring of an existing buildings infrastructure is proposed or on new building projects.

Transient Surge Suppression must be considered when designing electrical systems. TVSS devices shall be fitted at appropriate points of the installation. If not used a documented risk assessment must be compiled.

B.2.11 Harmonic Conditioners

Measures to mitigate the effects of harmonic currents shall be implemented particularly in buildings employing large amounts of harmonic generating loads whilst conducting business critical operations.

B.2.12 Power Factor Correction Units

Power factor correction units shall be considered on all supplies. Power Factor units must be suitably sized and automatically switched in banks to ensure a minimum building power factor of 0.97 with all the services operational.

B.2.13 Electricity Metering

Utility metering

Electricity Utility supply meters (HV/LV) shall be installed to the specification of the metering company.

The Building Services Designer must make all the necessary arrangements with the respective meter providers for any installation requiring a new connection from the supply authority.

Allowance must also be made for a telephone line and CAT box, to be installed for remote monitoring of this system, to the particular stipulation of the metering company, and UCL's energy section respectively.

Incoming meters

All incoming meters must have the facility to measure energy usage and power quality. The meters must have the following features:

- an accuracy of at 0.2%
- Manufacture standard to IEC61000-430
- Ethernet port for LAN connection

Critical supplies metering

All critical supplies meters must have the facility to measure energy usage and power quality. The meters must have the following features:

- an accuracy of at 0.2%
- Manufacture standard to IEC61000-430
- Ethernet port for LAN connection

Feeders/sub metering

All critical supplies meters must have the facility to measure energy usage and power quality. The meters must have the following features:

- an accuracy of at 0.5%
- Manufacture standard to IEC61000-430
- Ethernet port for LAN connection

It is preferential to meter lighting, small power and mechanical services separately. At the design stage 1 a comprehensive meter strategy must be provided by the Building Services Designer and approved by UCL Energy Management Team.

Information on any existing metering system can be obtained from the UCL Operations and Infrastructure Teams.

In meeting the requirements of Building Regulations UCL is progressively installing check meters on their EMON (monitoring system) that are networked to provide power quality and energy consumption information. The Building Services Designer must contact the UCL Operations and Infrastructure Teams for detailed information on these meters and this system.

The full specification of this system must be included in designs where check metering is to be installed. Allowance must be made for commissioning of these meters to be carried out by Schneider Electric, Digital Energy Division.

Please also refer to UCL's Metering Strategy and Metering Specification.

B.2.14 Earthing Systems

The design must ensure a fully functional earthing system is provided for any new or altered installation. The earthing system shall be designed and installed in accordance with BS7671, as amended.

Circuit Protective Earthing:

In accordance with BS 7671, as amended, providing where necessary a low ohmic impedance earth rod and full bonding of potential extraneous conductive materials and structure.

Protective Bonding Earthing:

In accordance with BS 7671, as amended, providing where necessary a low ohmic impedance earth rod and full bonding of potential extraneous conductive materials and structure.

Lightning Protection Earthing:

In accordance with BS EN 62305, as amended, providing protection of occupants, prevention of direct damage and fire, flashover or explosion due to direct lightning strike. System to also aid the dissipation of short circuit currents.

Equipment protection and functionality Earthing:

In accordance with BS 7671, BS EN 61000, BS EN 50310, all as amended, and equipment manufacturers recommendations. Earthing system must protect electronics by providing a low impedance path to interconnect equipment. Proper cable routing, zoning and shielding are important aspects of the design and have a significant purpose in preventing possible disturbance from electromagnetic and radio frequency interference.

Expert advice on earthing solutions to be obtained where necessary.

B.2.15 Small Power Services

Accessories for small power services must be to BS 1363, BS 8300 (for colour contrast), as amended and all other relevant standards. Finish for wiring accessories must be as specified by Building Services Designer and approved by UCL and the Architect where applicable.

Wiring of small power systems as ring and radial are to be specified with suitably sized cables whilst allowing for containment systems to maintain the physical and magnetic integrity of the circuits. RCD's protection as stipulated elsewhere.

For a final circuit with a number of socket-outlets or connection units intended to supply two or more items of equipment, where it is known or reasonably to be expected that the total protective conductor current in normal service will exceed 10 mA, the circuit shall be provided with a high integrity protective conductor connection complying with the requirements of Regulation 543.7.1. The following arrangements of the final circuit are acceptable:

Cleaners sockets must be provided at every 15 metre interval, or within each door zone, for cleaning purpose and clearly labelled 'Cleaners'. All outlets to be provided with DB circuit reference labels.

Double power socket to be installed in cleaner's cupboard to facilitate the charging of battery powered equipment such as vacuum cleaners, glass partition cleaners and robot floor vacuums.

The Building Services Designer is required to select items of equipment suitable for the environment and purposed usage or outline stringent stipulations where the selection of equipment is included as part of the contractor responsibility.

Circuit protection devices shall be new unless otherwise stipulated with full discrimination calculations carried out and where cascading protection has been designed in, settings associated with adjustable devices to be clearly stated.

Variable speed motor drives for HVAC equipment's must be installed, where possible adjacent to the motor which it controls. Where this is not possible consideration must be given to the EMC screening of the wiring and isolator.

Where this is specified or deemed necessary, allow for EMI &RF filtering as close to the point of connection for equipment to be protected.

Alternative power supplies in the form of battery back-up, UPS's, standby Generators, or alternative source from a different substation or H.V. ring to be given full consideration as design warrants.

Additionally the Building Services Designer must assess the possibilities for using smaller UPS units, which would be installed as client managed items, local to the equipment or system being served. Where necessary Building Services Designer must advise on the benefits of such as system to users work process for the UCL Operations and Infrastructure Teams and the UCL Project Officer to make and informed decision at design stage.

All circuits, both sub-mains and final, must be complete with separate CPC.

For further inclusivity requirements please refer to Section A.25 of this document.

B.2.16 Wiring Containment

All wiring systems must be of an approved manufacturer, continuous and provide sufficient support, spare capacity, screening and earthing where necessary.

Approved systems:

1) Metallic conduit
2) Metallic trunking
3) Cable trays
4) Cable baskets
5) Ladder systems

UCL preference is metal containment systems which are more durable, can be used as an earth path and provides better screening properties if installed correctly. **Under no circumstances must cables be allowed to rest on any suspended ceiling grid/tiles.**

With the exception of conduits, containment systems shall be selected to provide 25% spare capacity for future use.

All surface run containment must be fixed to the ceiling/wall using appropriate clips/ support at every 300mm interval or as recommend by the manufacture.

Flat-sheathed fixed mains cable, containing two insulated current-carrying conductors and a smaller earth conductor. "Twin and earth" type cable is not acceptable for UCL installations. All containment systems must be fire stopped internally/externally when passing through fire compartments.

B.2.17 Cable Types & Colours

Apart from the colour outlined in Table 51 of BS 7671, as amended, the following colour assignments must apply to all installations.

All cables sheath must be Low Smoke Zero Halogen (LS0H) and must be BASEC approved and this must be clearly identified on the cable drums.

System	Cable type	Colour
Voice & Data	UTP structured Cat 5e – 6	Cat 5e: Orange (old grey) Cat 6: Purple
Voice PSTN	BT spec cable	White
Addressable Emergency lighting comms network	Screened or Unscreened Twisted pair Belden	Green
Lighting control bus	To system manufacturers specification	Red and white
Fire Alarms systems	Pirelli FP 200Gold, FP200 Plus, Pyrotenax MICC	Red
Fire Communication (for critical data communications)	Pyrotenax Pyro TwistE	Red
Induction loop cable	As Specialist Spec.	Blue

B.2.18 Interior Lighting Levels and Zoning

All luminaires selected and intended to be used at UCL shall be manufactured to BS EN 60598, as amended, and meet all EMC, CE and ENEC requirements.

The Building Services Designer is required to accurately assess each area requiring new lighting to determine the use and parameters. The Building Services Designer is encouraged to follow the requirements of CIBSE Code for lighting and any subsequent guides for the design of lighting.

Designs must also conform as far as they are applicable to the following Guidance and Limitations:

1) Building Regulations
2) BRE (BREEAM)
3) BS EN 12464-1, as amended.
4) The Equality Act
5) HSE Lighting at Work
6) SKA
7) WELL Building Standard

The Building Services Designer must be aware of imminent industrial changes to the recommendations and standards and where prudent allow for such changes within their design. Where possible task lighting to be considered as an option and lighting strategy to be agreed with the UCL engineer during the design stage.

Building Services Designers are also encourage to think carefully about human centric lighting installations and the use of tuneable white luminaires where considered beneficial. This is to be discussed with UCL during the design stage.

Appropriate maintenance factors as recommended by CIBSE will be considered for the lighting calculation. Illuminance levels to be checked after initial source lumen in accordance with CIBSE/SLL recommendation.

Internal lighting in all relevant areas of the building shall be designed to provide illuminance (lux) levels and colouring rendering index in accordance with the SLL Code for Lighting 2012 and any other relevant industry standard. Internal lighting must be appropriate to the tasks undertaken, accounting for building user concentration and comfort levels.

For areas where computer screens are regularly used, the lighting design must comply with CIBSE Lighting Guide 7 sections 2.4, 2.13 to 2.15, 2.20, and 6.10 to 6.20.

Room / Area / Facility	Lux (Avg)	Colour Rendering	Notes
Entrance Halls & Circulating areas	200	Ra 70-90	Aesthetic general lighting must be complemented with feature lighting where possible.
Reception Desk	500	Ra 80-89	Localised / Directional lighting
Rest Room	150	Ra 70-80	Wall lights to be considered in addition to ceiling system where possible.
Toilets	150	Ra 70-80	Wall lights to be considered in addition to ceiling system where possible.
Disabled Toilets	250	Ra 70-80	Apply best practice for DDA environment.
Kitchens	500	Ra 80-89	Recommended figure is general illuminance. Task lighting to be allowed where necessary
Refectory / Canteens	300	Ra 60-79	General Array lighting unless otherwise specified.
Plantrooms	200	Ra 60-69	Luminaire to be positioned to suit equipment layout and to best illuminate areas where maintenance will be carried out.
Electrical Switchrooms	250	Ra 60-79	Luminaire to be positioned to suit equipment layout and to best illuminate areas where maintenance will be carried out.
Office areas	400	Ra 80-89	Recommended illuminance to be achieved by general lighting array. Output regulating ballast to be used where possible for flexibility and energy efficiency. User must be capable of adjusting lighting level from user interface control in addition to the ON
Computer Cluster rooms	300	Ra 80-89	To the recommendations of LG3, implementing Intelligent lighting control monitoring occupancy.
Library Areas	300-400	Ra >90	Good vertical illumination required. Work planes must be vertical for book rack areas and horizontal for write-up spaces. Precise lighting control required where energy saving lighting control measures are incorporated.

Room / Area / Facility	Lux (Avg)	Colour Rendering	Notes
Laboratories	500	Ra >90	Regulating ballasts to be considered where these will not affect working conditions. Occupancy and daylight sensors to be employed for energy efficiency.
Workshops	500	Ra >90	Manual control but with presence control on lights over corridor or walkway areas where possible.

B.2.19 Exterior Lighting

All foot paths, walkways communal areas, car parks, access roads and external plant areas associated with new or existing installations must be provided with adequate exterior lighting to meet all applicable local authority and building control requirements.

Switching for exterior luminaire must be in groups utilising a common photocell and/or time clock or photocell on BMS and/or time clock and must incorporate an override facility for maintenance purpose. All exterior lighting schemes must utilise low energy long life lamps to minimise operating and maintenance cost over the full projected life cycle of the installation.

All exterior lighting schemes must utilise low energy long life LEDs to minimise operating and maintenance cost over the full projected life cycle of the installation. Average luminous efficacy must not be less than 70 luminaire lumens per circuit unless otherwise agreed.

All external lighting must be specified in accordance with the following:

- BS 5489-1 Code for the practice for the design of road lighting. Lighting of roads and public amenity areas, as amended.
- BS EN 12464-2 Light and lighting - Lighting of workplaces - Part 2: Outdoor work places, as amended.
- BS8300-1, as amended.

External lighting shall provide illuminance levels that enable users to perform outdoor visual tasks efficiently and accurately, especially during the night.

BREEAM requirements for minimising light pollution must be followed:

- The external lighting strategy has been designed in compliance with Table 2 (and its accompanying notes) of the Institution of Lighting Professionals (ILP) Guidance notes for the reduction of obtrusive light, 2011
- All external lighting (except for safety and security lighting) can be automatically switched off between 23:00 and 07:00.
- If safety or security lighting is provided and will be used between 23:00 and 07:00, this part of the lighting system complies with the lower levels of lighting recommended during these hours in Table 2 of the ILP guidance notes.
- Illuminated advertisements are designed in compliance with ILP PLG05 The Brightness of Illuminated Advertisements

Illuminance must be to those recommended in the CIBSE lighting code where not otherwise stated below:

Room / Area / Facility	Lux (Avg)	Colour Rendering	Notes
Plantrooms	200	Ra 60-69	Luminaire to be positioned to suit equipment layout and to best illuminate areas where maintenance will be carried out.
Electrical Switchrooms	250	Ra 60-79	Luminaire to be positioned to suit equipment layout and to best illuminate areas where maintenance will be carried out.
Workshops	500	Ra >90	Manual control but with presence control on lights over corridor or walkway areas where possible.
External Path ways	20	Ra >90	Photocell/Time clock control
Car Parks - External	30	Ra >90	Photocell/Time clock control
Car Parks - Underground	100	Ra >90	Photocell/Time clock control
External ramps and stairs adjacent to building entrances and exits	100 min		

Lighting designs must target to achieve a maximum of 6W/m^2 for normal internal general lighting.

Lighting solutions must ensure that illumination is considered not just on the horizontal working plain but also effective vertical illumination of the space and ensuring uniformity utilising spacing to height ratio figures provided by manufacturers.

Sample luminaires must be required by project team for inspection before final approval of any manufacturer's product.

LED Luminaires

UCL encourages the implementation of LED products as a default. It is recognised however that there are a vast of inferior quality products in the market and as such the Building Services Designer must source products from the list of lighting manufacturers provided in the Preferred Manufacturers List (Appendix B). Where a suitable product is not possible from these manufactures alternative proposals will need to be approved by Operations and Infrastructure Teams prior to being committed to the design.

The Building Services Designer must be required to satisfy his/herself with the "binning" approach of the manufacturer, and their approach to future replacements, will provide considering consistent colour rendering of same specification products.

The Building Services Designer is required to carry out necessary lighting design calculations, obtaining photometric data from manufacturers as necessary. The low energy consumption properties of LED products makes them an attractive option; but the Building Services Designer must ensure the products selected are practical, robust, easily replaceable and achieves the light levels required. Allowance must always be made for the possibility of premature failure of these products, ensuring access and a maintainable solution is part of the design.

The LEDs must have a life of no less than 50,000 hours and not lose any more than 70 % of their lumen output after a period of 3 years.

LED lighting products must be considered for external lighting proposals.

For maintenance factor assessment the Building Services Designer must apply a 3 year duration between luminaire cleaning.

B.2.20 LED Colour Temperature Guide

Lamps/LED's must in the first instant afford suitable lumens output, efficient energy consumption and maximum life expectancy.

In the absence of specific requirements in the project brief the following must apply.

Areas	**Colour Temp**
Corridors General circulating & Toilets Plantroom	4000 k (white)
Offices Write-up areas Computer Cluster Rooms	4000 k (White)
Laboratories Workshops Libraries	4000 k (White)
Where specified & BSU	6000k (Daylight)

Areas outside the scope of the above table to be confirmed with the Principal Electrical Engineer.

B.2.21 Lamps and Ballast preference

LED luminaire light engine and control gear must be high output, high efficiency LED chipset optimised for the application and must include dimming options using a DALI or DSI protocol.

LEDs must have a L value of not less than L70

LEDs must have a B value of between B10-50.

LEDs must have a maximum McAdam step of 3.

For linear fluorescent luminaires where possible T5 lamps must be specified with Multi-Watt control Ballast. UCL's preferred ballast manufacturer is Tridonic whose units affords flexibility of control systems possible.

Digital dimmable ballasts, such as Tridonic Excel (one for all), must be implemented where possible, and where integrated with automated control systems offers energy efficiency control and flexibility to adjust light levels.

Compact fluorescent luminaires preferences:

- TCL, circular T5 lamps
- Opal or Polycarbonate diffuser
- Good flashing.
- Where more than one TCL lamp is used failure of one must not compromise operation of the other.
- Multi-Watt ballast where possible.
- Low Voltage halogen spot lights must be avoided where possible due to their high maintenance.

B.2.22 Lighting Control Systems

Control of lighting must enable user interface as well as provide energy conservation in relation to daylight contribution and occupancy. It is strongly recommended that design proposals for automated controls are reviewed by lighting controls specialist to ensure complete coverage and reliable operation.

Internal lighting is to be zoned to allow for occupant control. Zoning must be in accordance with the criteria below for relevant areas present within the building:

- In office areas, zones of no more than four workplaces
- Workstations adjacent to windows or atria and other building areas separately zoned and controlled
- Seminar and lecture rooms: zoned for presentation and audience areas
- Library spaces: separate zoning of stacks, reading and counter areas
- Teaching space or demonstration area
- Whiteboard or display screen
- Auditoria: zoning of seating areas, circulation space and lectern area
- Dining, restaurant, café areas: separate zoning of servery and seating or dining areas
- Retail: separate zoning of display and counter areas
- Bar areas: separate zoning of bar and seating areas
- Wards or bedded areas: zoned lighting control for individual bed spaces and control for staff over groups of bed spaces
- Treatment areas, dayrooms, waiting areas: zoning of seating and activity areas and circulation space with controls accessible to staff.

Areas used for teaching, seminar or lecture purposes have lighting controls provided in accordance with CIBSE Lighting Guide 5. BREEAM requirements for minimising light pollution are included within Internal Lighting and External Lighting Sections of this Guide.

Control Systems must:

- Be operating on digital control protocols such as DALI
- Incorporating bus cabling and driver devices, linking all lighting control devises.
- Employ microwave sensors or high definition PIR dependant on space usage and mechanical services.
- Interface with the Building Management System to facilitate occupancy based HVAC control.
- Implement Corridor linking and Daylight sensing.
- Utilise digitally dimmable control gear in luminaires to regulate light output and maximise energy efficiency.

- Web access monitoring and control of system through the BMS VLAN network.
- Interface with AV systems.
- Interface with the Building Management System to facilitate occupancy based HVAC.
- Employ microwave sensors or high definition PIR dependant on space usage and mechanical services.
- Be viewed and manipulated from offsite and manipulated via BMS controls interaction.

Absence detection must be utilised where possible, along with the policy of implementing task lighting where required. User interface must be allowed, as wall mounted switches where possible (potentially wireless where required), compatible with the system and where necessary supplemented with hand held controllers. The Designer must consider implementation of wireless wall mounted switches which will facilitate future changes with minimum disruption and cost.

Final requirement must be agreed with the UCL Principal Electrical engineer.

Record information of the lighting control system must be included on drawings, and must consist of Addresses, Zonal information, device locations, cable routes and an indication of the control strategy.

Digital DALI lighting protocols now provides a common platform for system to be developed around employing intelligent control ballasts with individual addressability and must be utilised where possible on designs. Utilise Dali broadcast where possible ensuring post installation maintenance is low. Dali addressable must be considered where additional levels of control will be required.

UCL standardises on distributed intelligence systems. For further details refer to the Preferred Manufacturers List (Appendix B).

B.2.23 Specialist Lighting

All lighting designs associated with the floodlighting of buildings, theatre lighting of stage areas, and feature lighting of moving objects or water features must be referred to a lighting specialist with a proven track record.

Particular consideration must be given to Photographic Darkrooms to eliminate possible afterglow issues commonly associated with discharge lamps.

B.2.24 Emergency Lighting

UCL's buildings are served by emergency lighting in accordance with BS 5266 and BSEN 62034, as amended. UCL require Building Services Designers to hold BAFE certification and the designs to be BAFE registered.

UCL's policy of emergency lighting design:

UCL's requirement is to have LED standalone addressable emergency lighting in lieu of central battery system. Any deviations to this being agreed with UCL Operations and Infrastructure Teams and only considered where a separate system could adversely impact or not be practical solution.

Non-Illuminated exit signs must be provided as per the UCL Fire Safety Technical Guide,

TN 020 Emergency Lighting – UCL General Design Guidance.

Non-maintained surface / recessed (as appropriate) luminaires must be installed as standalone 3 hour duration units obtaining live feed from the local associated lighting circuit,

Conversion / Combined emergency luminaires shall not be installed, except for the following exceptional conditions. In each one of these conditions, the Building Services Designer must seek specific written approval from Principal Electrical Engineer.

- Areas with high ceilings and where wall mounted emergency lights would not meet the requirements.

- High Profile aesthetically pleasing areas where a standalone emergency light would adversely compromise the effect of the space or not be a practical solution. (ie Listed buildings). In these instances, small recessed LED's must have been considered and discounted prior to seeking approval for Converted / Combined Luminaires.

- Where space restrictions dictates in listed buildings retaining a certain period feel.

- Emergency units to be incorporated within luminaire or remote mounted only on luminaires that are mounted in accessible suspended ceilings.

LED emergency lighting must be installed as the UCL standard, however where LED lighting may not be suitable traditional light sources may be considered.

For refurbishment projects the contractor/design team must carry out necessary survey to establish the existing interface and testing facility and protect the integrity of existing loops. Any additional luminaires added as part of the project must be included within the existing addressable emergency lighting testing system.

B.2.25 Emergency Lighting Testing Systems

Testing systems must be in accordance with BS 5266. Addressable testing system must be as a UCL approved system installed fully to the manufacturer's recommendation and in accordance with UCL's policy:

Manual test key switch system (preferably ganged with the local light switch control), must be provided where an automated addressable testing system neither exists nor is proposed as part of the project specific brief.

Emergency Lighting Addressable System

Addressable emergency lighting testing systems has been installed in a number of buildings and the policy is to extend the coverage where possible.

Where systems currently do not exist the Principal Electrical Designer must determine the requirement for the project, and which system is to be installed.

Where a system exists the Building Services Designer must allow for their adaptation for the new proposals, and must liaise with the system manufacturer to develop the design and work elements.

For existing buildings where no system currently exists, UCL's preferred manufacture is Zumtobel On-Lite system.

Refer to Preferred Manufacturer's list for details of Addressable lighting system manufacturers.

In all cases where works are carried out on the system, commissioning back to head end PC on the main site is required, with handover constituting:

- A fault free 3 hour duration test on system (and printout where necessary).
- Set-up and back-up files of the system as commissioned.
- Commissioning Certificates and Random Check list.
- Record information must include drawings with addresses, device numbers, and or group numbers; indication of routes of communication cabling plus other associated equipment.

The employment of either of these systems must be based on the guidance of UCL's Engineers with only one of these systems being installed within any given building. The Building Services Designer must liaise with the Operations and Infrastructure Teams for final confirmation on system to be installed on each project.

The Building Services Designer must also allow for the installation of data socket adjacent to the control panel of these systems and advise the PM or ETL of the port numbers to enable UCL to arrange configuration of the IT network, for secure communication to the remote PC.

B.2.26 Fire Alarms and Detection System

The design must ensure a fully functional fire alarm and detection system is provided for any new or altered installation. Any alterations to existing systems must not impact the ongoing integrity and performance of the system.

All designs shall comply with the following:

- BS 5839, as amended
- UCL's Fire Technical Guides
- UCL insurance requirements
- BS 6266 Code of protection for electronic equipment installations, as amended.
- BS 7273-1 Extinguishing systems, as amended.

UCL's fire policy is for the protection of life as the overriding rule (Category Group L as defined by BS 5839, as amended), however not all systems will fit neatly into the different recommended categories for an entire building. As such for higher risk location, property protection must be assessed and allowed for as necessary.

Implement property protection policy where stipulated or where value of equipment within area or associated with facility is £500,000 or more. Final requirement to be reviewed with UCL's insurers.

The design specification must cover (where applicable) the following:

- Category(s) of system is designed to
- Type and location of detectors, sounders, control panels, keypads and power supplies
- Cable type and method of installation.
- Alarm signalling

- Communications / reporting function
- Standby battery time and battery capacity calculation
- Connection of ancillary services
- Smoke extract systems
- Fireman's switches
- Warning and evacuation signs
- Other Ancillary services connections
- Fire alarm interface override facility to isolate plant, gas valves, fire dangers etc. during testing.
- Facilities for Equality Act alerting and evacuation.

Detection loops and sounder circuits must be sized to ensure fault free operation so that protective devices are not blown or tripped during fire alarm activation.

All systems must be zoned, including on addressable systems, and cable routes indicated.

In the event that the design proposal constitutes a deviation from British Standards recommendations this must be agreed with UCL's Fire Safety Team and all relevant interested parties, ensuring the variation is fully documented on commissioning certificate.

UCL's policy employs Apollo protocol devices and open protocol panels in accordance with UCL's Fire Safety Technical Notes.

Preferential panel manufacturers: Morley IAS or Advanced.

Fire Alarms Ancillary Systems

Where applicable, allowance must be made for the integration of the following other services to the fire alarms system:

- Equality Act systems (such as Digital Messaging System)
- Sprinkler systems
- Door closers / door hold–open devices.
- Fire fighting services
- Fire evacuation lifts
- Passenger Lifts and Mechanical control panels.
- Security systems.
- PV systems
- AV systems

Note: The interfacing of the above systems must not compromise the reliability and functionality of the Fire Alarms and detection system.

All designs must be approved by UCL's Fire Safety Team. . A Specialist third party accredited contractor must provide the fire alarm design certificate (BS 5839 part 1, as amended).

For refurbishment projects the contractor/design team must carry out necessary survey/decommission within the construction areas of the building and protect the integrity of existing system.

For Data centre/comms room and other high risk areas must be provided with suitable fire suppression systems.

UCL has a 24 hour 365 days of the year Communication centre which monitors all alarm signals. The Building Services Designer must liaise with the Comms Room manager with regards to requirements for linking the system to this monitoring station.

Cabling must be specified as enhanced type cables. Where cables are clipped to the ceiling, metal type cable clips must be utilised at every 45mm centres.

B.2.27 Alarms & Services for those requiring Support and Assistance

In meeting the BS8300 and Approved Document M requirements, the following must be considered during design and allowed for where feasible:

- Electrical supplies to disabled lifting systems, including back up power supply.
- Increase illumination levels in circulating areas
- Mounting heights of accessories in accordance with BS8300 and AD M legislation.
- Access facilities including allowing for door hold open devices where necessary.
- Egress facilities via evacuation lift for persons with mobility problems in line with the London Plan requirement for one per lift core.
- Services for Disabled Refuge Areas
- Induction loops for meeting rooms, classrooms and seminar spaces etc.
- Digital Messaging System integrated to BS 5839-1, as amended.
- Visual Alarm Device on alarm circuit of fire alarms.
- Emergency alarm call systems in toilets and other areas as necessary.
- Panic alarms
- Induction loops of sound field systems for Lecture Theatres and Seminar room via Honeywell system, linked to Security.

Refer to UCL's Inclusive Design Strategy.

B.2.28 Electrical Vehicles and Scooters Charging System

In accordance with 'Infrastructure for the charging of electric vehicles: Approved Document S' and IET Code of Practice, UCL requires an open protocol system and standardises on Schneider EVLink products which provide interfacing and monitoring back to our EMON PME system. Specific information provided on Manufacturers' List.

Designer must allow for Schneider commissioning of the system on site. Proposed designs to be reviewed by Fire Teams and C, E & I Engineers before implementation. Products are to be supplied with data connectivity, to enable interfacing with PME systems.

B.2.29 Induction Loops

Audio Frequency Induction Loop Systems (AFILS) must be designed and installed to conform to BS 7594 and BS 6083 IEC 118 Part 4, as amended.

A conformance certificate must be issued on completion, clearly stating the dB level of the AFILS and any adverse characteristics of the installed system.

Where disable pager panel is to be installed on a fire alarm system both the power supply and signal link must be monitored.

For systems that require linking back to the comms room monitoring station a normally closed volt free pair relay must be allowed on the control panel.

Liaise with the UCL Operations and Infrastructure Teams for wiring and point of interfacing information.

B.2.230 Ancillary Alarms

Other alarms systems can generally constitute Safety monitoring systems where hazards exits.

Systems proposed are to be approved by the UCL Operations and Infrastructure Teams.

Communication link back to comms room requires NC volt free relay.

B.2.31 Intruder & Panic Alarms

System shall be designed to conform to all latest relevant standards.

Installing companies must be NSI or SSAIB approved.

Liaise with the UCL Operations and Infrastructure Teams on proposed designs and interfacing system with Comms Room respectively.

B.2.32 Access Control & CCTV Security Systems

All access control & CCTV security systems shall be designed in accordance with all latest relevant standards and UCL's "Electronic Access Control Turnstile Integration Specification Guidance".

The Building Services Designer must liaise with the UCL Security team for information on system design and interfacing system with Central Security Comms Room.

B.2.33 Communication Systems

All communication systems shall be designed in accordance with all relevant Standards as outline in UCL's ISD Standard Specifications for IT Voice and Data networks Installations.

The Building Services Designer must liaise with the UCL ISD team or PM for information on system design.

B.2.34 Media Systems

This generally relates to Audio Visual systems design brief for which must be obtained from UCL's Information Systems Division through the Project Manager. All design proposals must be submitted back to the said department for final approval.

B.2.35 Labelling of Services

The labelling for LV distribution systems must be carried out with engraved Traffolyte Black on White, fixed with plastic rivets of nylon screws using the following format:

MAIN SWITCHBOARD: (5mm lettering)		
Fields	***Details***	***Explanation***
Ref:	**UCL PANEL A**	This must be the main switch panel ref.
Fed from:	**….. SWITCHROOM "MP2-7"**	Details of where the supply emanates from (item in quotation is the cubicle ref if applicable)
Service Rating:	**400A**	Maximum current rating of the supply device.
Protection Type:	**MCCB**	Up-stream protection device details
Incoming Cable:	**240mm/XLPE/SWA/LSF + CPC**	Self explanatory (must include size of CPC)

OUT GOING DEVICES CUBICLES: (5mm lettering)		
Fields	***Details***	***Explanation***
Ref:	**Panel A/4**	This must be the particular switch cubicle reference (example adjacent Panel A/4 representing Panel A cubicle # 4)
Serving	**DB.....**	Reference and or description of equip / DB being served.
Location	**Level** **Room**	Location of equipment or distribution board being served.
Device type and relay:		i.e ACB, MCCB TH. Mg or Elec Manufacturer and order Ref:
Max Device Rating:		Self explanatory
Device Setting		Applies to MCCB devices that allows for adjustment of "In" protection level
Cable Size / Type:		Self explanatory (always indicated cpc where installed)

Note: spare cubicles to be labelled with Ref and other fields blank.

For field sub-mains and final distribution boards. (5mm lettering)

Fields	***Details***	***explanation***
Ref:	**Gnd/DB1**	Identity of distribution board (either obtained from

		Estates or as per design drawings)
Serving	**Ground floor lighting and power.**	Reference and or description of equip / DB or services being supplied.
Fed From	**Tap off on Rising busbar.**	Equipment / system serving this unit.
Cable Size / Type:		Self explanatory

For field Switch/fuse, Fuse/switch and Isolators. (3mm lettering)

Fields	***Details***	***explanation***
Ref:	**DB1/ Cir4**	Identity of circuit (taken from upstream DB circuit way)
Serving	**Any Equipment.**	Reference and or description of equip or services being supplied.
Fed From	**Some DB**	Equipment / system serving this unit.

Tap-off boxes to have ref. identification only.

Cables must be labelled with the following information (3mm lettering)

Fields	**Details**	**explanation**
Serving		Reference and or description of equip / DB being served.
Location		Location of equipment or distribution board being fed.
Cable Size / Type:		Self-explanatory

Other systems to be labelled:

- All socket outlets and power disconnectors – labelled with circuit ref.
- All conductors in distribution boards, MCC etc. to be labelled with termination ref.
- All fire alarms equipment with necessary addresses and zones.
- All emergency lighting addressable luminaires with addresses etc.
- All emergency luminaires identifying them as emergency lights.
- Any other control / monitoring system that required peripheral connections to be identified.

These labels can be of a stick on type to be approved by UCL.

C.1 MECHANICAL DESIGN CRITERIA

The following criteria has been provided for guidance only. The Building Services Designer must ensure that all design criteria are compliant with all current mandatory standards and are in line with the recommendations of CIBSE Guide A, BSRIA or other such recognised industry bodies. However, the Building Services Designer must also consider and allow for higher summer outdoor temperatures, as per the recent trend, for research critical facilities with continuous operation. Any deviation from these standards and guidelines must be identified and agreed with the UCL Operations and Infrastructure Teams prior to commencing the design. Reference must be made to the UCL District Heating policy, as well as other low carbon district network opportunities.

C.1.1 Environmental criteria, External Conditions

Summer (General)	30°C dry bulb 20.5°C wet bulb
Summer (BSU areas)	32°C dry bulb 22.5°C wet bulb
Winter (General)	-3°C dry bulb saturated
Winter (BSU areas)	-5°C dry bulb saturated

Frost coils on air handling plant, when units are off must be sized to provide frost protection and meet design with ambient external temp of –5°C; and protect plant from freezing down to –8°C.

Heat rejection plant to be selected to achieve design at 32°C dry bulb temperature but must continue to operate satisfactorily with an ambient dry bulb temperature of 38°C.

C.1.2 Environmental Criteria, Internal Conditions

Teaching and Research Laboratories, Support Areas, offices etc.

Winter	20°C dry bulb min RH uncontrolled. (unless demanded by a process)
Summer (when cooling is specified)	25°C dry bulb max RH uncontrolled (unless demanded by a process)
BSU Areas	55% RH ± 10%

Each holding room must be capable of being held at any set point between 19-23°C ± 2°C unless directed otherwise by the User Department on room data sheets, to be considered on a project by project basis along with upgraded self-contained units.

Lecture Theatres	Winter 21°C dry bulb ± 2°C within occupied zone RH 30% minimum Summer 24ºC dry bulb ± 2°C within occupied zone.
Seminar & Tutorial Rooms	Winter 20°C dry bulb minimum

	Summer 24°C dry bulb max (where cooling is specified) RH uncontrolled.
Stairs & other circulation	Winter 18°C dry bulb minimum spaces on refurbished buildings. New buildings may not require heating to these areas.

Consideration must be made to differential between internal and external temperatures.

C.1.3 Ventilation Requirements

Rates not to be higher

Teaching & Research Labs	Rate to be determined by assessment of required dilution or containment with increased levels of ventilation where dictated by high density of fume cupboards or special extracts. Rate must be the lowest to meet these requirements.
BSU Areas	20 air changes per hour min with increased rates to suit heat gain if necessary. Home Office requirements to be followed.
Lecture Theatres	10 l/s per person
Seminar/Tutorial Rooms	10 l/s per person where cooling is provided with increased rates as appropriate where not cooled.
Toilets	10 air changes per hour extract, 8 air changes per hour make up (where appropriate to provide make-up air).
Shower rooms	15 air changes per hour or an extract rate of 30 l/s per shower whichever is the greater.
Offices	Outdoor air should be supplied at either 10 litres per second per person (current guidance) or 1 litre per second per m^2 floor area (new guidance) – whichever provides the highest total rate.

C.1.4 Filtration Standards

Teaching and Research Laboratory	EU3 pre-filters with EU8 bag filter with increased levels where dictated by special facilities.

All other areas	EU3 pre-filters with EU6 bag filters.

Where relevant, consideration can be made to use carbon or HEPA filters, where the environment requires it.

C.1.5 Internal Heat Loads

In addition to the solar, lighting, and heat loads from occupants, the air conditioning/cooling systems (where appropriate) must be designed to offset the loads from equipment and computers, derived from room data sheets. Must the stated equipment gains result in an exceptionally high load expressed in terms of watts per metre squared then this must be discussed with the UCL Operations and Infrastructure Teams to decide if a diversity or similar reducing assessment is appropriate.

Overheating assessment to comply with latest editions of CIBSE TM 52 (commercial) and TM 59 (residential). Or assessments/guidance that are equal and approved on a project-specific basis.

C.1.6 Water Services

i) Cold Water Storage

Laboratories (category 5 water)	To be assessed from room data sheets and discussions with users.
Domestic (category 1 water)	45 l/person Lab staff 20 l/person Student

ii) Hot water Storage

Domestic (category 2 water)	4.5 1/person (to be considered on a project-by-project basis)
Laboratories (category 5 water)	To be assessed from room data sheets and discussions with users.

Consideration must be made to select appropriate storage volume to suit building type and to avoid over sizing water storage. With the overall aim to promote good throughput and turnover of water in tanks along with avoiding prolonged standing water in tanks and prevention of bacteria / legionella build up. Guidance to be taken from current Water Quality Regulations.

C.1.7 Noise Criteria

Internal noise levels (from CIBSE Guide A, as amended)

TYPES OF ACCOMMODATION	SOUND LEVEL RANGE (NR)
Residences/Dwellings:	
Bathrooms	-
Bedrooms	-
Hall/stairs/landings	25

TYPES OF ACCOMMODATION	SOUND LEVEL RANGE (NR)
Kitchen	40–45
Living rooms	-
Toilets	30
Educational buildings:	
BSU	To comply with Home Office Code of Practice and BSU Manager's project specific requirements.
Computer rooms	35–45
Corridor	35–45
Gymnasium	35–45
Laboratory (without fume cupboards)	30 – 40
Laboratory (with fume cupboards)	40 - 50
Lecture halls	25–30
Print room	35 – 45
Research write-up	30 - 35
Seminar rooms	25–35
Teaching spaces	25–35
Tissue cultures	35 – 45 (to be confirmed on a project by project basis)
Workshops	35–40
Exhibition halls	40
General building areas:	
Corridors	40
Entrance halls/lobbies	35–40
Kitchens (commercial)	40–45
Toilets	35–45
Showers	35 - 45
Waiting areas/rooms	30–35
Hospitals and health care buildings:	
Audiometric rooms	20–25
Bedheads/wards	30
Circulation spaces	35
Consulting/treatment rooms	30
Corridors	35–40
Kitchens	35–40
Laboratories	35-40
Nurses' station	35
Operating theatres	30–35
Staffroom, recreation	30–40

TYPES OF ACCOMMODATION	SOUND LEVEL RANGE (NR)
Washroom/toilet	35–45
Launderettes	45–50
Libraries:	
Lending/reference areas	30–35
Reading rooms	30–35
Store rooms	-
Museums and art galleries:	
Display	30–35
Storage	30–35
Offices:	
Large conference room	30
General, small conference room	30
Executive office — open–plan	35
Places of public assembly:	
Bars/lounges	30–40
Concert hall, theatre	20–30
Changing/dressing	35
Circulation spaces	40
Foyers	40
Multi-purpose halls	-
Restaurants/dining rooms	35–40
Night club, public	40–45
Small shops	35–40
Sports halls:	
Changing rooms	35–45
Hall	40–50

Cross talk attenuation control measures are to be reviewed by a qualified acoustic designer for each project. The client is to advise upon noise sensitive areas and an agreed attenuation level is to be ascertained.

C.1.8 External noise arising from installed plant and equipment

Noise arising from installed plant and equipment is becoming increasingly important. Failure to comply with the noise criteria and requirements set out in planning consents can lead to enforcement action being taken by the Local Authority for breach of statutory nuisance. Even if statutory nuisance is not demonstrated, noise complaints are time-consuming and expensive to investigate. Considerations must be made to identify whether the additional noise caused by the plant and/or equipment will have an impact on whether the fire alarm is still achieving an adequate dB reading.

The noise levels acceptable for planning are generally be determined by Local Authority requirements. The requirements of LB Camden are typically expressed as: “Noise levels at a point 1 metre external to sensitive facades shall be at least 5dB(A) less than the existing background measurement (LA90), expressed in dB(A) when all plant / equipment (or any part of it) is in operation unless the plant / equipment hereby permitted will have a noise that has a distinguishable, discrete continuous note (whine, hiss, screech, hum) and/or if there are distinct impulses (bangs, clicks, clatters, thumps), then the noise levels from that piece of plant / equipment at any sensitive façade shall be at least 10dB(A) below the LA90, expressed in dB(A).”

The specific requirements associated with LB Camden along with all other Local Authorities, that UCL fall within, are to be investigated during each project – where deemed as applicable.

In general there are three user requirements which need to be carefully managed in order to comply with planning criteria

- The expansion of working hours and move to 24/7 operation means that more equipment will be required to run out of hours or over night
- The requirement to operate more temperature-sensitive equipment and processes leading to a consequent requirement for additional process cooling
- User expectation to work in a temperature-regulated environment leading to a requirement for increased comfort cooling

At design stage a number of factors need to be considered if an installation which meets user requirements is also to meet planning requirements:

Who will be affected by the noise?
Consideration needs to be given to those who might be affected and when they might be most sensitive to noise. For residential premises this might neighbouring residences at night time, for a place or religious worship this might be during the day time on weekends.

What existing plant is already in operation?
Any new plant will add to the noise from existing plant. It is important that combined noise from both new and existing plant meet the noise requirements for planning criteria. Where the existing plant installation is extensive and/or complex then the noise modelling must be sufficiently robust to clearly demonstrate that the planning criteria will be met at all times.

Selection of quiet equipment
Consideration must be given to the selection of equipment which comfortably operate within the acoustic constraints as set out in the planning requirements. Reliance cannot be placed on the installation of acoustic shielding to mitigate the effects of noisy plant and equipment as planning permission may not be given for the shielding.

Location to avoid noise reflection and acoustic resonance
Consideration must be given to the location of newly installed equipment to minimise noise reflection and/or amplification through acoustic resonance. Here again acoustic modelling can be employed to predict the operational noise levels from a particular installation.

Placement to allow changing of filters and maintenance of moving parts
It is important that plant are installed to allow easy access for maintenance operations, including

- Replacement of filters
- Tensioning of drive belts
- Lubrication and servicing of motors

Operational hours

Plant and equipment must be configured not to operate outside of the agreed operating hours. Where a building has 24/7 access but the plant is permitted to operative only during restricted hours neither user controls not automatic presence/absence detection must be configured so as to cause the equipment to operate outside these hours. Where night time operation is required the equipment must be configured, where possible, to operate in quiet or night time mode if this is provided.

Exceptions must be made for: 24 hour operation of equipment, frost protection. Considerations must also be made for fire alarm cause & effect.

Sequential start-up

Where services are provided by more than one item of plant or equipment, they must be configured so as to start up sequentially, so as to allow each item to adjust to its running load before the next item is started. The same applies to shut down. These actions allow for a gradual, rather than sudden, transition in noise level.

Acoustic shielding

Acoustic shielding must be employed only once all other options have been exhausted.

- The visual massing associated with shielding may not secure planning consent
- The shielding applies a fixed attenuation value which may not be sufficient if/when the plant/equipment are modified or adapted in the future

C2 GENERAL REQUIREMENTS

ZONING

Need to have appropriate zoning – taking into consideration different uses of the building, Building Regulations compliance and UCL Sustainability requirements and Part L (which needs to be assessed on a project specific basis).

C.2.1 Utilities and Infrastructure

No utility supply contracts may be entered into by contractors in UCL's name. Where new supplies or changes to existing supplies are required these must be discussed and agreed with UCL's Energy Manager – who will arrange any new contracts to be drawn up.

All buried services are to be back-filled and identified in accordance with British Standards. Magnetic detection tape/trace cable is to be installed along the services length unless agreed otherwise on a project-specific basis. Reference is to be made to HSG 47 or future equivalent.

Meter specifications/requirements found within UCL's Metering Specification.

Gas

Where gas is required, buildings must be provided with a main incoming gas meter and governor in a ventilated room including high and low-level natural ventilation in accordance with IGEM and Gas Safe Regulations and BS 6644, as amended.

If mechanical ventilation is deemed necessary, all relevant safety requirements of IGEM and Gas safe regulations to be implemented and interfaced with gas proving / detection systems.

New meters must be supplied by the Statutory Authority in a position agreed with them and UCL's Energy Manager. The meter and shutoff valve must be fully accessible from the front. The meter must have an integrated Automatic Meter Reading device (with a 30-minute read schedule).

The gas meter must be capable of accepting up to 120% of the design load. All meters must be 'low pressure drop' type, pulsed, and connected to the BMS for monitoring of consumption (in 30 min intervals). All gas solenoid valves must be selected with a 'low pressure drop' in order to comply with the Gas Installation Regulations. Solenoids to be hardwire interlocked with gas proving systems and safety circuits. (IE: heat and carbon monoxide (CO) detection).

Use of boosters must be avoided where possible..

The use of medium or high pressure natural gas is to comply with Gas Regulations in its entirety.

Incoming gas pressures and volumes to be validated in conjunction with Utility Provider/transporter on a project-specific basis during design.

All gas running within buildings must be ventilated either via suitable high and low level grilles in risers which link to an external space or where this is impractical, via pipe in pipe installation.

Carbon monoxide (CO) monitoring and alarm detection is a requirements within all UCL plantrooms.

UCL and the Designer are to review and consider hydrogen-ready appliances where appliable – in the event of a natural gas infrastructure changeover.

Water

Buildings must be provided with a metered incoming water supply from the Statutory Authority's network. New meters must be supplied by the Statutory Authority in a position agreed with them and UCL's Energy Manager. The Authority meter must be pulsed to allow for BEMS monitoring of consumption. Suitable interfacing is to be discussed with the Utility/meter provider at design. It must be where the statutory meter is located remote from the building boundary, a second client check meter with BEMS connected pulsed output must be provided and the flows compared to act as leak detection. The BEMS must also use intelligence to determine demand patterns over time and identify out of range use. Certain UCL buildings and applications will require the leak detection to be hardwire interlocked with motorised control valve(s) that shut down the building/zone in the event of a leak detection – whilst sending a "high level" alarm over the BMS.

Commissioning must ensure that the connection of the meters to the BMS system has been achieved.

Steam

The existing steam district heating system is being phased out. This means that no new connections must be made to this system. This includes proposed works where it is proposed to reuse existing connections. Any buildings which may be affected by this must be discussed with the UCL Principal Mechanical Engineer at the earliest stage in order to agree a suitable alternative strategy. Where a building is to be disconnected; steam usage and load assessment to be revisited to determine suitable centralised or localised plant selection and type of steam generation, i.e. electric or natural gas.

Alternative autoclaves are to be reviewed for each project, where existing/new autoclaves are to be installed. i.e. electrically driven autoclaves to replace and phase out UCLs steam generation and future use.
For further details refer to UCL Employers Requirement document: Design Requirements for Connections to the UCL District Heating Network.

Early discussions and coordination with the UCL CHP District Hearting Management Team, is imperative.

C.2.2 Pipework Systems

No plastic pipework systems to be specified for any heating, cooling or domestic hot and cold water systems, except in specific laboratory applications or process cooling. No push fittings are allowed.

Alternative materials or systems such as thin wall stainless steel may be considered through prior agreement with the UCL Principal Mechanical Engineer.

Lab/medical grade systems shall be entirely supplied, installed, commissioned and maintained by an accredited and UCL approved specialist.

All pipework insulation must be installed by the pipework installation subcontractor and not the lagging subcontractor complete with clear external identification, to include:

- Service identification
- Direction of flow
- Un insulated pipework dimension

For pipework arrangement refer to schedule within Appendix F.

All flanges and valves must be insulated alongside the pipework with easily removable/refit table insulated jackets. Same applies to applications where aluminium clad insulation, valve and flange boxes are installed. All brackets and drop rods to be insulated to provide continuity.

Where pipework is being installed on an existing system, any missing insulation within that system must be re-instated as part of the works.

Prior to the start of a project the Building Services Designer must obtain a domestic water Legionella risk assessment for all existing systems from the UCL Operations and Infrastructure Teams / maintenance team.

Notwithstanding the risk assessment is to include all relevant wet systems such as chilled water, LPWH heating, chilled water, process water, steam/condensate etc.

A water hygiene review must be carried out at RIBA Stage 3 with a detailed review and verification of the Designers design by a UCL approved specialist and the system treatment and maintenance regimes presented to the UCL Operations and Infrastructure Teams for comment and approval prior to proceeding to detailed design. The dosing of systems with chemicals must be avoided wherever possible with specific attention being given to the overall system filtration / strainer requirements. Consideration must be given to equipment warranties.

Mains water applications are to include sampling and laboratory testing, with accompanying report, illustrating its suitability as a wholesome/potable water supply.

UCL's incumbent Water Hygiene specialist shall update the building's risk assessment documentation to reflect all alternations.

Where buildings or areas are being refurbished all redundant pipework shall be removed back to the to the live pipeline with the redundant tee-piece completely removed and line-size pipe section installed to eliminate the dead leg entirely.

Transducers must be specified on all secondary circulation pumps and other main plant items to monitor water flows through BMS alarms in order to assist with proactive maintenance regimes.

Binder test points must be provided on all systems for testing, sampling and commissioning purposes, specifically the monitoring of calorifiers / storage vessels water temperatures for system analysis.

All pipework to be labelled to BS170 and BS4800, as amended.

Dead legs must be avoided on all pipework systems. If deemed as impractical to remove/avoid the up-to date Water Regulations advice is to adhered to in relation to acceptable and compliant maximum dead leg lengths. IE: 1.5 times pipe diameter.

Trace heating to piped services is to be discussed on a project specific basis. External pipework or pipework installed in locations which could be prone to freezing are to have trace heating installed.

Refer to the preferred manufacturers schedule for recommended all pump and pressure set suppliers.

Where practicable toilet facilities, cleaners cupboards and catering areas must be provided with automatic motorised shut off valves on the cold water supplies linked to presence detection. This function must incorporate the full requirements / specification identified by UCL.

All heating and chilled water systems must provide accessible shut off facilities to all floors or appropriate zones for system maintenance, leak isolation or future fit-out activities. These valves must be motorised with BMS monitoring and control facility.

Refer to Drainage Section for details of pipework used for this application.

Where pumps are required within the system, they must be to the highest efficiency as possible, and where the load allows variable speed drives must be used.

C.2.3 Heating, Boilers & Humidification

Buildings on the Central Campus

- Do not use 3-port diverting valves which would divert water at flow temperature back to the return in low load conditions. Utilise 2 port control valves and variable volume pumps taking due regard of minimum flow requirements of the pumps and boilers. Hydraulic (DPCV) or automated (PICV) bypass arrangements to be installed as required.

UCL has a district heating system serving the majority of buildings on the central campus. New buildings or refurbishment projects on this campus must be connected to this heat source unless this has been agreed with the Deputy Director of Campus Experience and Infrastructure.

A project specific carbon appraisal shall be conducted and signed off by UCL's Sustainability Team.

1. District heating for all main campus and IoE sites.
2. Off campus – Condensing boilers
3. Ground/water source heat pump for major refurbishment
4. District heating
5. System resilience and part/N+1 back up provisions.

VT preferred on major works and where practical on refurbishment projects.

Consideration to be made to the most environmentally friendly option (the least carbon intensive). Hydrogen-ready appliances to be considered, when available.

Projects must be provided with heating appropriate to the schemes as listed above.

Systems must be designed to keep the secondary return temperature to the PHE below 70C to ensure maximum efficiency of heat recovery from, and cooling of, the CHP engines and to avoid the need for waste heat rejection. The primary district heating is designed to maintain 80C on the secondary flow when heating is required. This results in the following design criteria being generally adopted:

Tables around operating temperatures for VT and CT

- LPHW to be designed for 80C flow and 65C return.
- PHE designed to operate at 82C maximum flow
- Maintain a minimum flow through the PHE so that the immersion sensor in the secondary flow will record a true temperature (if designing a total variable temperature system then this must include a constant volume loop with mixing valve set to control on the return temperature to the PHE. Details to be discussed with Estates engineers).
- Provide a volt free signal pair to the primary control panel to indicate that heating is or is no longer required (e.g. to coincide with optimum on/off)

Consideration to the primary heating arrangement entering each satellite plantroom to be discussed with the UCL District Heating Team during design and specification to suit equipment preferences, hydraulic and automated/monitoring control standards.
For instance - Samson hydraulic differential pressure control valves, heat metering, 2-port MV, BEMS F&R (primary and secondary) temp sensors, separate primary and secondary control panels - maybe required as a UCL standard.

Careful consideration of boiler selection and firing sequence of multiple boilers via BMS/controls and their back protection circulation maintaining boiler chest content temperatures, will need review. Primarily related to where connected into district heating network and hence avoid “cold slugs” of water being introduced into system

Buildings outside of the Central Campus or IOE - boilers

Buildings outside the reach of the district heating network managed by UCL must be provided with high-efficiency condensing gas boilers which are fully automatic in operation. Energy efficiency and lifecycle costs must be the guiding principles in the selection of system type and equipment selection. Systems must be designed with adequate provision to maintain suitable heat output in the event of a failure of a single item of heating output. This will generally require a minimum of two boilers rated at 66% of design load or three boilers at 40%. Any back up provision to be approved by the Principal Mechanical Engineer. Considering improvements to the building’s thermal efficiency/fabric improvements. Buildings that are not served by the district heat network can be reviewed on a project to consider whether it is feasible to in fact connect them.

Designer to consider, with UCL, the feasible implementation of heating strategies such for example, but not limited to, GSHP’s, ASHP’s etc. Consideration to be reviewed against impact to circuits, emitters, coils etc within the building which maybe sized and selected based upon different operating temperatures and system differentials.

The preferred system will utilise direct boiler flow temperature modulation and maximum use of condensing modes particularly within new build projects. Return temperatures of 30°C-40°C are preferable but must be considered in relation to the size and cost of heat emitters. Consideration must be given to separate gas fired water heaters and in relation to constant

temperature circuits and their overall impact to system mixing during winter and summer operating conditions.

Boiler selection must seek to achieve class leading reduction in emissions (NOx <40mg/kWh) and high overall efficiencies. All plant and equipment must be selected to operate within acceptable noise levels. Each gas fired boiler must be able to modulate and turn down to a minimum of 20% of the maximum output and accept a variable volume flow. The gas fired boilers must have stainless steel heat exchangers, a large internal water capacity and must be capable of operating with a variable flow volume.

Ventilation to boiler plant rooms must be provided at high and low level in accordance with BS 5440 , IGEM UP or BS 6644 (to suit the gross gas input requirements), as amended, where applicable. Boiler flues must be stainless steel, twin walled and insulated and must be fire rated for 2 hours at 300°C for the entire length. Flues must be provided with trapped drain for rainwater and condensate, which must be taken back to the nearest gully in the plant room and safely discharged. Where supplementary flue fans are required hardwired interlocks (not via BMS network) including flow switches - to the plantroom ventilation and boiler operation itself, are to be installed.

Heat pumps

In some instances, the use of heat pumps may be an appropriate source for heating and/or cooling. Either air-source or ground-source heat pumps may be considered, however close attention must be paid to the COP and SEER of the unit by selecting appropriate operating temperatures. Ground source heat pumps must have a minimum COP of 3.5 in heating mode. Specialist advice.

Typically heating must be no greater than 40-45°C flow and cooling must be no less than 12-15°C flow, although there may be exceptions to this. Where ground source heat pumps are used, it is important to ensure that there is either a balanced heating or cooling load or that the ground is suitably recharged over the year (for example by using solar collectors to deposit heat into the ground in summer for predominantly heating systems, or by using dry coolers to reject heat in winter during predominantly cooling systems).

A Geologist is to be appointed early in the design process to undertake desktop advice and intrusive geothermal ground testing – to inform any further designs/considerations. Note that the Local Authority may need to approve any proposed heat sourcing/sinking loads.

Plate heat exchangers may be required to separate external glycol circuits from systems within the building. All glycol systems must contain food-grade glycol.

Where radiators are used for space heating, VT circuits must be provided with independent run and standby pumps complete with variable speed drives – control of pumps must be pressure led (i.e. taking into account TRV use). Systems must be split into primary and secondary systems where local plant incorporating multiple boilers is used. Radiator valves must be lockable, and tamper/vandal proof. The Thermostatic Radiator Valves (TRVs) must be to BS EN 215-1 as amended.

Heat emitters within accessible toilets or similar areas must be of the low surface temperature type with a maximum surface temperature of 43°C.

Where fan coils or fan convectors are proposed, fans and motors must be mounted on a chassis independent of the convector casings. The motor must be positioned prior to the

convector element to eliminate damage by excessive air temperatures. Fan convectors must be served by constant temperature circuits only.

Valved normally-closed flushing loops must be fitted at all fan convectors and fan coil units. Fan coil units must be complete with internally fitted thermostats and low temperature cut-out switches. In-line strainers must be fitted before all control valves on fan coil units. Consideration to be particularly made to existing systems. Chemical treating/dosing – validated this is done and PPM is up to date. This will inform decision on whether automatic filtration is to be considered further in relation to installation onto centralised systems. Access panels must be provided to facilitate easy maintenance of filters, motors, control valves etc. Internal filters must be fitted and have an atmospheric dust spot efficiency of at least 55% when tested in accordance with BS 6540, as amended. Control must be by interface units to the BEMS system (monitoring only).

Use of humidifiers must be avoided where possible, however where the internal environmental conditions required necessitate the use of humidity control, the preference is to use resistive steam type as opposed to electrode boiler due to the reduced maintenance and spares costs. It may be necessary to provide Reverse Osmosis (RO) water to the humidifiers. BMS interfacing/full control to be reviewed for each project.

Where in-duct humidifiers are installed, ensure the downstream absorption distance is sufficient; typically 1.5m. On larger installations, consider the use of electric humidifiers rather than gas fired humidifier in the first instance. Building load assessment to inform detailed design.

Heat station (primary to secondary)
As detailed in the Heat Network (Metering and Billing) Regulations 2014, as amended, heat meters must be fitted to meter any connection from the district heating system to a building. Where new boilers are installed, there must be a heat meter to monitor heat output from the boiler. All heat meters installed must be connected to the BMS system (kW and kWh).

C.2.4 Cold Water Services

Systems must be designed in accordance with the Water Regulations 1999, CIBSE TM13, ACOP L8 and HSG274. All plant and equipment to be WRAS approved.

Thames Water have instigated a programme to reduce the pressure in their mains to reduce leakage rates. They are only bound to provide 1 bar gauge pressure at the main and may progressively reduce to this minimum. Projects involving provision of new storage systems and substantial mains water distribution must therefore be designed with booster sets. Consideration must be given to building height when determining whether booster sets are necessary.

Booster sets must include duty/standby pumps as a minimum with IE2 or IE3 motors and auto-changeover. Booster sets must be provided with a control panel. Booster assemblies incorporate variable speed motors, outlet pressure reducing valve as deemed necessary, distribution pipe network surge protection device, integral anti vibration mounts, volt free contacts BMS linked, flexible inlet/outlet connections and set plus component parts to be fully WRAS approved.

Cold water storage tank volumes as calculated must be considered and capacity sized as an absolute minimum requirement of 15 minutes run time of booster set at full flow compliant with BS EN 8558. Along with promoting even draw through and sufficient water turn over within the tank.

Water consumption can be less than that indicated by design guides and interpretation of occupancy levels from room data sheets, leading to hygiene risks due to low turnover of stored water. Water cisterns must be sized in the normal way but fitted with Aylesbury “KB” type delayed action float valves with adjustable water and differential levels, to allow for seasonal variation, otherwise an equilibrium float valve is to be fitted . The levels must initially be set at lower than the listed actual capacity of the cisterns and must be adjusted to suit actual turnover under “in-use” conditions.

Tanks must consist of pre-insulated sectional GRP panels (hot press panels are to be used). Adequate ‘headroom’ to be provided above tanks to allow for tank entry for cleaning purposes and valve replacement/adjustment.
All tanks must have a minimum of 900mm clear above for access and must be installed on plinths a minimum of 500mm high. Access must be via external galvanized steel ladders and internal stainless steel ladders. Screened vents must be minimum 100mm diameter. No internal hollow box section steel tank supports are to be used. Preferred “I” beam steel supports on dwarf walls/plinths bases.

Tank base shall be, where possible, fully self-draining for ease of cleaning and maintenance.

Raised ball valve boxes with side access shall be considered to utilise tank capacity.

High level alarm linked to automatic water shut off.

Low level sensor incorporated and linked to booster pump set where used.

Controls and sensors shall be replicated within each compartment of sectionalised tank.

Mains water inlets and cold water draw off connections shall be arranged at opposite sides to promote good cross flow through tank.

Header/draw off manifolds and connections shall be arranged to avoid dead legs or pockets which could promote bacterial growth
In new buildings the cold water storage for laboratory and for domestic use ~~must~~ shall be totally segregated in accordance with the water categories.

In existing buildings the extent of the segregation must be discussed with the UCL Operations and Infrastructure Teams to agree what can be reasonably achieved within the cost restraints of the project. The minimum requirement must be to segregate the water services in the new project area even though these might be connected to a common point outside the project area. This will provide a ready point of connection when services to the remainder of the building are brought into line with the regulations.

Although the risk assessments for a particular project may identify laboratory use water as category 4, all laboratory use water (except wash basins in laboratories) must be designed as category 5. The reasons for this are:

- RPZ valves are not generally acceptable due to the costs to maintain these on a register and the ongoing maintenance liability. Use of RPZ valves requires approval from the UCL Principal Mechanical Engineer.
- Laboratory use can change within a short time and flexibility of use is required.

The wash basin provided in a laboratory for use at point of exit must be served with category 1 domestic water. If eye-wash points are specified, then these must also be served with category 1 domestic water.

Category 5 water supplies must generally be boosted.

Water purifiers must be served by category 5 water.

Where extending from existing CWS circulation pipework, the new pipework must be of the same material as existing to avoid dezincification. However, galvanised steel pipework must not be installed in UCL buildings and all existing removed wherever practicable and or economical. Plastics pipework systems will not be considered unless by approval of the UCL Operations and Infrastructure Teams or for specialist requirements with labs etc. All other pipework systems must be either copper or steel.

Stainless steel braided EDPD (or similar) flexible hoses must not be used for final connections to outlets. All final connections to outlets to be in hard copper pipe, unless connecting to vibrating equipment. Corrugated copper flexible connectors are an acceptable alternative, providing they are WRAS approved.

A suitable water treatment system must be specified in agreement with the UCL Operations and Infrastructure Teams where required.

Water services shall be labelled “cat 1 water” or “cat 5 water” and drinking water.

Provide combined constant flow regulators/ isolation valves on all final connections to all appliances to provide system flow balancing. Back flow prevention must be provided as necessary. Where water pipework runs externally, it must be trace heated.

Provide 230 volt solenoid valves on the CWS to all toilet areas, in order to isolate the water supplies when the toilet areas are not occupied (this must be achieved by connection to the local PIR within the toilets via a relay where two WCs are connected to a single solenoid valve). Where solenoid valves are used, consideration must be undertaken in relation to sudden back pressure and pipework failure.

C.2.5 Hot Water Services

Hierarchy

1. If on network connection to PHE
2. Direct fired gas fired water heaters (where alongside condensing boiler) or from existing non-condensing boiler plant
3. Instantaneous water heater
4. Electric point of use

Systems must be designed in accordance with the Water Regulations 1999 and CIBSE TM13 and ACOP L8.

On the main campus primary hot water for category 2 domestic use must generally be provided by a new plate heat exchanger (PHE), connected to the CHP district heating system or connection to the secondary side of an existing PHE, as described for the heating. Where duplicate PHE’s are considered, approval to be sought from UCL’s Principal Mechanical Engineer. In the first instance, consideration must be made for the provision of a spare PHE, provided under the project.

Projects outside the main campus must be provided with HWS appropriate to the scheme. PHEs are the preferred option, rather than storage cylinders.

Dual PHE configuration with 1 unit serving the heating and 1 unit serving the DHWS must be used.

Where gas-fired hot water plant is selected for off-campus sites, this must be high efficiency with flue considerations as per that for boiler plant.

User Departments must be consulted to establish the minimum number of hot water outlets required in a laboratory, as a hot supply is not always required to a laboratory sink. The laboratory hot water for small projects can be served by local electric water heaters connected to the category 5 boosted cold water, unless there is an existing category 5 HWS system available for connection. Where a larger number of laboratory outlets justifies the requirement for central category 5 HWS plant, then this must be totally segregated from the category 2 supplies with separate secondary cold feeds and circulation pipework.

The wash basin provided in a laboratory for use at point of exit must be served with category 2 domestic water. Where either PHE or centralised hot water generators are used, the system must be designed flow and return. Where the domestic hot water system converts to flow only, self regulating electrical heat maintenance trace heating tape must be installed within 500mm of the outlet to ensure the water does not drop below the required temperature. The maximum temperature of this tape shall be limited to avoid excess strain/stress pressure build up due to expansion on tape. Installation of tape shall be strictly in accordance with manufacturer's requirements.

Electric point of use water heaters must be on a time clock and be provided with all necessary inlet pressure and temperature safety devices.

Where local hot water heaters are used, any hot water pipe run supplying an outlet further than 3m from the water heater must also be fitted with heat maintenance tape to maintain the required water temperature.

Hot water to washbasins in accessible and changing places toilets or general public/student use areas must be provided with point of use thermostatic mixing blending valves limiting the temperature to 43°C at the outlet. Hot water supplies to laboratories and staff accommodation are not considered "public" areas and do not require this control. Such sinks must be clearly labelled "Caution – very hot water". Blending valves (TMV,Thermostatic Mixing Valves) are to be complete with isolation valves, non-return valve, strainer and test port along with insulated jackets/boxes. They must readily accessible and be installed in positions to allow for maintenance.

Consideration must be given to the specification and use of Thermo taps wherever possible in lieu of blending values in order to avoid unnecessary dead legs.

All water services branches must be provided with pressure regulation to limit pressure and control fluctuations where the static system pressure exceeds 2.0 bar. Where extending from existing HWS circulation pipework, the new pipework must be of the same material as existing to avoid dezincification. However, galvanised steel pipework must not be installed in UCL buildings and all existing removed wherever practicable and or economical. Plastics pipework systems will not be considered unless by approval of the UCL Operations and Infrastructure Teams or for specialist requirements with labs etc. All other pipework systems must be either copper or steel.

Stainless steel braided EDPD (or similar) flexible hoses must not be used for final connections to outlets. All Final connections to outlets to be in hard copper pipe, unless connecting to vibrating equipment. Corrugated copper flexible connectors are an acceptable alternative, if WRAS approved.

Deadlegs must be avoided where control sensors or thermometers etc are installed. Transducers must be provided on the delivery side of the pump to monitor operation via the BMS.

Services must be labelled “cat 2 water” or “cat 5 water”

C.2.6 Above Ground Drainage

An intrusive CCTV survey is to be undertaken with full surveyors report and identified remedial works clearly shown on base drawing for is undertaken any existing building and associated drainage system including utility sewer connection outlets in order to define a full scope of works and risk assessment. Any remedial works to existing systems must be agreed with the UCL Operations and Infrastructure Teams. Coordination with the Structural Engineer’s below ground drainage scope must be discussed to validate the associated below ground drainage system by, potentially, the same CCTV survey.

The above ground foul drainage systems must be installed to discharge all waste and effluent via gravity from all sinks, FF&E, sanitary fittings, kitchen appliances and any mechanical plant/equipment etc. Pipe work must be routed down through the building to ground level to connect to the below ground drainage system. The system selected shall be suitable for the building served and as a minimum must be a modified one pipe partially ventilated system.

All internal vertical soil / waste vent pipes and foul water drainage pipes passing through occupied areas outside the main service risers must be insulated acoustically. Automatic air admittance valves are to be discussed with UCL, where practical. All rainwater collection pipework in ceiling voids shall be insulated both acoustically and thermally against condensation. Access must be provided on all vertical foul drainage stacks at 1200mm above each finished floor level, rainwater stacks shall include access at alternate floors, to the centreline of the access door and on horizontal pipe work in accordance with the requirements of the Building Regulations and BS EN 12056-2, as amended.

All DX Units, fan coil unit and air handling units must be provided with condensate drainage, with the required air break detail. In addition NRV’s/waterless traps are to be fitted prior any other connection before discharging into the main stack via inline waterless traps..

Where laboratory drainage is provided, this must carry chemical laden waste water including fume cupboards, laboratory benches, equipment, floor drains, etc. for final discharge into the below ground drainage system. Drainage stacks carrying radioactive waste must be suitably labelled at all access points and periodically / each floor throughout its length, also where it discharges to the foul drain sewer/or manhole. Laboratory stacks must be separate and not be combined with WC usage. Lab sinks/outlets are to incorporate a form of “running-trap”. The Building Services Designer must check with the relevant department for information on the substances to be used with the drainage to ensure correct material selection. Typically, Vulcathene or similar drainage will be appropriate. The main ventilating pipe work must be installed to suit the design of both the above ground laboratory drainage system and the below ground drainage systems as necessary and must terminate to atmosphere.

Rainwater systems must typically comprise gravity systems and these must be generally be collected from roof areas by a combination of rainwater outlets and gutters with downpipes. Pipework must be routed to discharge flows via gravity, vertically down through the building. Full coordination with the project Architect will be required where necessary in relation to rain water scope and package of works.

All services passing through building fabric must be sleeved and insulated, and must be continued through the building fabric. All pipe work and equipment must be earth bonded. Access must be provided on all vertical internal rainwater pipes at 1200mm above each finished floor level, to the centreline of the access door and on horizontal pipe work in accordance with the requirements of the Building Regulations and BS EN 12056-3.

Gradients of all rainwater pipes must be a minimum of 12mm/m, but must be to suit the individual flow characteristics of each rainwater pipe, to achieve a minimum self-cleansing velocity.

Consideration may be given to the use of a syphonic rainwater system in conjunction with the Architect and input from a specialist system supplier.

Suitable access provision must be allowed for throughout the building and the system to allow for adequate maintenance which must include for consultation with the UCL Facilities Department to determine any specialist traps and grease removal management.

The use of sewerage pumping units to be approved by the Principal Mechanical Engineer.

C.2.7 Chilled Water & Cooling Systems

Hierarchy

1. No air conditioning
2. Mechanical ventilation
3. Comfort cooling
4. Air conditioning

Where there is significant load, a chilled water system must be considered.

Free cooling must be considered in the first instance, with absorption cooling and chillers applied where this is not possible. Delivery mechanisms shall be in the form of fan coil units and chilled beams.

CIBSE approved overheating assessments and energy modelling must be discussed with UCL and the Designer as part of the project's initial brief in relation to cooling requirements..

Cooling systems must only be provided where absolutely necessary; passive means of conditioning must be prioritised in the first instance followed by mixed mode (extract only during warm conditions). Consideration must be given to design of high temperature (flow 14°C or above) or seasonally adjusted cooling systems in order to maximise free cooling and operating efficiency. Only where dehumidification is required must lower flow temperatures be implemented.

Process cooling and requirements for server rooms to be sized carefully to meet operating requirements. Proposals are to be approved by the Principal Mechanical Engineer. Backup systems and arrangements to be discussed and approved during design.

Environmental and process cooling to be separated (chillers, plate heat exchangers etc.).

Consideration must be given to specialist cooling requirements such as:

- Process loads.
- Absorption chilling
- Highest EER/SEER as possible.
- Central packaged chillers must generally utilise scroll or multiple screw compressors. Associated free cooling equipment to be assessed for the application.

Modifications to existing water-to-waste cooling systems shall not be permitted and shall be replaced with dedicated process cooling circuits, where possible.

Building Services Designers must require tenderers to identify the COP at design conditions as well as EER/SEER as part of the tender submission. All specified refrigeration systems must have minimal or zero global warming potential (GWP) wherever suitable equipment is available.. The Building Services Designer must when selecting cooling/chiller plant take due consideration of the F-Gas Regulations and HFC phase down.

Chillers must be provided with electronic soft starters or other low-current starting device. Buffer vessels must be provided to minimise starts at low load conditions. BEMS control must include operational status, on/off and CHW modulation. Glycol content and trace heating to be reviewed on a project specific basis along with manufacturer warranty's.

Friction free, magnetic bearing (Turbocor type) chillers must be considered for reduced energy costs and carbon emissions, but must be agreed with the UCL Operations and Infrastructure Teams and the UCL Maintenance Team.

Care must be taken to assess the effect of plant failure and maintenance on serviced areas, and any necessary contingency provided. This risk assessment is particularly relevant to animal areas and/or critical operational areas e.g. main computer server rooms, where the maintenance of specified temperatures is either legislative or operationally required. Such considerations must include 100% independent back up with auto changeover, remote alarm of high temperature and/or plant changeover to a continuously manned monitoring position and UPS/standby electrical generator.

CHW must be split into primary and secondary circuits. The circuits must be provided with independent run and standby pumps complete with variable speed drives and 2-port control valve in an injection circuit.

Space cooling must be by chilled beam where possible on a (typically) 14°C flow and 17°C return circuit, however it must be noted that at these temperatures, fresh air dehumidification will typically be required at design conditions. Where other forms of cooling are used it is essential that control of water flow be by 2-port control without local bypass. The use of low water temperature systems must be avoided, particularly where operation is required during periods of low external temperature. Automatically or hydraulically controlled bypass arrangements will need consideration for installation within the field pipework or plantroom circuitry – to only open in the event of low demand. No permanently open bypasses shall be permitted.

Valved flushing loops must be fitted at all terminal units. In-line strainers must be fitted before all control valves. If fan coils are used, these must be complete with internally fitted thermostats and low temperature cut-out switches. Access panels must be provided to facilitate easy maintenance of filters, motors, control valves etc. Internal filters must be fitted

and have an atmospheric dust spot efficiency of at least 55% when tested in accordance with BS 6540, as amended. Control must be by interface units to the BEMS system

The provision of cooling to server rooms, IT hubs and freezer equipment rooms etc. where cooling load would not be proportional to external temperature, must be selected with care. These areas are also operational on a 24/7 basis and cooling equipment must be selected on the basis of high CHW flow temperatures. Generally these areas must be provided with air supply to utilise local free cooling.

Refrigerant flammability to be discussed with UCL during design to determine any further measures that may need to be implemented as a result. IE: fire suppression, early warning detection etc.

Small areas or specific equipment requiring localised cooling may be served by DX split equipment. Building Services Designers must require tenderers to identify the COP at design conditions as well as EER/SEER as part of the tender submission. These units must be monitored by the BEMS system and leak detection must be provided to all refrigerant systems with consideration given to automatic pumpdown. Supplementary room-side leak detection systems to be reviewed where relevant to the application. Consideration of the consequences of equipment failure is essential. Where this is the case, consideration to be made to location, bearing in mind requirement to eject heat, noise and visuals.

Where central chiller installation are either not viable or feasible in terms of size, weight, loads or acoustics, consideration can be given to the use of Variable Refrigerant Flow (VRF) systems. This should be a last resort, using a 3-pipe system and requires approval.

All refrigerants must be zero ozone depleting with low global warming potential. For further details refer to the UCL Sustainable Building Standard.

At design RIBSA Stages 3 and 4 consideration must be given to the appropriate refrigeration specification with a detailed feasibility report being produced which identifies the advantages and disadvantages of each refrigerant. This report must be presented to the Operations and Infrastructure Teams and Sustainability teams for comment and approval prior to proceeding with the design.

Where extending from existing chilled water circulation the use of the original system component types must be considered along with Geberit “Mapress” stainless steel pipework to reduce the risk of interaction between dissimilar metal materials. Imperial size ABS tube (class E up to 50mm and class C above 50mm) must be specified as this has a higher rating than the metric size range. Where adapting from screwed fittings to plastic, male threaded plastic fittings must be used. Female threaded plastic fittings must NOT be used as these have been found to readily split when the joint is tightened. Durapipe Superflow thinwall ABS MUST NOT BE USED. Where separate new plant and pipework is provided then ABS, stainless steel, or copper must be used as appropriate.

Where plastic pipework is considered, approval to be sought from Principal Mechanical Engineer.

Where pumps are required within the system, they must be to the highest efficiency as possible, and where the load allows variable speed drives must be used.

Interface with BMS to prevent simultaneous heating and cooling, appropriate dead band to be configured.

C.2.8 Expansion and Contraction

Provision for expansion and contraction of pipe services must be designed and detailed on the tender drawings rather than covered by a general clause in the specification. The preference is to build in expansion loops and natural flexibility as opposed to using bellows (expansion joints).

C.2.9 Isolating Valves

Isolation valves must be detailed at main pipework junctions and at all branches from risers to enable future adaptations without the need to isolate large areas of a building. All terminal units must be provided with isolating valves as must components which may require removal for maintenance such as strainers.

Gear operated butterfly isolation and commissioning valves are to be installed in all plantroom applications and on field pipework discussed with UCL at design stage to ensure full-closure of the valve during its entire economic design life.

The Designer must ensure that all isolation valves are checked and adequately tested / proven during the construction, testing and commissioning stage.

C.2.10 Equipment Cooling

Where scientific equipment requires process cooling then this must be provided by closed circuit systems incorporating a chiller (or a plate heat exchanger if central chiller plant is available). Buffer vessels must be incorporated to provide stable temperatures. Where removal of residual heat from equipment is required in the event of electrical or chiller failure then an automatic, standby, water to waste system utilising normally open and normally closed solenoid valves must be considered after discussion with the UCL Operations and Infrastructure Teams.

The use of solenoid valves to be kept to a minimum due to the ongoing maintenance of the products.

User Departments must be consulted to obtain installation requirement data for the equipment to establish:

- Heat gain
- Min/max water pressures
- Tolerance to back pressure (e.g. some electron microscopes will not operate if the outlet back-pressure/static lift exceeds approximately 3 metres head)
- Flow rate
- Whether tap water or treated water fill is required (e.g. de-ionised water may require special components)
- The required cooling water flow temperature to avoid condensation
- Whether there is a requirement for removal of residual heat from equipment in the event of electrical or chiller failure.

C.2.11 Mechanical Ventilation

Mixed mode systems must be used where natural ventilation is insufficient to ensure comfortable internal conditions throughout the year. This will include an extract fan which is operated when certain internal conditions are reached, with make up air typically via

automated façade ventilation. It is preferable that each space has its own extract fan to avoid scenarios where unoccupied rooms are overcooled in the mid season due to the adjacent room being occupied and triggering mixed mode operation.

Where dedicated extract fans are implemented, discussions with UCL are to be had in relation to the practicalities a form of heat recovery being implemented.

Heat recovery must be provided on all supply and extract systems where appropriate and the exhaust air stream is not unsuitable for the purpose. Preference must be given to high efficiency systems such as hygroscopic thermal wheels (80%+ efficiency), followed by non-hygroscopic (70%+ efficiency), then plate heat exchangers (50%+ efficiency) followed by heat pipe/runaround coils (40%+ efficiency). Use of double thermal wheels may be considered in some circumstances. Fully modulating motorised bypass dampers must be provided on plate heat exchangers.

Generally, ventilation fans must be centrifugal, of the backward bladed type with a fan total efficiency of not less than 50%. Where fans are belt driven, a minimum of two belts must be used. Particular consideration must be given to Specific Fan Power (SFP) of mechanical ventilation installations, particularly in new build projects. Direct drive plenum fans are more efficient and must be considered first, over other products.

All fans must be provided with variable speed drives. In new buildings, design of systems including heat recovery must aim for a minimum SFP to provide compliance with the current Building Regulations. Within existing buildings where riser or distribution routes are constrained, this may be relaxed.

Maximum velocity across cooling coils in AHUs must be 2.0m/s and all coils must be provided with trapped condensate drains . Traps to be transparent to allow non-intrusive inspection. All AHUs must be compliant with CEN class L3 or greater for leakage.
Duct and all component air velocities are to comply with CIBSE guidelines.

WCs must be provided with extract ventilation and make up must be either via doors only (for smaller WCs) or via a combination of doors and supply make up air. Make up air must be supplied at 85% of the supply rate to ensure negative pressurisation. Consideration may be given to constant pressure systems whereby the fan provides trickle extract during unoccupied periods and ramps up to full extract for a pre-set period when occupancy is sensed via PIR. Run and standby twin fans with auto-changeover must be provided on WC extract systems. Humidistats can be utilised in shower/moisture laden applications. BEMS monitoring and changeover provisions to be installed for duty/standby fan applications.

Kitchen designs to be fully compliant with DW 172. Commercial kitchen extract systems must be installed in 2 hour fire rated stainless steel ductwork with bifurcated axial extract fans. The minimum velocity in kitchen extract ductwork must be 9m/s to prevent grease from falling out. Discharge velocity must be 12-15m/s. Regular access panels must be provided in accordance with DW172. Any supply fan must track the extract fan at 85% of its flowrate. All supply and extract fans must be interlocked with the gas supply to ensure that gas Is not supplied to the room when the ventilation system is not in operation.

Suitable attenuation must be provided to all ventilation systems. The maximum pressure drop for primary attenuators must be 50Pa and crosstalk attenuators must be no greater than 10Pa. Consideration must also be given to suitable sizing of weather louvres where used such that velocity and pressure drop are not excessive; typically less than 4m/s face velocity and 50Pa pressure drop or lower depending on noise criteria. Refer to DW172 for high velocity discharge cowl arrangements.

Within laboratories mechanical ventilation must be designed as a full fresh air system with heat recovery where appropriate (e.g. heat recovery from fume cupboard and safety cabinet exhausts is not considered appropriate). Consideration must be taken in relation to return air from laboratories and corrosion affecting heat recovery units. Thermal wheels and cross flow plate heat exchangers are preferred to heat pipes and run-around coils.

LPHW heating coils must be provided rather than electric heating except in exceptional circumstances (e.g. standby heating for BSU's).

Frost coils must have wide spaced fins to minimise fouling.

In areas other than BSU's control of humidity must normally be only provided if specifically requested.

Supply air diffusers must be designed and located to minimise air movement at the face of fume cupboards and microbiological safety cabinets which would otherwise have an adverse effect on containment. Designer to verify whether turbulent/excessive air movement directly over other areas or items of equipment are also deemed as relevant and need to be avoided.

Laboratories must generally be designed to operate at negative pressure (i.e. greater extract than supply) for containment. Where there is a specific requirement to design a laboratory for positive pressure for cleanliness then this must be referred to Principal Mechanical Engineer for approval. If this is accepted then a lobby must be incorporated to provide containment and to prevent spread of smoke and fire to corridors and means of escape. Certain applications to be agreed with UCL to incorporate photohelic or magnehelic for local and remote visibility in relation to the differential air pressure.

Generally all mechanically ventilated areas must be designed to operate at negative pressure to prevent spread of smoke and fire to corridors and means of escape.

Supply/make-up air systems for local exhaust systems (fume cupboards etc.) must be controlled such that this is isolated when the local exhaust system is off to avoid pressurising the room. Where appropriate, systems must include constant volume devices to maintain the system balance when interlocked make-up air supply branches are isolated.

All air handling units must consist of the following components as appropriate:

- Twin wall insulated frames
- Pre-filters to unit and heat exchanger, secondary bag filters
- Heat recovery (thermal wheels, cross plate and run around coils)
- High efficiency, variable speed fans
- CO2 control
- Chilled water or DX cooling coils
- LTHW or gas fired heating coils
- Inspection sections for maintenance
- Inspection windows
- Internal and external lighting complete with manual local switching
- Humidification (where deemed as required)

All air handling systems must be fitted with a full set of clean filters and provided with a full set of new spare filters at handover. Filters shall be of the easily replaceable type and shall be fitted with dirty filter indicators. Bag, HEPA and carbon filters shall have a pre-filter. DPSs must be considered for remote interfacing with the BMS as well as visual indicators.

The O&M manuals must contain a separate sheet listing the number, size, and type of all filters so that this information can be readily accessed to update the master schedule for the Campus.

Transducers for the monitoring of air flow on all fans and filters must be provided and interfaced with the BMS system.

Fresh air inlets shall be positioned so as to be unaffected by vehicle exhausts and to be as far away as possible from fume cupboards, other exhaust points and heat rejection equipment such as chillers.

Fume exhausts to terminate at least 3.0m above finished roof level of which the associated fume exhaust fans are sited. Project-specific risk assessments maybe required where higher neighbouring roofs are in close proximity to the fume exhaust termination.

Careful consideration to be made when deciding where ventilation points are located. Disabled individuals are more likely to struggle to control core body temperatures so it is important that ventilation points are not above locations where disabled individuals are forced to sit, for example above the wheelchair viewing spot in lecture halls, above an accessible toilet, above the change table in a changing places toilet etc.

The Building Services Designer must give consideration to the potential for build-up of smells/CO_2 and implement controls to combat this, but without adversely impacting energy consumption.

C.2.12 Cooling Towers and Dry Coolers

Air blast and adiabatic air blast (dry) coolers must be employed where practical but, subject to consultation with the UCL Operations and Infrastructure Teams, adiabatic cooling and cooling towers can be considered.

On smaller dry coolers, EC fans must be used where economically viable. Noise from dry coolers must be borne in mind when locating them. Operating efficiency of dry coolers may be improved in some circumstances by using evaporative cooling meshes on the air intake path. Several dry cooler manufacturers are able to provide such systems to suit their own products.

Where cooling towers are specified, there are many factors to consider and in particular, care must be taken to prevent the presence of legionella at all cost. Maintenance requirements are significant and therefore dry cooling systems are preferable. Key design aspects include:

- Water treatment – scale inhibitors, sidestream filtration and biocide dosing direct into tower sump (multiple biocides alternated)
- Location – prevention of recirculation, noise, pluming, distance from air intakes
- Winter operation – sump heaters
- Capacity control – variable speed fans
- Noise Attenuation
- Access – ladders and inspection hatches
- Local Authority requirements
- Structural implications

C.2.13 Biological Services Units (BSUs)

Systems for holding rooms and other such licensed areas must comply with the current code of practice for the Housing and Care of Animals used in Scientific Procedures published by HMSO.

Design for a minimum of 20 ach in holding rooms and increase as necessary where required due to high heat gains. Consideration must be given to the use of self-contained holding cabinets with integral environmental controls.

Maintaining the ventilation, cooling and humidification to these areas is critical and where stand-by power generation is available the AHU's must be arranged to operate in the event of mains power failure. This requirement would not generally extend to the associated chiller plant due to the high power demand of such plant but the User Department must be consulted. The AHU's must be provided with duplicate components to maintain the ventilation but this need not necessarily mean duplicate 100% duty plant but could be designed to maintain say 66% duty on failure of one component. Boilers and chillers must comprise modular components and duplicate pumps etc must be provided to maintain reasonable conditions in the event of failure of one item of plant.

Terminal reheat designs are preferred for good humidity and temperature control. Hot and cold dual duct systems are not generally acceptable.

Single head pump configurations, not twin head pumps, are to be installed in a parallel fashion to act as a back up arrangement.

Humidifiers must be of the steam generation type and gas-fired units must be considered as well as electric units. Resistive humidifiers are preferred and are to installed complete with reverse osmosis (RO water treatment plant.

BSUs can be particularly sensitive to noise and vibration from adjacent spaces and from building services. Noise and vibration requirements must be discussed with User Department during design stages and this must be used to inform building design. For refurbishment works being carried out in buildings housing BSUs, noise and vibration from construction works will need to be limited to meet User Department requirements.

BSU installations must be controlled by a Building Energy Management System (BEMS) linked to the various supervisor terminals on the main campus. Additionally, the BSU must be provided with a supervisor terminal for management by the Users, but this must have access limited to the particular BSU only. The controls must be configured to log temperature and humidity in each licensed room, and to relay critical environmental alarms to UCL's permanently manned communications room. User Department to be consulted to define which alarms and at what set points it is appropriate to activate these alarms to summon "out-of-hours" attendance. User Department to also be consulted to define data logs length and frequency requirements.

Prior to project hand over BSU/lab cooling applications to have heat load and humidity control testing using temporary portable heaters ramped up/down to simulate heat gains and system reaction. BSU Manager and Home Office representative to advise upon duration of testing required.

Calibrated temperature/humidity/CO_2 loggers are to be placed within the rooms for a certain period of time/number of days - to ensure systems control within the correct limits under given min/med/max temperature and occupancy conditions etc. in order to soak test the system reaction and performance.

C.2.14 Controls

Unless projects are of a minor nature then installations must be controlled by a Building Energy Management System (BEMS) linked to the various supervisor terminals on the main campus. Designer to provide detailed description of the building and system controls whilst adhering to UCL BMS Standard Specification. Full BMS Specification included as Appendix D of this document.

The UCL Operations and Infrastructure teams should be consulted to discuss requirements.

C.2.15 Continuous and Out-of-Hours Operation of Plant

Where a room or area such as an equipment room or constant temperature room requires continuously operating cooling or heating then consideration must be given to the provision of independent plant rather than connecting to central plant, to avoid extended operation of a larger, central, system which could otherwise be controlled by a time schedule.

Where a Lecture Theatre or similar facility is likely to be used or let for use beyond the normal time scheduled hours of operation for the building in which it is located consideration must be given to the provision of independent plant to avoid extended operation of the whole building. Where appropriate separately time controlled zoning may be employed to achieve this requirement.

The UCL Operations and Infrastructure teams must be consulted on this issue at design stage.

C.2.16 Fume Cupboards (FCs)

All Fume Cupboard installations will comply with BS EN 14175, as amended.

All new F/C's considered for use within UCL will comply and have passed the Containment Robustness Test to BS EN 14175, as amended.

The supply and installation of fume cupboards will generally form part of the construction contract.

Ensure that a "**Standard F/C Information Sheet**" (available from the UCL Operations and Infrastructure Teams) are completed and signed by the User Department so that all the criteria required by the end user is encompassed within the design.

This information will help identify any special requirements or needs to aid the best design, this types of information may include:-

1. Radio Active Works.
2. Hydro Chloric Acids – Special Sashes.
3. Air Scrubbers
4. Ventilated under F/C Cabinet Cupboards.
5. Walk in F/C's.

Water supplies, sink/drip cup, cover over sink/DC - constructed of adequate materials to suit the use, gases, suppression, emergency lighting, FEF BEMS interfacing, power

requirements within FC itself, size requirements, chemicals/acids used. Drainage to be S-trap/running trap (no bottle traps). Available floor to ceiling must be denoted.

AV/cameras within/adjacent FC itself - for teaching/demonstration purposes.

Fire man's override switch to be located outside the lab or within a certain building location - to suit the specific risk assessment of that project/building.

Copies of this form, plus any information regarding the existing F/C, which are to be removed, are to be submitted to the UCL Operations and Infrastructure Teams for assessment, as they hold historical information upon each UCL F/C.

Upon completion of any new or replacement F/C works, the air velocity test results in the form of a '**F/C Test Certificate'** are to be submitted to the UCL Operations and Infrastructure Teams.

This information is essential to help maintain the F/C Schedule, as required by legislation.

The design scheme for all F/C Installations are to ensure:-

a) That individual Lab F/C Exhaust duct are independently routed separately and not connected to any neighbouring Labs, as a part of the UCL Safety Regime. Groups of F/C's within a single Lab can be joined together and exit the building, but F/C's within groups of individual Labs cannot be joined together, as this can cause safety issues, by mixing potential dangerous mixture of chemicals within a restricted duct, this situation must be avoided and design out. Hydraulic or electric CAV's for each FC to be installed, along with associated controls/monitoring system.
b) That the exhaust ducts from the F/C's, must where possible, exit the Lab and building immediately, reducing the requirement for Fire Dampers or fire collars, where F/C Exhaust ducts are routed through the building via unprotected fire zones, these ducts must be protected within fire proof enclosures until they either exit the building of enter a fire protected mechanical riser.
c) That there's an adequate Supply / Make-up air being supplied to the space.
d) The F/C shall be positioned, so there is no direct air flow from a supply louvre or A/C Unit being blown into the front or across the face of the F/C.
e) The F/C shall be positioned within the Lab:-
    1. With the correct space in front and sides (including overhangs/protrusions) of the F/C, to minimise any disturbances and prevent disruptions to the air flow across the face of the F/C, for the user and access space.
    2. No equipment shall be placed in the vicinity of the F/C to impede the air flow in anyway or hinder the user or access space.
f) Designated zones could be shown on the floor in front of the F/C using different colour floor covering.

If a FC can be switched off as part of its required use - the general extract serving that space needs to be interlocked/interfaced with the operation in order to ensure that the necessary extract air volume is achieved when the FC is "off".

The Installation of new F/C's shall be only installed using the following guide lines: -

1 All new F/C's installed within any of the UCL Campus Sites will be of the Low Velocity Type, have been selected using the European/BS Standards incorporating ASHRAE 110 Standards. F/C manufactured by either S+B UK or Waldner are the only F/C Manufacturers that have carried out the Containment

Tests across all their range of F/C's and passed with a Containment Percentage of +90%, also another important factor is the Recovery Time taken when the air in front of the F/C Sash stabilises after the air has been disturbed by a passing objects.,
UCL Standards & Specified Limits for Average Face Velocities when installing Low Velocity F/C's. = 0.35 m/s; Radio-active F/C's 0.55 m/s
S+B UK Ecoline & Waldner Units are presently specified for use at the UCL, as all their Controls are based beneath the F/C Work Bases and are easily accessible, and can be repaired quickly without removing F/C side panels. So reducing down time to the users.

2 Each F/C will be installed within any Lab area with the correct installation and access space around the F/C.

3 An adequate Supply Air System shall supply the correct Air Volume to the Lab Space to allow the F/C to function and operate correctly, the Supply Air Louvres to the Lab shall be defused and positioned so there'll be no direct air flow directed at or across the F/C Sash Opening

4 All the F/C Exhaust Ductwork Systems will be installed in Plastic ducting. External ducting will have an application of an external GRP Coating to the external faces of the F/C Duct, and will protect the F/C Duct against UV Light degradation and will also strengthen the F/C Ducting against strong winds and storms.

5 The F/C Discharge Stacks will be minimum height of 4.0 metres above any building structure or structure that any standing Maintenance Personal are required to work in, within a 10m radius area surrounding this F/C Discharge. The F/C Discharge Velocity from this F/C Stack to have a discharge velocity of 10 m/s. This will assist any fumes being discharged above the Pressure Bubble that naturally surrounds the building.

6 The correct F/C Ductwork support brackets are to be used. External Brackets to be galvanised.

7 All large rectangular PVC F/C Exhaust Ducts will be constructed using flanged sections of PVC Ducting, assisting the duct with strength and rigidity, the sections will be connected together using S/S Bolts and Spring Washers.

8 Where practicable the F/C Exhaust Duct is to exit the Lab/Building as soon as possible, and rise to a discharge point on the roof, limiting the use and requirement of Fire Dampers within the Duct run across the floor area

9 F/C Exhaust Systems from different Labs upon a floor or different floors shall not be joined together, but be discharged separately.

10 If VAV F/C's are to be considered for this installation, further discussions would be required regarding the overall design and operational systems being proposed. UCL in the past have experienced the Phoenix Type Controls which are problematic when faults are found and replacing these controls are awkward and complex, creating long down time to the Labs and users.

11 Would be an advantage if the locations of the F/C's could be located upon the upper floors of these buildings, this would reduce the length of the F/C Duct runs from F/C to F/C Discharge point. Leaving space for the other services to be routed freely across the areas.

12 New F/C's will be specified to be supplied with :-
a) Audible & Visual Alarm Units [ITT 1000 Alarms]
b) Auto Sash Closure Mechanism
c) Drip Cup or Sink & Cat 5 Water Supply, to facilitate good House Keeping of F/C.
d) Various Gas/Medical Gas Taps, Specified by User Department.
e) Nat Gas Connections to F/C's shall not made
f) LED Lighting / Emergency Lighting Packs

13 Construction of F/C side panels will be constructed of Trespa Panels, giving the F/C added strength & making them robust.

14 Some F/C's may require special features designed into their systems:-
i) Scrubber Systems incorporated within the F/C Exhaust Outlet.
ii) Fire Protection Systems – PSFFSS – Jactone Monnox Powder
iii) Stainless Steel or Glass F/C Inner Chamber Liners.
iv) Ventilated Chemical Storage Under-Cupboards.
v) Polycarbonate Sash Glass, for Sulphur Acid Works.

All new Projects, which require the installation of F/C's, these will all be designed using Low Velocity Constant Volume Type F/C Units, these will be designed with an average face velocity of 0.35 m/s at 500mm sash height for a general purpose cupboard, and an average face velocity of 0.75 m/s at 500mm sash height for use with radioactive substances.

- Sash to have adjustable "stops" and neat markings to ensure the sash height cannot be exceeded.
- For both VAV and CAV fume cupboards, target narrower models where feasible to further minimise energy usage.

VAV fume cupboards only:

- Specify default sash heights of 400mm - ensuring that this can be overridden and raised to 500mm for testing purposes, taller users and setting up. This may be achieved using sash locks and/ or alarms. (Note: For CAV fume cupboards the default sash height shall remain at 500mm as varying the sash height does not impact on energy usage.)
- Install passive infrared monitoring linked to automatic sash closures to set back air volume in absence of users.
- Any sashes with auto-closure functionality must have handles removed to avoid users breaking units. Appropriate training and signage must be provided.

Note: Setting sash heights at 400mm rather than 500mm can result in energy savings of 20%. However, testing must always be carried out at 500mm where fume cupboards open to this level.
In all cases health, safety and welfare must take priority. User input and risk assessments must be reviewed and adhered to when setting sash heights.

Currently UCL accepts Low Face Velocity F/C's from two manufacturers, who have satisfactorily demonstrated that their F/C conform & have passed the "Containment Robustness Test to BS EN 14175". These F/C's being manufactured by: - S+B "Ecoline" and the Waldner "Secuflow", these are the only F/C's who have currently been approved.
From the F/C Information Sheet will determine the type of composition of the F/C Inner Chamber / Worktop, the user is to re-confirm this.
The total exhaust volume for the Waldner cupboard needs to be 80 m3/hr greater than the sum of the average face velocity to allow for the support fan volume which is a component of this cupboard.
Construction details must be discussed at an early stage as fume cupboards have many options and are generally on an extended delivery.

All existing & new F/C will be fitted with "Audible Alarms" & "Visual Indicators" to show the user or operative that the F/C is safe to use, if the alarm is sounding this must be reported to the Lab Manager or reported as a fault to the UCL Helpdesk, for action.

Each F/C of banks of F/C's will have an adjacent means of Isolation which will isolate the electrical power supplies serving the F/C or F/C's Dedicated natural gas proving system is advisable. Along with any other lab gas isolation serving a bank of FC's.
All new Low Velocity F/C's will be illuminated by LED Lighting, where an Emergency Lighting System is required, on the dictates of the UCL Fire Officer, these will also be LED Lights.
End Users to advise upon importance/safety of completing a task/making-safe a task in the event of a power failure. This may also impact general/emergency lighting requirements.

All new F/C's to have proximity sensor to close sash after pre-determined absence time (variable up to 15 mins with sensor to stop sash if obstructed).
Sash's will be normally be specified to slide in the vertical plane, this will enable proximity sensors to be positioned above the F/C as an energy saving mechanism to close the sashes when left un-attended for a period or not in use, as previously stated.
Horizontal sliding doors can also be specified, but are not the norm.
All the Vertical Sashes will be fitted with opening stops, set at 500mm on each unit, which can be released to allow loading F/C with equipment within the F/C Chamber.
A maximum operational Sash height marker [500mm] label will be placed on the side of all F/C's, to notify the user of the maximum operating sash height.

Rear of chamber to be fitted with grid of scaffold mounting points.

Where possible, any Lab which has a multi-installation of F/C's, must incorporate a design to include VAV controls, in an effort of obtaining the maximum energy efficiency. This design may be dependent on the suitability and location of the Supply AHU.
Sensing Pressure Grids will be fitted within the main F/C exhaust duct, this will in turn control the F/C Extract Fan, increasing or decreasing the Velocity & the Air Volume, via an inverter, a control signal to the Supply AHU Fan, which will act in unison with the demands of the Labs F/C's, F/C Extract Fan. To prevent the F/C Extract fan from stalling VAV controlled ambient air intake dampers to maintain required efflux velocity will be installed within the Main Extract Duct Run.
Fireman switch will be installed adjacent to the Lab entrance/exit door, and be
Hard wired in fire rated cable/containment.
FEF to have BEMS and fire alarm interfacing.

F/C Exhaust Fans must generally be direct drive units with inverter control for commissioning purposes.

FEF's and all associated components to be externally rated and to be mounted on AV mounts and neoprene sheeting/Tico pads. FEF to be labelled stating where FC is located. Similarly, corresponding FC is to be labelled stating where FEF is located (UCL plant/equipment labelling procedures are to be followed).

Multi F/C Installation will also require stand by motor operation on the F/C Exhaust fan

F/C Systems are to be designed for 100% diversity in Chemistry (other locations to be discussed). VAV controller to have max response time of 3 seconds and to interface with make-up air controller.

Proximity sensors are to be fitted above sash opening thereby controlling the position of the Sash by closing the sash when the F/C is unattended.

A number of face velocities measured reading must be taken and recorded across the face of 500mm high Sash opening, based upon a grid, in accordance with BS EN 14175, as amended, the average reading of these will suffice for site tests of single conventional cupboards. Maximum/minimum face velocities across the measurement grid must not deviate from the average by more than 20%. Full containment tests are required on site for multi-cupboard installations in accordance with BS EN14175, as amended. These must include inner and outer grid SF6 gas measurements.

F/C Exhaust ducting will be installed in UPVC ducting, with all external ductwork sections being coated with GRP Coating to provide mechanical protection and to eliminating UV Solar degradation. Other materials can be used where determined by a specific F/C requirement. F/C Exhaust systems must be independent of, and NOT combined, with general extract systems.

Where deemed as required inline fume exhaust ductwork attenuators of the same/compatible materials shall be installed to comply with internal noise design criteria and external noise criteria for planning purposes.

Humane external bird control measures are also to be considered for runs of external ductwork.

The external F/C Exhaust duct will be supported from the building structure via galvanised gallows type support brackets manufactured for external use. These will be designed, sized and manufactured correctly to support the F/C Exhaust ducts, these will support the galvanised brackets or bands which are connected and surround the UPVC Duct. Supports, FE ductwork and FEF arrangements/locations to be reviewed on a project-specific basis by a Structural Engineer.

Discharge stacks must be a minimum of 3 metres high above the immediate roof level or, where a nearby roof level within a 15 metre radius on which maintenance or other personnel will stand is higher, then 3metres above that higher roof. Discharge stacks must terminate with a high velocity cone giving an efflux velocity of 10 to 12 m/s.

On dictates of the UCL Fire Safety Team and for additional Fire Protection. Any F/C's that use flammable chemicals, shall be fitted with a PAFSS Fire Protection System, as specified by the UCL Fire Safety Officer. PAFFSS - Monnox Fire Protection Dry Powder Canisters can be installed either beneath the F/C or at H/L on the side panel of the F/C. These units are manufactured by Jactone, and can be Retro-fitted to F/C's.

Each F/C must be fitted with an audible Alarm included within an Alarm Panel, this panel also must indicate to the user visual indication that the F/C is safe to use in operating normally.

Engage users to determine if the provision of vented storage cabinets can minimise the size and/ or number of fume cupboards. **Fume cupboard chambers must not solely be used for longer term storage**

"Ventilated-Under F/C Chemical Cupboards" can be installed for Chemical Storage, these are to be requested at time. All materials to suit chemicals and acids. Ventilated cabinets to extract 24/7 and have seals around the doors. Make up air into the cabinet to be considered as part of the cabinet construction itself.

Where Fireproof Chemical Cupboards are requested these are standalone items, but can be positioned beneath the F/C, but not vented through it.

C.2.17 Microbiological safety cabinets (MSC's)

Systems incorporating microbiological safety cabinets (MSC's) must comply with BS 5726 and BS EN 12469, as amended.

MSC's are generally supplied and installed as part of the construction contract OR are supplied by the User Department. In either case the provision of all associated ducting and ancillaries and the integration into the overall systems must form part of the construction contract. Ensure that on site containment tests as described in the BS are carried out and certificates issued to the User Department on completion.

Class 1 MSC's are similar to fume cupboards but have a HEPA filtered exhaust. Refer to manufacturers for the required exhaust rates.

Class 3 MSC's have full glove box protection

Class 2 MSC's have single HEPA exhaust filters where ducted to outside but must have double HEPA exhaust filters in series where arranged to recirculate within a room. Although other methods of fumigation are available this is commonly carried out by boiling formalin to produce formaldehyde and provision must be made to exhaust the fumigant on completion.

Fumigation requirements to be confirmed for each project. Local or centralised/ducted system.

The Safety Advisory Officer of the UCL Operations and Infrastructure Teams must be consulted to confirm if a room recirculation cabinet is appropriate for particular works carried out by a User Department.

The UCL Operations and Infrastructure Teams must be consulted to discuss and agree the options for exhaust ventilation from MSC's. Exhaust systems must be independent of, and NOT combined, with general extract systems.

If SC can switched be off dedicated CAV and interlocking with the general extract will be required. Along with make up into the space from air filtered transfer grilles - which may also be fire rated and automated fire-smoke dampers.

See also “The management, design and operation of microbiological containment laboratories” by the Advisory Committee on Dangerous Pathogens (ACDP) published by HSE books.

C.2.18 Microbiological laboratories

Microbiological laboratories must be designed to the requirements of category 2 of “The management, design and operation of microbiological containment laboratories” by the Advisory Committee on Dangerous Pathogens (ACDP) unless identified as a higher grade.

C.2.19 Containment level 3 (CL3) Laboratories

Where identified as a containment level 3 laboratory this must be designed to the requirements of CL3 of “The management, design and operation of microbiological containment laboratories” by the Advisory Committee on Dangerous Pathogens (ACDP) and the UCL CL2 Laboratory Standard, unless identified as a higher grade.

Estates and Facilities must be consulted to discuss UCL specific requirements for these laboratories. These requirements include:

- The exacting standards of workmanship and design necessary to achieve a room which is completely sealable, without re-entry, in the event of an emergency fumigation being necessary following a spillage or similar accident. Service entries to be sealed with formaldehyde resistant mastic and ventilation ducts to have motorised gas tight dampers.
- Room sealing to be air pressure and smoke tested using a certified specialist to a project-specific +ve Pa rating and -ve Pa rating. Similar arrangement for ventilation/ductwork systems serving the same space.

Provide duplicate extract fans, with automatic non-return dampers, to ensure that an inward airflow to the laboratory is maintained during work with pathogens. Duty share changeover must take place by running both fans simultaneously before dropping out the duty fan. Full BEMS controlled and monitored. Displays/visual/audible alarms to be installed within the lab/lobby areas to indicate a "safe" and "unsafe" condition? All monitored back to the BEMS.

- All duty/standby plant to be electrically served from different building locations/risers/bus-bars/DB’s etc – to promote as much resilience as practically possible.
- Typical pressure regimes to be based upon the lobby/prep room being at -20pa relative to the corridor and the laboratory a further -30pa relative to the lobby/prep room (i.e. laboratory -50pa relative to external). This must be controlled and regulated using pressure weighted non-return air transfer dampers.
- Extract fans to be wired to a maintained supply where available.
- Extract fans to be inverter controlled, with velocity sensor control, to maintain the design extract rate as HEPA filters become dirty. Velocity sensors to have remote alarm and analogue/digital interfacing.
- Provide HEPA filters in any extract connections from the laboratory where not already included as part of a safety cabinet exhaust. DPS with BEMS interfacing to be set up with "clean", "dirty" and "replace" settings - across all filters individually. An indicator within the lab itself may assist with ensuring the lab users are aware of this approaching operation or requirement to change the filters.

- Provide a safe change HEPA filter in the extract at the common point of exit from the laboratory or in the ducting before the extract fan set. This is for additional protection of maintenance staff working on the remote extract fans etc.
- Where possible, all maintainable plant must be located outside the laboratory.
- Make up air supplies must be fitted with non-return dampers to prevent reverse airflows and constant volume devices. Supply diffusers must be designed to avoid draughts across the face of MSC's, which might otherwise effect containment.
- Supply fan to be hardwire interlocked with extract fan such that extract must be proven to run before enabling supply. This can result in high negative room pressures at start up and the Building Services Designer must ensure that the Architect is advised of the resultant loadings on the structure (particularly relevant to suspended ceiling support). Fast acting PID controls, equipment and logic to be installed.
- MSC's to be connected to extract system. MSC's to be arranged to continue to operate in the event of main extract fan failure but alarms must be provided with a clear label to advise that Users must carry out an immediate controlled shut-down of work. General and emergency lighting within/adjacent MSC/FC's or any other areas within the lab(s) themselves, to be risk assessed and discussed on a project-specific basis.
- Provide electrical isolation for the MSC's in the lobby outside of the laboratory. Similar arrangement for lab gases, natural gas, water etc to be discussed during design and agreed with UCL.
- Provide dedicated power sockets within the laboratory for formalin kettles. These sockets to be located close to the door so that a kettle can be plugged in by leaning into, rather than entering, the laboratory and to be switched from the lobby.
- Provide pressure differential alarms, clearly labelled, to advise the Users if the negative pressure is not maintained. Provide time delay to allow for opening of door for entry/exit. Provide magnahelic gauges for ready visual indication. Photohelic gauges with auxiliary connections to be installed where required.
- Locate control panel for category 3 system in lobby/prep room for operation of systems in emergency, including control of fans, motorised dampers etc. The systems must operate "on demand" at the local panel and not be over-ridden by a time schedule on the central BEMS. The BEMS must be configured for monitoring only of this panel.
- Ventilation to be designed for full fresh air. Extract rate to exceed make up air rate and to be greater than sum of MSC exhausts, extract ducted to atmosphere (not re-circulative). Rates to be increased if necessary to allow sufficient air changes to deal with room cooling loads.
- Provide 10mm (100 mm long maximum.) test port through laboratory door, with cap on lobby side, for testing for residual formaldehyde following fumigation.
- Carry out smoke tests on completion to validate air-tightness for fumigation.
- Consult with users to establish whether lone working is anticipated and provide "lone working" alarms as appropriate.
- Provide gas tight dampers in ducting outside the laboratory for fumigation and ensure that no non-airtight items such as heater batteries are positioned on the laboratory side of these dampers.
- Compressed air – leaks, location, noise, different types. Energy efficiency guide to compressed air.

C.2.20 Plant Maintenance

The first year maintenance of “primary plant” within the defects liability period must be included within the project. This is particularly relevant to plant where the guarantee is dependent upon a prescriptive maintenance schedule such as chillers, boilers, compressors, etc.

C.2.21 Water hygiene risk assessments/method statements

To satisfy the provisions of the Health and Safety at Work Act and specifically L8 –The control of legionella bacteria in water systems - UCL must not accept handover of the installations until full and adequate information concerning the installations is in the possession of the operating and maintenance staff.

The Building Services Designer must carry out their own risk assessments at design stage and consult with the UCL approved specialist as necessary.

The Building Services Designer must specify that the contractor must employ a specialist to carry out risk assessments of the water systems and to prepare a method statement, for inclusion in the O&M manual, for maintenance of the control of legionella bacteria.

The specialist must be provided from the approved UCL supplier list.

The risk assessment must cover the whole of the systems in new build situations and where dedicated systems are installed to serve a refurbished area.

In refurbishments where the existing systems are adapted then the risk assessment must comprise a review/revision of the current assessment and method statement for the building. This requirement must not apply must the works be limited to relocation of one or two draw-offs unless such minor works include a shower or similar atomizing spray device when this requirement must apply.

C.2.22 Plant and services adjacent to project site

Roof works on new projects must take full account of existing services on the same or adjacent roofs. An example would be where existing fume extract discharge stacks may need to be raised to comply with the clearances stated elsewhere in this document and existing fresh air inlets may be affected by new fume exhausts.

Where construction of a project may affect the maintenance, operation and reliability of existing plant then risk assessments must be carried out and appropriate measures specified and costed in the project. Examples would be:

a) Arranging to turn off air handling systems if possible where dust or fume is generated by the works and/or changing of air filters every 2 weeks whilst such work is in progress.
b) Protecting existing condensing units or chillers whilst still allowing sufficient free air flow and cleaning of the condenser coils during and after such work.

C.2.23 Pressure gauges and thermometers

Regardless of the fact that systems may have sensors giving readings to a BEMS system pressure gauges and thermometers must be provided to facilitate maintenance and fault finding without access to a the BEMS.

Pressure/altitude gauges must be fitted to at least the inlet and outlet of circulation or booster pump sets, heat generation plant, buffer and expansion vessels.

Thermometers must be fitted at least to each storage vessel, chilled water F&R, heating F&R, heat generating plant, HWS F&R, supply and fresh air ducts and extract ducts where recuperation is employed adjacent to air handling units, and in cold water storage cisterns.

Analogue T and P gauges to be installed to all domestic water (WRAS approved), HTG and CHW circuits leaving/entering a plantroom. Similarly, on larger buildings analogue T and P gauges be installed as piped services exit/enter within a services riser.

For laboratory refurbishments that have cascading pressure regimes across adjacent rooms, UCL requires pressure differential sensors to be installed across each pressure zone. These pressure differential sensors shall either be connected back to the BMS to allow UCL to remotely monitor the differential pressure across each zone, or should be connected back to a physical gauge in the rooms themselves. The preference is to have a BMS connection.

C.2.24 Electrical power supplies to pumps

Where practical final power connections to pumps must be made using Commando type sockets with integral isolator switches to enable ready disconnection and removal by maintenance fitters without the need for the attendance of an electrician.

APPENDIX A – MEP STAGE GATE DELIVERABLES / ROLES & RESPONSIBILITIES

Stage	RIBA	Overview	Key Activities	Documentation Produced
Stage 1: Need	N/A	The high level details about the 'idea' are captured, and the idea is assessed for alignment to the Estates' Strategic Objectives, and prioritised.	- Alignment to strategic objectives - Prioritise project - Create project brief - Cost estimate for feasibility and/or stage 2 - Collect information on the project register	- Project Register Record - Project Brief - Schedule and Cost estimate for feasibility study and/or stage 2 - Key stage docs checklist
Stage 2: Initiation	A-C	The idea is developed into a concept design and an outline business case produced.	- Identify stakeholders & create stakeholder strategy and comms plan - Define project management approach - Define objectives, scope and deliverables - Identify risk, issues, dependencies and assumptions - Create high level project schedule - Produce outline business case - Produce Project Initiation Document (PID) - Carbon approval model for feasibility (if appropriate) - Carbon approval model for Stage C Design - Assessment of existing assets - Validation of existing systems	- Project Brief (updated to include feasibility outcomes) - PID / EAC Estates Supporting Docs - Outline Business Case (including options appraisal) - Funding approval confirmation - Sustainability Reports (Carbon appraisal model, Sustainability brief, Ska and/or BREEAM (or equiv.) design reports as applicable) - Schedule of key interfaces - Detailed schedule for stages 3 & 4 - Validation Report - Derogation report

Stage	RIBA	Overview	Key Activities	Documentation Produced
Stage 3: Development	D	The concept design is developed into a detailed design.	- Set up project in FIS - Produce design/detailed specification - Produce plant replacement strategy	- Detailed Design Brief - Sustainability Design Report (if applicable) - Updated derogation report
Stage 4: Planning and Budgeting	E-H	The implementation stage is planned in detail, costings detailed, and tendering implemented.	- Produce a detailed implementation - Tender process - Update the outline business case to a full business case - Produce a detailed plant replacement strategy - Maintenance responsibility	- Project Implementation Plan - Interface milestones schedule - Tender Evaluation Report - Full Business Case (inc. options appraisal) - Funding approval confirmation - Report on any changes to utilities - Updated derogation report
Stage 5: Implementation	J-K	Implementation of the Brief	- Mobilisation - Implementation of the brief - Monitoring and controls - Soft Landing	- Handover Plan (including Sustainability handover report) - Building User Guide (if applicable) - Benefits Realisation Plan - Updated financial tracker - Pre-Construction CH1 Checklist
Stage 6: Operational	L	Deliverables are handed over to the operations and the defects liability period takes place	- BREAAM post construction review - Ska post occupancy review - Seasonal commissioning	- Sustainability Reports (such as BREEAM construction assessment or Ska post occupancy report) - Seasonal Commissioning checklist and adjustments
Stage 7 Post Project	L	Final activities to prepare the project to be closed down.	Lessons learned Close out review of business case including benefits Close down finances	Project Close Out Report Lessons Learned

MEP STAGE GATE DELIVERABLES / ROLES & RESPONSIBILITIES – SMP PROJECTS

Stage	Overview	Key Activities	Documentation Produced
Stage 1: Need	The high level details about the 'idea' are captured, and the idea is assessed and prioritised.	- Prioritise project - Create Project Initiation Document - Cost estimate for feasibility and/or stage 2 if applicable - Collect information on the project register	- Project Initiation Document & Project Request - Schedule and Cost estimate for feasibility study and/or stage 2 if applicable - Key stage docs checklist
Stage 2: Initiation	The idea is developed into a concept design and a Business Case produced.	- Identify stakeholders & create stakeholder strategy and comms plan - Define project management approach - Define objectives, scope and deliverables - Identify risk, issues, dependencies and assumptions - Create high level project schedule - Produce Business Case - Carbon appraisal model - Assessment of existing assets - Validation of existing systems	- Business Case (including options over £250k - Funding approval confirmation - Sustainability Reports (Carbon appraisal model, Sustainability brief, Ska and/or BREEAM (or equiv.) as applicable - Schedule of key interfaces - High level project schedule - Stage Gate Supporting Docs - Validation Report - Derogation report
Stage 3: Development	Not applicable for SMP Projects		

Stage	Overview	Key Activities	Documentation Produced
Stage 4: Planning and Budgeting	The implementation stage is planned in detail, costings detailed, and tendering implemented.	- Produce a detailed programme & cost plan - Tender process - Update the business case as necessary - Produce a detailed plant replacement strategy - Maintenance responsibility	- Updated Project Implementation documentation (Programme, Cost Plan, Risk Register, Directory) - Tender Evaluation Report - LOI & Tender Return Form - Revised Business Case if applicable (inc. options appraisal) - Stage Gate Supporting Docs - Report on any changes to utilities - Updated derogation report
Stage 5: Implementation	Implementation of the Brief	- Mobilisation - Implementation of the brief - Monitoring and controls - Soft Landing	- Handover Plan (including Sustainability handover report & CH1,2,3 forms) - Building User Guide (if applicable) - Practical Completion Certificate - Final Account - Stage Gate Supporting Docs - Pre-Construction CH1 Checklist
Stage 6: Operational	Deliverables are handed over to the operations and the defects liability period takes place	- BREAAM post construction review - Ska post occupancy review - Seasonal Commissioning	- Sustainability Reports (such as BREEAM construction assessment or Ska post occupancy report) - Seasonal Commissioning checklist and adjustments

APPENDIX B – UCL MEP PREFERRED MANUFACTURERS AND SUPPLIERS

UCL MANUFACTURERS LIST

Guidance Note

This schedule lists UCL's preferred manufacturers and specialist of building services plant and equipment.

Design teams may use these to help the generation of the Schedule of Manufacturers document for a project.

It is for the project team to determine the suitability of manufacturers products for the relevant to the project.

If the Consultant / Contractor intend to propose an alternative manufacturer to those listed in this schedule, then approvals must sought from the UCL Engineering Maintenance & Infrastructure(EM&I) and Facilities Maintenance Teams.

These Schedules complement the MEP Design Guidance document and other Guidance / Specification which should be consulted.

ELECTRICAL

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Carville Switchgear	Switchpanel Manufacturer									
Prism Power Group	Switchpanel Manufacturer									
AF Switchgear	Switchpanel Manufacturer									
Schneider Electric	Switchpanel Manufacturer									
UEP Switchgear	Switchpanel Manufacturer									
Schneider-Electric	Distribution Board manufacturer									
Schneider (Merlin Gerin)	Protection Devices									
ABB	Protection Devices									
Honeywell MK	Small Power Accessories									
Schneider-Electric	Metering									
Schneider-Electric	EV Chargers - EV Link									Open Protocol
Solar Edge	PV Generation optimisation system.									

LIGHTING

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
RIDI Ltd	Lighting Luminaire Products									
Thorn Lighting	Lighting Luminaire Products									
Zumtobel	Lighting Luminaire Products									
Hacel Lighting	Lighting Luminaire Products									
Havell Sylvania	Lighting Luminaire Products									
Glamox Luxo Lighting	Lighting Luminaire Products									
Philips Lighting	Lighting Luminaire Products									
Modular Lighting	Lighting Luminaire Products									
DAL Lighting	Lighting Luminaire Products									
Cooper Lighting (Eaton)	Lighting Luminaire Products									
Beta Calco Lighting	Lighting Luminaire Products									
Fagerhult	Lighting Luminaire Products									
Siteco Ltd	Lighting Luminaire Products									
Whitecroft	Lighting Luminaire Products									
Thorlux Lighting	Lighting Luminaire Products									
ETAP	Lighting Luminaire Products									
MID Lighting (Marlow Integrated Designs)	Lighting Luminaire Products									
Ex-Or (Honeywell)	Lighting Controls									
Advanced Electronics	Emergency lighting Addressable Testing system									
Zumtobel / Thorn On-lite	Emergency lighting Addressable Testing system									
Ex-Or (Honeywell)	Emergency lighting Addressable Testing system									

SPECIALIST

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Assurity Consulting	Legionella Risk Assessments									
Socotec	Legionella Risk Assessments									
Contact the Principal Mechanical Engineer	Pressure System Regulation Written Schemes/Reports									
Banyards	Commissioning Management									
Troup Bywaters and Anders (TB&A)	Commissioning Management									
Moore Environmental Commissioning	Commissioning Management									
Operation and Maintenance Manuals	End Systems									
Finning (main CHP)	CHP Engine Maintenance									
Ener-G	CHP Engine Maintenance									
To be confirmed	LEV Specialist (Laboratory systems)									
To be confirmed	LEV Specialist (Dust Extraction)									
Contact the Principal Mechanical Engineer	Internal Ductwork Cleaning									
Artic Building Services	F-Gas regulation (Register)									
Timeguard Emergency Assist Alarms.	Disabled Alarms									
Vertiv (Emerson)	UPS									
APC Schneider	UPS									
Socomec	UPS									
Clos-o-Mat	Disabled Toilet/Changing Facilities Hoist									
Arjo Humleigh	Disabled Toilet/Changing Facilities Hoist									
Contact the Principal Mechanical Engineer	CCTV Above and Below Ground Drainage Surveys									
Contact the Principal Mechanical Engineer	Fumigation									
Contact the Principal Mechanical Engineer	Geologist Ground Review / Bore Holes									
Contact the Principal Mechanical Engineer	Catering Equipment/Services									
Contact the Principal Mechanical Engineer	Operations and Maintenance Manuals (O & Ms) Compilation									
Contact the Principal Mechanical Engineer	External plant enclosure									
Contact the Principal Mechanical Engineer	Roof services support systems (i.e. big-foot)									

SPECIALIST cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Refer to the Vertical Transport Guide	Vertical Transportation									
Filtrex	Specialist Filters IE									
Dwyer	Gauges									

PACKAGED PLANT ROOMS

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Ellison AC Engineering	Packaged plantrooms									
Ormandy	Packaged plantrooms									
IPT (Integrated Plantroom Technologies	Packaged plantrooms									

HEATING

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Broag-Rehema	Boilers - oil and gas Solar water heating Bio-mass boilers	ISO9001	ISO14001	Yes	Yes	10%	5 years			
Hamworthy	Boilers - oil and gas Solar water heating Bio-mass boilers									
Potterton	Boilers - oil and gas Solar water heating Bio-mass boilers									
Ideal Boilers	Boilers - oil and gas Solar water heating Bio-mass boilers									
Viessmann	Boilers - oil and gas Solar water heating Bio-mass boilers									
Babcock	Boilers - steam Generators - Steam									
BIB Cochran	Boilers - steam Generators - Steam									
Fulton	Boilers - steam Generators - Steam									
Certus	Boilers - steam Generators - Steam									
Riello	Burners									
Nu-way	Burners									
Dunphy Combustion	Burners									
Limpsfield	Burners									
A1 Bridge Flues	Flue systems									
Stelkirk	Flue systems									
Spirax Sarco	Steam Ancillaries									
Trovay and Cauvin	Steam Ancillaries									
Gestra	Steam Ancillaries									
Grundfos	Pressurisation Units Pumps Expansion Vessels Water booster sets									
Armstrong Holden and Brooke	Pressurisation Units Pumps Expansion Vessels Water booster sets									
Pullen	Pressurisation Units Pumps Expansion Vessels Water booster sets									
DAB	Pressurisation Units Pumps Expansion Vessels Water booster sets									

HEATING cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Rycroft	Calorifier Buffer vessels Plate heat exchangers									
Stokvis	Calorifier Buffer vessels Plate heat exchangers									
Alfa Lavall	Plate heat exchangers									
Danfoss	Plate heat exchangers									
Spirotech	Air and Dirt Separators									
Enwa	Water treatment (new and existing)									
Legionella Compliance Services	Water treatment - cleaning and chemical treatment									
Aquzur	Water treatment - cleaning and chemical treatment									
Clearwater	Water treatment - cleaning and chemical treatment									
Water Technology	Water treatment - cleaning and chemical treatment									
Hattersley	Valves and ancilliaries									
Crane	Valves and ancilliaries									
Oventrop	Valves and ancilliaries TRV's									
Zehender	Radiators Convectors Radiant Panels									
Hudevad	Radiators Convectors									
Stelrad	Radiators Convectors									
Runtal	Radiators Convectors									
Jaga	Trench Heaters									
Dunham Bush	Trench Heaters Fan Convectors									
Biddle	Fan Convectors Air Curtains									
Envirotech	Air curtains									
Dimplex	Electric Heaters									
Comyn Ching & Co	Radiant Heaters (MTHW/LTHW/)									

HEATING cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Frenger Systems	Radiant Heaters (MTHW/LTHW/Electric)									
Ambi Rad	Radiant Heaters (Gas)									
Roberts Gordon	Radiant Heaters (Gas)									
Rehau	Underfloor heating									
Wirsbo(Uponor)	Underfloor heating									
Contact the Principal Mechanical Engineer	Potable (WRAS) submersible pumps									
Contact the Principal Mechanical Engineer	Sump pumps									
Contact the Principal Mechanical Engineer	Trench Heating (LPHW and Electric)									
Contact the Principal Mechanical Engineer	Compressors plant									
Contact the Principal Mechanical Engineer	Hydronic differential pressure control valves (typical for district heating system)									

VENTILATION

Preferred Manufacturer/Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Trane	Central Air handling Plant									
Swegon	Central Air handling Plant									
Daikin	Central Air handling Plant									
Nuaire	Local Ventilation Systems									
Ventaxia	Local Ventilation Systems									
Flaxt Woods	Local Ventilation Systems									
AAF	Specialist Filters i.e. Hepa									
Camfil	Specialist Filters i.e. Hepa									
S&P Coils	Heating coils Cooling coils (in duct applications)									
Euro coils	Heating coils Cooling coils (in duct applications)									
Hygromatick	Humidifiers Dehumidification									
Condair	Humidifiers Dehumidification									
Humidity Solutions UK	Humidifiers Dehumidification									
IAC	Anti-vibration Attenuation									
Alloway Acoustics	Anti-vibration Attenuation									
Spirax Sarco	Humidifiers Dehumidification									
IAC	Anti-vibration Attenuation									
Alloway Acoustics	Anti-vibration Attenuation									
TBA	Anti-vibration Attenuation									
Gilberts	Fire Dampers Access Panels Volume Control Louvres Diffusers Grilles									
Actionair Group	Fire Dampers Access Panels Volume Control									
Trox	Louvres Diffusers Grilles VAV and CV Boxes									
Waterloo Air Management	Louvres Diffusers Grilles VAV and CV Boxes									

VENTILATION cont.

Preferred Manufacturer/Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Coleman Moducel	Louvres Diffusers Grilles VAV and CV Boxes									
Halton	Louvres Diffusers Grilles VAV and CV Boxes									
Cantech	Kitchen Ventilation									
Halton	Kitchen Ventilation									
Britannia	Kitchen Ventilation									
Dust Extraction	Dust Extract/Collection									
Nederman	Dust Extract/Collection									
Parmatic	Dust Extract/Collection									
Raven	Dust Extract/Collection									
Plymovent	Dust Extract/Collection									
Contact the Principal Mechanical Engineer	Heat Recovery Units									
Contact the Principal Mechanical Engineer	Kitchen Extract Fans									
Contact the Principal Mechanical Engineer	Cooker Hoods									
Contact the Principal Mechanical Engineer	Smoke dampers									

AC - REFRIGERATION

Preferred Manufacturer/Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
JSA Service Ltd	Chiller specialist									
Airedale	Chiller Plant									
Carrier	Chiller Plant									
Trane	Chiller Plant									
Daikin	Chiller Plant									
York / Johnson Controls	Chiller Plant									
ICS	Chiller Plant									
Mitsubishi	Chiller Plant									
Grundfos	Pressurisation Units Pumps Expansion Vessels Water booster sets									
Ability	Fan coil units (2 & 4 pipe)									
Quart	Fan coil units (2 & 4 pipe)									
Dakin	Fan coil units (2 & 4 pipe)									
Mitsubishi	Fan coil units (2 & 4 pipe)									
NOTES: Daikin and Mitsubishi are Preferred suppliers any deviation from this must be agreed first via ops team. All AC systems installed via Daikin must be a D1 contractor UCL will benefit from a 7 year warranty and will also have a UCL discount on selected products. All AC systems installed via Mitsubishi must be a BSP contractor UCL will benefit from a 7 year warranty and will also have a UCL discount on selected products										
Daikin	DX VRF Split Units Heat Pumps									
Mitsubishi	DX VRF Split Units Heat Pumps									
Foster Refrigeration	Cold Rooms									
Oxford Refrigeration	Cold Rooms									
Watford Refrigeration & AC	Cold Rooms									
George Varcas	Cold Rooms									
Stulz	Computer Room Units / CRAC									
Uniflair Air Conditioning	Computer Room Units / CRAC									
Emersons	Computer Room Units / CRAC									
Aspen	Condensate pumps									
Contact the Principal Mechanical Engineer	Data Centres									
Contact the Principal Mechanical Engineer	Floor Standing AC									

AC - REFRIGERATION cont.

Preferred Manufacturer/Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Contact the Principal Mechanical Engineer	Process cooling flow measuring/adjustment devices									

DOMESTIC SERVICES

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Dewey Waters	Water storage tanks	ISO9001	ISO14001	Yes	Yes	10%	5 years	Mr x tel email:		
Balmoral	Water storage tanks									
Braithwaite	Water storage tanks									
AC Plastics	Water storage tanks									
Clearwater Technology	Water treatment - chemical - Chlorine Dioxide Water treatment - Laboratory - RO Water treatment - Softening Plant Water treatment - Deionised/Distilled									
Goodwater	Water treatment - chemical - Chlorine Dioxide Water treatment - Laboratory - RO Water treatment - Softening Plant Water treatment - Deionised/Distilled									
Elga	Water treatment - chemical - Chlorine Dioxide Water treatment - Laboratory - RO Water treatment - Softening Plant Water treatment - Deionised/Distilled									
Hydrotech	Water treatment - chemical - Chlorine Dioxide Water treatment - Laboratory - RO Water treatment - Softening Plant Water treatment - Deionised/Distilled									
Liff Industries	Water Conditioners - non chemical based									
The Rodin Group (Scale-Buster)	Water Conditioners - non chemical based									
Enwa	Water treatment - chemical/filtration - heating and cooling									
Grundfos	Pressurisation Units Pumps Expansion Vessels Water booster sets									
Andrews	Direct gas fired water heaters									
Lochinvar	Direct gas fired water heaters									
Heatrae Sadia	Electric water heaters									
Santon	Electric water heaters									
Zip	Electric water heaters									
Horne	Thermostatic mixing valves Showers									
Kohler Mira	Thermostatic mixing valves Showers									
Contact the Principal Mechanical Engineer	Water hygiene risk assessors									
Contact the Principal Mechanical Engineer	Flushing/Dosing Specialists									

DOMESTIC SERVICES cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Contact the Principal Mechanical Engineer	Water commissioning engineers									
Contact the Principal Mechanical Engineer	Tank monitoring equipment									
Contact the Principal Mechanical Engineer	Tea point 2-in-1 / 4-in-1 water dispensers									
Contact the Principal Mechanical Engineer	Instantaneous Boiling-Chilled Water Taps									
Contact the Principal Mechanical Engineer	Hot water electric immersion heaters									
Contact the Principal Mechanical Engineer	Leak detection									
Contact the Principal Mechanical Engineer	Sensor Taps									

LABS AND CLEANROOMS

Preferred Manufacturer/Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Clean Room Design (CDC)	Cleanrooms									
Clean Room Construction Ltd	Cleanrooms									
Clean Air Technology	Cleanrooms									
Medical Gases	Laboratory Gases									
Medical and Industrial Manufacturing	Laboratory Gases									
BOC	Laboratory Gases									
Atlas Copco	Compressed Air									
Compare	Compressed Air									
Ingersol Rand	Compressed Air									
Motivair	Compressed Air									
Absolute Vacuum Services UK	Vacuum									
Leybold Vacuum	Vacuum									
Medical & Industrial Manufacturing	Vacuum									
Girovac	Vacuum									
Flamefast	Gas proving systems (natural gas)									
TCW Services	Gas proving systems (natural gas)									
Astec	Safety Cabinets									
Envair	Safety Cabinets									
Safe Lab	Safety Cabinets									
Medical air Technology	Safety Cabinets									
APMG	Fume Cupboards Fume Extract									
Fumair	Fume Extract Plastic Fans									
Premier Laboratory Systems	Fume Extract									
Mac-Aire	Fume Extract									
S&B	Fume Cupboards									
Central Fans (Colasit)	Plastic Fans									
Parsons Plastics	Plastic Fans									
Contact the Principal Mechanical Engineer	Smoke testing									
Contact the Principal Mechanical Engineer	Building/air pressure testing									
Contact the Principal Mechanical Engineer	Medical Gases									
Contact the Principal Mechanical Engineer	Medical Gas Alarm Systems									
Contact the Principal Mechanical Engineer	Liquid Nitrogen									
Contact the Principal Mechanical Engineer	Gas solenoid valves									

CONTROLS

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Schneider Electric	StruxureWare BMS supplier									
Kendra	Schneider / Trend - PPM Service contractor									
Satchwell	Motorised Valves									
Landis-Staefa	Motorised Valves									

Notes :
1) All controls wiring by Controls Specialist
2) UCL has legacy system as Trend and Schneider Electric Sigma. For new projects Schneider StruxureWare is the default installation. Where work are partial refurbishments, the BMS manager (Marek Rutkowski) should be consulted on the system upgrade approach.
3) Heat, Gas and Water metering data capture on the BMS system should be linked to the EMON management systems as well.
4) M&E main project contractors Should use BMS contractors who are:
Trend Control System Specialists. All contractors should be Trend Technology Centre approved partners. Controls Engineers should be certified Trend Experts.

PASSIVE SOLUTIONS

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Research & Development	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
To be confirmed	Solar water heating									
Monodraught	Ventilation Cooling Daylight									
Passivent	Ventilation Cooling Daylight									

FIRE ENGINEERING

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Environment & Sustainability	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Colt	Smoke extract									
SE Controls	Smoke extract									
Abbot Fire Group Ltd	Fire stopping & certification									
Checkmate Fire Solutions Ltd	Fire stopping & certification									
Gunfire Ltd	Fire stopping & certification									
Tyco	Sprinklers Systems (high mist)									
Tyco	Sprinklers Systems (traditional)									
Tyco	Fire Suppression systems									
Dry Riser Services	Sprinkler Systems Maintenance									
Dry Riser Services	Dry Riser Maintenance									
Contact the Principal Mechanical Engineer	Stand pipes and fire hydrants									
Contact the Principal Mechanical Engineer	Fire-rated ductwork/cladding									

Consult UCL Fire Team for final agreement.

ANCILLARIES (FITTINGS & ITEMS)

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Environment & Sustainability	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Y10 Pipes, Fittings & Accessories Listed here are manufacturers of specialist systems / equipment.										
Engineering Appliances	Expansion Bellows and Flexible Connections									
Isolated Systems Ltd.										
J & P supplies Ltd.										
N Minikin & Sons										
Brockington Scott (Teddington Bellows)										
Yorkshire Fittings– Tectite push–fit, Pressfit	Specialist Pipework Systems									
Geberit Mapress (press-fit system)										
Victaulic grooved system										
SAV UK Ltd. (plastic coated aluminium pipe for final run outs to terminals)										
TYCO Building Services Products (Grinell grooved system)										
Omegaflex (“TracPipe”) Corrugated Stainless Steel Tube for natural gas to BS EN 15266										
Flexenergy heating and cooling products (PB) Flexalen	Underground pre-insulated pipe systems									
Durotan Ltd.(PE-Xa / Steel)										
REHAU (PE-Xa)										
Watts Industries (Microflex PE-Xa)										
Vital Energi (Steel)										
Extensis Ltd.	Support Systems									
IHL (Industrial Hangers Ltd.)										
Walraven										
Roof Pro										
Unistrut										
Y10 Valves / Strainers										
	General service and commissioning									
Broen										
Crane / Hattersley										
Frese										
Herz valves										
TA Hydronics (Tour & Andersson)										
Yorkshire										
Oventrop										
SAV UK Ltd.										
SAV	Manifold Commissioning Systems									
Crane										

ANCILLARIES (FITTINGS & ITEMS) cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Environment & Sustainability	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
TA Hydronics (Tour & Andersson)										
Danfoss Randall	Differential pressure, high limit, flow control and other									
Frese										
Herz valves										
Honeywell Control Products										
Oventrop										
Samson Controls										
Spirax Sarco										
SAV UK Ltd.										
TA Hydronics (Tour & Andersson)										
Frese	General Control valves + TRV's									
Herz valves										
Oventrop										
Broen										
Aquaflow Regulators Ltd. (flow restrictors)										
Bailey Birkett (Safety Systems UK Ltd.)	Safety / Pressure relief									
Nabic Valves (Delta Fluid Products Ltd.)										
Spirax Sarco										
Donkin Gas Valves Ltd.	Specialist Valves									
Honeywell ACS Control Products (Thermostatic mixing, pressure regulating /reducing, back flow prevention, thermal balancing / disinfection for HWS)										
Hopkinsons (Steam)										
Horne Engineering (thermostatic mixing)										
Caleffi (thermostatic mixing)										
Reliance Water Controls (thermostatic mixing)										
Safi (Chemical / corrosion resistant)										
Landon Kingsway – (Gas/oil shut off)										
Alcon Solenoid Valves – (Gas/oil/water shut off)										
Watts Industries (thermostatic mixing, pressure regulating, backflow prevention)										
Carter Environmental (filters)	Filters, dirt separators, deaerators									
Plenty Filters (filters)										
Engineering appliances Ltd (dirt separators / deaerators)										
Spirotech (UK) Ltd. (dirt separators / deaerators)										
Armstrong	Steam Traps									
Spirax Sarco										
Trouvay and Cauvin										
Isopad	Trace Heating									
Raychem										
Thermon (UK) Ltd.										
Armacell UK	Thermal Insulation									

ANCILLARIES (FITTINGS & ITEMS) cont.

Preferred Manufacturer/ Specialist	Equipment/Service	Quality Assurance	Environment & Sustainability	Environment & Sustainability	CPD	UCL Preferred Rates	Warranties (post defects)	Account Manager	Status (RAG)	Comments
Kingspan Tarec										
Neville Thompson (Isogenopak cladding)										
Rockwool										
Contact the Principal Mechanical Engineer	Air balancing commissioning engineers									
Contact the Principal Mechanical Engineer	Floor gullies									
Contact the Principal Mechanical Engineer	Drainage traps									
Contact the Principal Mechanical Engineer	Local drainage pumps (general use, lab use)									
Contact the Principal Mechanical Engineer	Centralised drainage pumps/macerators									
Contact the Principal Mechanical Engineer	Temp/humidity loggers									

APPENDIX C – RELEVANT UCL EMPLOYER'S REQUIREMENTS PAGES

UCL Employer's Requirements are available on UCL Estates Website.
Within the Employer's Requirements, please refer to the following pages specifically (but not limited to):

- UCL's Information for Contractors and Designers suite of documents
- BIM – Employer's Information Requirements
- UCL Biodiversity Strategy & Action Plan
- Building User Guide Template
- Cost & Carbon Tool
- UCL Data Collection Form
- Design Requirements for Connections to the UCL District Heating Network
- Estates Emergency Lighting Planned Preventative Maintenance
- EHS Rules for Contractors
- Estates Metering Strategy
- EV Charging Guidelines
- UCL Fire Safety Technical Notes & Mandatory Instructions
  or request from UCL Fire Safety Team fire@ucl.ac.uk
- Health & Safety (H&S) File and Operating & Maintenance (O&M) Manuals
- UCL Heating, Cooling & Ventilation Policy
- Inclusive Design Strategy
- Mini-Ska Template
- UCL Post Project Review Guidelines
- PV System Guidelines
- Seasonal Commissioning Employer's Requirement
- Soft Landings Framework
- UCL Sustainable Building Standard
- UCL Sustainability Strategy
- UCL Travel Plan
- UCL Vertical Transport Design Guidance

APPENDIX D – BMS SPECIFICATION

Building Management System Standard Specification

Version 3.0

Nov' 2019

Building Management System Standard Specification

Version Control

Version	Date	Nature of Revision	Author	Approved By	Signed
V1.0	16/01/17	Draft Issue	John Johansson	Martin Earlam	
V2.0	15/06/18	Amendments – Network Ethernet Switches, Pressure Switches	John Johansson	Martin Earlam	
V3.0	08/11/19	Added standard for Graphics & general document update to UCL format	Marek Rutkowski	Martin Earlam	

Note: it is policy to convert all procedural documentation in PDF format once complete and signed off. This document is to remain Microsoft Office Work format to allow for copying and pasting where required.

Contents Page

Section **Page**

1.0 Introduction 5
1.1 Related Documents 5
1.2 Overview 5
1.3 Building Management System Selection 5
1.4 General 6
1.5 Designers' and Contractor's Responsibility 6
1.6 Preferred Suppliers 8
2.0 Building Management System (BMS) 9
2.1 Description of Work Items 9
2.2 Operator's Station 10
2.3 System Configuration 21
2.4 Controllers 23
2.5 Intelligent Unitary Controllers (IUCs) 24
2.6 Remote Panel Facia Mounted Touch Pad/Display Panel 25
2.7 Uninterruptible Power Supply (UPS) 25
2.8 Controller Software 25
2.9 Mechanical Power Distribution Boards 31
2.10 Controls Equipment 31
2.11 Power and Controls Wiring 31
2.12 BMS IT Network Shared 33
2.13 Labelling 36
2.14 Commissioning 36
2.15 Demonstration 39
2.16 Documentation 40
2.17 Training 43
2.18 Warranty & Maintenance 43
2.19 Tender Requirements, Tender Quantieties 44

3.0 BMS Standard Operations 45
3.1 Guidance 45
3.2 Control Panels 45
3.3 Equipment Interfaces 47
3.4 General Software Control Functions 48
3.5 District Heating System 54
3.6 Mechanical Ventilation Systems 55
3.7 Natural Ventilation 67
3.8 Heating Systems 68
3.9 Domestic Hot Water Services 77
3.10 Chilled Water 78
3.11 Pump Control 80
3.12 System Pressure Monitoring 81
3.13 Sitewide Controls 82
3.14 Fire Control 84
3.15 Miscellaneous Plant Monitoring 84
3.16 Environmental Monitoring 85
3.17 BREEAM Standard Requirements 85
3.18 Energy Monitoring Requirements 86

1.0 Induction

1.1 Related Documents

The Building Management System Standard Specification should be read in conjunction with the tender particular specifications, drawings and relevant Contract Documents.

1.2 Overview

The University currently has a site wide Building Management Systems as manufactured by Trend Controls and Schneider Electric, these report back to servers within the BMS room at Medawar building.

The Trend system comprises of a 963 Server with IQ1 to IQ4 controllers in the field, there is a programme in place to upgrade legacy IQ controllers.
The Trend system also controls the UCL District Heating System as defined in section 2.4 of the BMS Standard Operations; currently in transition to the Schneider Electric SmartStruxure platform.

The Schneider Electric system is the Satchwell Sigma system which comprises of x96, x32 and Integration controllers in the field.

The Sigma platform is currently in transition to the Schneider Electric SmartStruxure platform.

The Schneider Electric SmartStruxure is the University's preferred future Building Management System platform, there is a StruxureWare Building Operation Enterprise Server located within the BMS room at Medawar building.

1.3 Building Management System Selection

As the University is currently in transition with the campus wide BMS, the preference is for a SmartStruxure Solution manufactured by Schneider Electric, when agreed by UCL the following circumstance shall determine the system on a project by project basis and will be defined in the particular specification.

Trend Controls System – If the building where the project is to take place existing point count is to be increased by >50% then all existing controllers shall be stripped out and replaced with SmartStruxure.

Due consideration is also required in establishing the IQ controller version of existing controllers to determine strategy.

Satchwell Sigma – As noted in section 1.2 the Sigma platform is currently being transitioned to the SmartStruxure platform, therefore any new projects carried out in

buildings that are controlled via the Sigma system shall have Automation Servers installed with associated I/O modules for new system points and integration points. Automation Servers will be engineered directly to the StruxureWare Building Operation Enterprise Server including associated graphics. If not already carried out the BMS specialist will ensure the Sigma controllers within the building are transitioned to the Building Operation Enterprise Server including the correct segment structure and association of graphics.

There are exceptions where Sigma will be acceptable:

- Existing capacity exists within the Sigma Controllers to incorporate the additional points
- It would be considered as not good engineering practice to incorporate Automation Servers

1.4 General

A Building Management System (BMS) shall be provided to give a high level of control and monitoring of the Mechanical, Electrical and Plumbing (MEP) systems and shall comply with British Standard BS EN 15232 which defines the building controls required to achieve required level of energy efficiency in UCL portfolio buildings, in order to achieve Class A of the standard and realise the potential of energy savings, SmartStruxure fully programmable BMS controllers are to be provided on all main plant controllers (i.e. packaged controllers are not acceptable). This will enable a fully integrated automatic system, where the use of the “Hand” positon which will only be used for:

- Engineering service applications
- Emergency situations and only until the problem has been eliminated

Any adjustment to any BMS set parameters can only be made by UCL authorized qualified personal. Any adjustments can requested via the UCL Customer Helpdesk which the UCL incumbent BMS contractor will assist.

At no time, will there be any facilities to make local adjustments to any BMS plant.

It should be noted that packaged controls of Air Handling Units, Multi Service Chilled Beams, Fan Coil Units, etc. **are not acceptable**. Where packaged pumps with integral variable speed drives are deployed the BMS shall directly control the speed pump based on pressure control.

1.5 Designers’ and Contractor’s Responsibility

This section defines the BMS Contractors’ scope of works for the electrical and controls requirements for each project.

The BMS Contractor shall furnish and install a direct digital control and complete building automation system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in the particular specification together with stripping out of all existing redundant control plant and updating Head-End graphics. All components of the system – workstations, servers, application controllers, unitary controllers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2007, or EIA standard 709.1, the LonTalkTM protocol, or Modbus protocol. No gateways shall be used for communication to controllers furnished under this section.
The BMS Contractor shall be responsible for carrying out the complete BMS design, supply, installation, engineering, commissioning, witnessing, O&M's and handover which shall include but not be limited to:

- Control panel design, including wiring diagrams, back plate and fascia layout.
- All power cabling emanating from Control Panels including terminations and connections.
- All controls cabling including termination and connections.
- Controls primary and secondary containment.
- Network design and installation which includes the following:
  - Fibre optic cable
  - CAT6 cabling
  - Network switches
  - Control enclosures
- Electrical connections from the local fused spur to fan coil units and VAV boxes, including any final containment and cables.
- Supply, install and commission VSD's.
- Selection of all control devices, control valves and actuators as defined in the preferred vendors section of this document.
- The free issue of control valves and thermowells to the Mechanical Contractor for fitting in the pipework.
- Supply, install and commission ultrasonic flow meters associated with control requirements.
- Energy Metering to comply with Part L and BREEAM which includes the following:
  - Heat Meters in accordance with The Heat Network (Metering and Billing) Regulations 2014
  - Water Meters
  - Gas Meters
  - Steam meters
  - Electric Meters (Refer to section 3.17)
  - Installation drawings
- Factory acceptance testing (FAT) if applicable
- Site acceptance testing (SAT)

- Coordination with the Mechanical Contractor for location of duct and pipe mounted devices
- Commissioning
- Witnessing
- Handover
- Record drawings and documentation
- O&M documentation including description of operation (Des-Ops)
- Documentation showing BEMS parameters (set-points, time schedules etc.) that have been implemented

1.6 Preferred Suppliers

1.6.1 Incumbent BMS Specialist

Kendra Energy Solutions are the incumbent BMS specialist responsible for the support and maintenance Building Management and Control Systems across the site wide campus.
To ensure security and continuity of the system the BMS contractor tendering must obtain costs from Kendra to carry out the following:

- Provide back up of system
- Provide controller references and structure
- Review description of operation
- Attendance at witnessing
- Merge new software onto site wide system

It shall not be acceptable for the BMS contractor to carry out the above works.

1.6.2 Recommended BMS Contractors

The following approved manufacturers/partners are recommended by UCL for the turnkey delivery of the BMS and control systems:

Trend Control Systems. All contractors are to be Trend Technology Centre approved partners. Control Engineers are to be certified Trend Experts.

Schneider Electric Systems. All contractors are to be a certified partner of Schneider Electric with certified Sigma and SmartStruxure capabilities.

2.0 Building Management System (BMS)

2.1 Description of Work Items

Comprises all sensing devices, control valves and actuators, damper actuators, interfaces, microprocessor based hardware, controllers, PC, printer, network devices, power supplies, Uninterruptible Power Supplies, filters and suppressors to form a complete and operational system.

2.1.1 BMS Architecture

It is expected that the BMS follows the following basic equipment structure and communications connectivity:

2.1.1.2 Management Level

All contractors are to be a certified partner of Schneider Electric with certified Sigma and SmartStruxure capabilities.
Management level devices include:

- Operator's Stations
- BMS Servers
- Web Servers
- BMS Client Computers
- Internet routers

These devices communicate over an IP Ethernet network. The same network is also used to connect to and between controller level devices.

2.1.1.2 Controller Level

Controller Level devices include:

- Controllers
- Networked touch pad displays
- Field Bus Routers
- Protocol Conversion Interfaces

These devices primarily communicate between each other over an IP network that also connects to the management level devices. Communications from controller level to field level can either be from a communications port on a Controller or from an IP to field bus router.

Dedicated protocol interface devices that convert from one protocol to another e.g. BACnet to Modbus are also expected to sit at this level.

Network connected touch pad displays, generally for fitting on control panel fascias, are expected to connect directly to the IP network rather than connect to a port on a Controller.

2.1.1.3 Field Level

Field Level devices include:

- Intelligent Unitary Controllers (IUCs)
- Intelligent sensors, switches, meters and actuators
- Packaged plant with communications capability

These devices primarily communicate over a multi-drop communications bus, typically using either a daisy-chained or free topology configuration. The communications used on this bus may, or may not be, the same one used at the controller and management level.

Wireless sensors reporting through a base station may connect to either at the controller or field level.

2.2 Operator's Station Medawar

The term "Operator's Station" here covers the functionality required of the Graphical User Interface (GUI) used by a BMS operator, regardless of how the system is configured, be it stand-alone computer(s) running dedicated suites of programs, web client-server architectures where the bulk of the programming and processing is done on a server or number of servers with minimal installed software running on the computer used as the BMS GUI, or a web client using a browser to access a web server front end.
The operator's station basic purpose is to display and format data and enable manual control functions (e.g. setpoint and program changes) to be performed in a user friendly manner. Operator's stations shall take no part in any plant or global control functions and shall not be used to transfer data between controllers on the BMS communications network.

The software for carrying out the various requirements detailed in the System Narratives shall be backed up on the system irrespective of whether the routines are normally held and operated from a controller or unitary controller. The operator's station shall have the ability to instigate the upload and download of controller configuration data via the communications network.

A fully automatic backup facility shall be provided, with the ability to also backup the system manually. It shall be possible to load selected files from this storage facility back on to the operator's station.

The BMS computers shall contain sufficient hard disk capacity for all database and software requirements described within this Specification plus sufficient hard disk capacity for all graphic displays, historical records and trends as described below:

Historical Records	1,000,000 events
Trends	10,000,000 samples

2.2.1 Colour Graphic Displays

The colour graphics shall incorporate automatic updating of real time field data that shall spell out in plain English any current condition, value, or action.

Each graphic shall incorporate up to 40 freely assigned connected or calculated points.

All plant symbols shall be drawn in a fashion so as to represent plant items and control devices as opposed to DIN standard type and shall be of a similar format to those shown under 'Sample Graphics'. Standard symbols libraries shall be augmented by user defined symbols. Editing features for adding, deleting and modifying data, shall be provided. Access to the colour graphics features shall be controlled so that only designated operators can display or modify files.

Each and every input, output and calculated BMS point shall be placed on an associated graphic display, the graphics shall be constructed as described below.

Each and every system shall be provided with a separate graphic display comprising a system overview screen, and engineering screens. For large systems several engineering screens shall be required to display all relevant information and setpoints. These displays shall be linked as described below.

It shall be possible to interrogate each item of plant or system by graphic penetration. That is, all graphics shall be constructed in levels as follows:

- Level 1 - Graphic detailing site overview
- Level 2 - Graphic detailing building/block overview
- Level 3 - Graphic detailing systems on each floor/within each plant room
- Level 4 - Graphic detailing a 2D system schematic
- Level 5 - Graphic(s) detailing system engineering parameters and setpoints
- Level 6a - Graphic detailing system description of operation (or a link to a read only file containing the description of operation)
- Level 6b - Graphic displaying system strategy diagram or flow chart (or link to a read only file containing the system strategy diagram or flow chart)
- Level 7 - Empty user definable graphic screen

The system software shall accept up to 10 levels of graphics. Changing from one graphic to another graphic shall be by the use of 'click' boxes on the graphics.

It shall be possible for a system operator to navigate from any level 4 Graphic to any other level 4 graphic in no more than four 'click' box operations.

Graphical representation of all plant and plant symbols (i.e. schematics) shall be two-dimensional in representation. Refer to ‘Sample Graphics’.

Level 4 graphics shall be the system operators 'window' to the system. They shall show the main functionality of the system, whether the system is 'required to run' and whether the system is 'available to run'. If a system is required to run but is not available then the operator would interrogate the system via the level 5 and 6 graphics which would contain the detailed operational information.

Primary system setpoints (such as supply air temperature) shall be displayed and accessible from the level 4 graphics. All other setpoints shall be accessed via level 5 graphics only. Where setpoints are calculated or scheduled within software, then the calculated value can be displayed on level 4 graphics, but shall be 'greyed out', so as to indicate to the operator that it is non accessible.

Where fans/pumps are variable speed, the drive enable, run and BMS speed outputs only shall be displayed on the level 4 graphic. All other drive related information shall be displayed on level 5 graphics.

All level 4 graphic screens shall comprise as a minimum the following:

- Date, time, outside air temperature and humidity. Outside air enthalpy (where required)
- Primary system setpoints (e.g. supply air temperature)
- Safety Interlock status
- Plant command (on/off)
- Plant status (e.g. fan, pump, boiler, etc)
- Measured values (e.g. temperature, humidity, static pressure, etc)
- Output values (e.g. valve and damper position etc)
- Alarms
- Critical/safety overrides (e.g. fire shutdown)
- Associated graphic 'click' boxes
- Facility to link to trend logs for all displayed plant values and status
- Facility to link to system description of operation

Level 5 graphic screen shall comprise as a minimum the following:

- Date, time, outside air temperature and humidity. Outside air enthalpy (where required)
- All setpoints/schedules
- Optimum start/fixed time program settings
- Plant command status (e.g. optimum start, fixed time start, boost, night low temperature cycle, manual, etc.)
- System demand signals
- Control loop parameters
- Plant run time status and associated hours run resets
- Normal overrides (e.g. primary heating loop temperature, enthalpy, standby power shutdown)
- System fault reset button(s)
- Associated graphic 'click' boxes
- Facility to link to trend logs for all displayed plant values and status
- Facility to link to system description of operation

Should a graphic be too large to place on a single display, it shall be segmented and each portion placed on separate graphics joined by 'click' boxes.

All setpoints defined in the System Narratives shall be able to be modified via the graphic displays.

It shall be possible to manually override (force) on/off each system and individual points via the applicable graphic screen. Indication shall be provided on a graphic when a system has been manually overridden and for each and every individual point overridden. The manual overrides shall be configured such that a competent operator with sufficient access rights shall have the ability to override system and individual points. An operator with lesser access rights shall have the ability to override complete systems only.

The colour of each point/symbol on a graphic display shall represent a different condition associated with the point/symbol. Symbol colours shall be in compliance with the basic guide below and as represented in the typical graphic samples.
The conditions of each point as described below are the minimum requirements.

Off	White
On/Enabled	Green
Overridden Off	White with 'hand' symbol
Overridden On	Green with 'hand' symbol
Alarm/Mismatch	Amber
Loss of	Display to product manufacturer's

Based upon the above representations the following examples are given for a pump or fan:

- If a pump or fan is enabled and a running status has been received by the BMS then the outer section of the symbol (enable output) would be green and the inner section of the symbol (run status) would be green.
- If a pump or fan were switched off by the BMS but overridden via the BMS/graphics by the operator then the outer section of the symbol would be green and the inner run status of the symbol would be green. Additionally a 'hand' symbol would be adjacent to the pump or fan symbol and a plant override alarm would be present on the BMS system.
- If a pump or fan is disabled and a running status has been received by the BMS (but has not been overridden via the graphics by the operator) then the outer section of the symbol would be white and the inner run status of the symbol would be green. Additionally a plant mismatch alarm would be present on the BMS system and a red flashing 'mismatch alarm' banner would be present on the graphics adjacent to the pump or fan symbol.
- If a pump or fan is enabled and a running status has not been received after the flow proving period then the outer section of the symbol would be green and the inner run status of the symbol would be red. Additionally a plant mismatch alarm would be present on the BMS system and a red flashing 'mismatch alarm' banner would be present on the graphics adjacent to the pump or fan symbol.

Positions of all items such as modulating dampers and control valves shall be shown as a percentage open figure adjacent to the symbol. Dynamic representation of damper positions shall be accepted in addition to the percentage figure where this is available. Where dampers and control valves are open/close types, then the controlling output and input status shall be represented in words. Where required mismatch alarms shall be adjacent to the word banners.

All ductwork shall be drawn to the same width as the symbols for plant items within that ductwork or AHU.

All sensors shall have 'failure' and 'out of limits' alarms displayed on level 4 graphics. If either condition occurs the device symbol shall turn from white to red and flash. A red flashing banner with white text adjacent to the sensor shall indicate which state has caused the alarm. Stem and capillary temperature sensors shall be represented by different symbols.

Plant and field equipment references (tags) used in the Equipment Schedules shall be included on all graphic screens. Where available, tag references shall normally be hidden, to be highlighted when the cursor is placed over the device, or shall have the facility to be turned on and off via a button on the graphic.

The background colour for the entire graphic shall be white. The specific shade chosen shall enhance the graphic display and not obscure any on-screen data.

2.2.1.1 Terminal Unit Graphics

Floor layout graphics shall be provided for all terminal units (e.g. FCUs, VAV boxes, chilled beams) showing for each terminal unit its location, reference number and space/return temperature value. Each terminal unit shall be represented by an active colour coded symbol - grey when disabled and green when enabled. Each terminal unit shall also be provided with an operational mode spot – either red, blue or no spot to indicate whether they are in a heating mode, cooling mode or are neither heating or cooling.
Each time program associated with a zone of a floor layout graphic shall be provided with direct link from that graphic.

A click box/hot spot shall be provided for each terminal unit to access a dedicated graphic for that unit. This graphic shall provide full information status including current mode of operation, i.e. time program status (occupancy/non-occupancy), heating boost, cool down, fabric low limit protection, extension time, fire status etc.
All input values, output values, settings and control parameters in the terminal unit IUCs shall be displayed on the individual terminal unit graphic and shall be adjustable from the graphic.

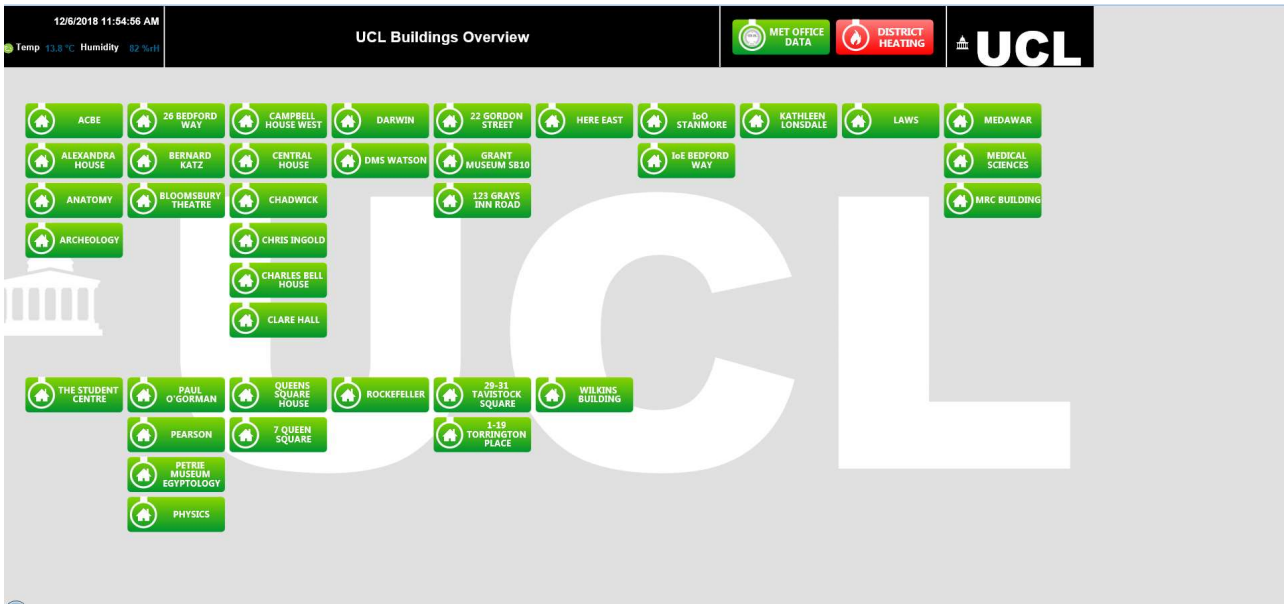
In addition, the terminal units shall be listed in tabular format on a separate set of graphics (15 terminal units maximum per graphic) on a floor by floor basis to enable the operation of a large number of terminal units to be compared at once. Information to be displayed per terminal unit shall include reference number, control sensor value, setpoint(s), status, valve and/or damper output values.

In addition to those graphics mentioned previously the following shall also be provided on separate graphics:

- All BMS CEs detailing their number and location.
- The BMS network and all items of intelligent BMS equipment complete with addresses and locations.

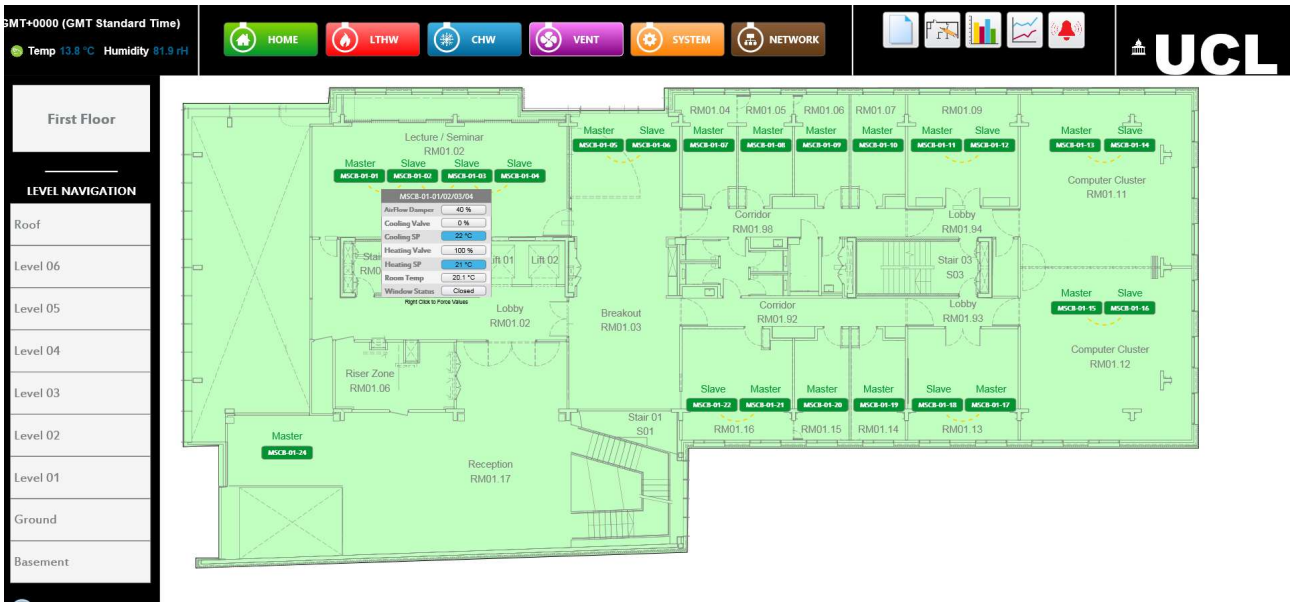
The following sample graphics are not project specific but are for indication of style only.

2.2.1.2 Level 1 - Graphic detailing site overview

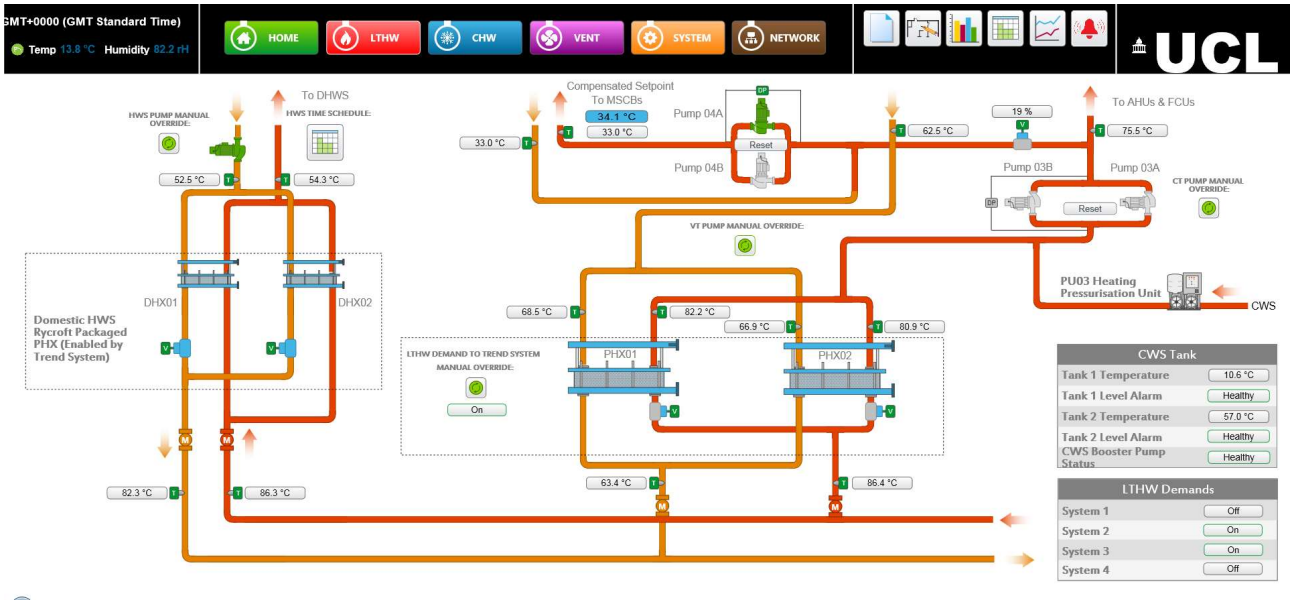


2.2.1.3 Level 2 - Graphic detailing building/block overview

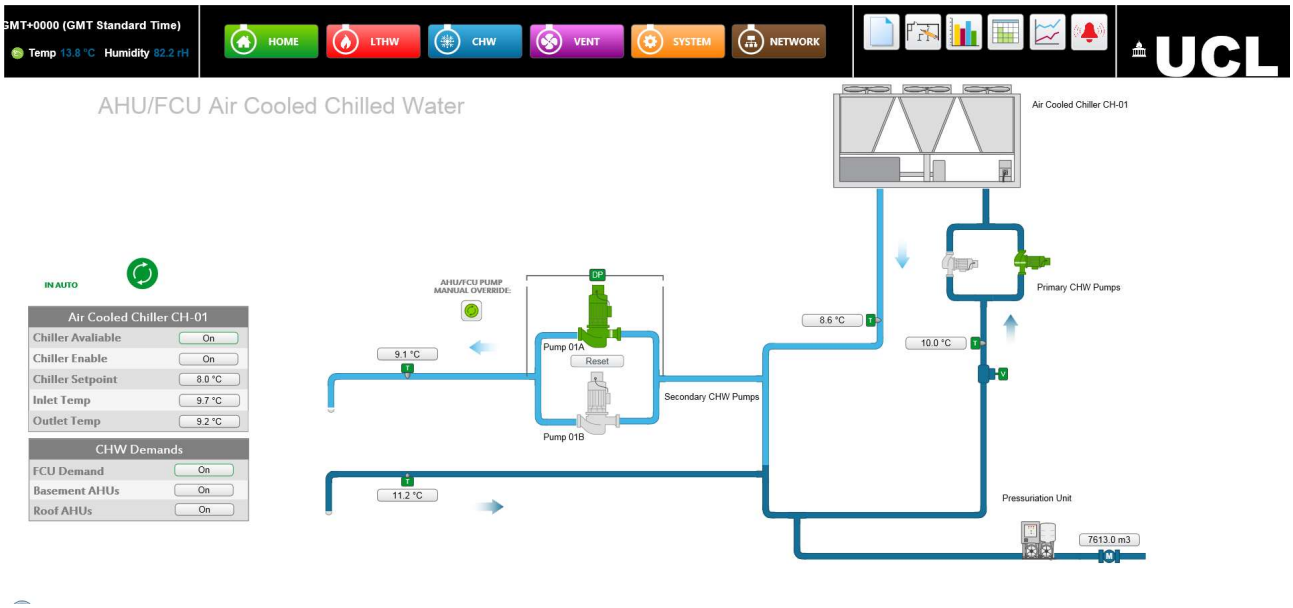
2.2.1.4 Level 3 - Graphic detailing systems on each floor/within each plant room



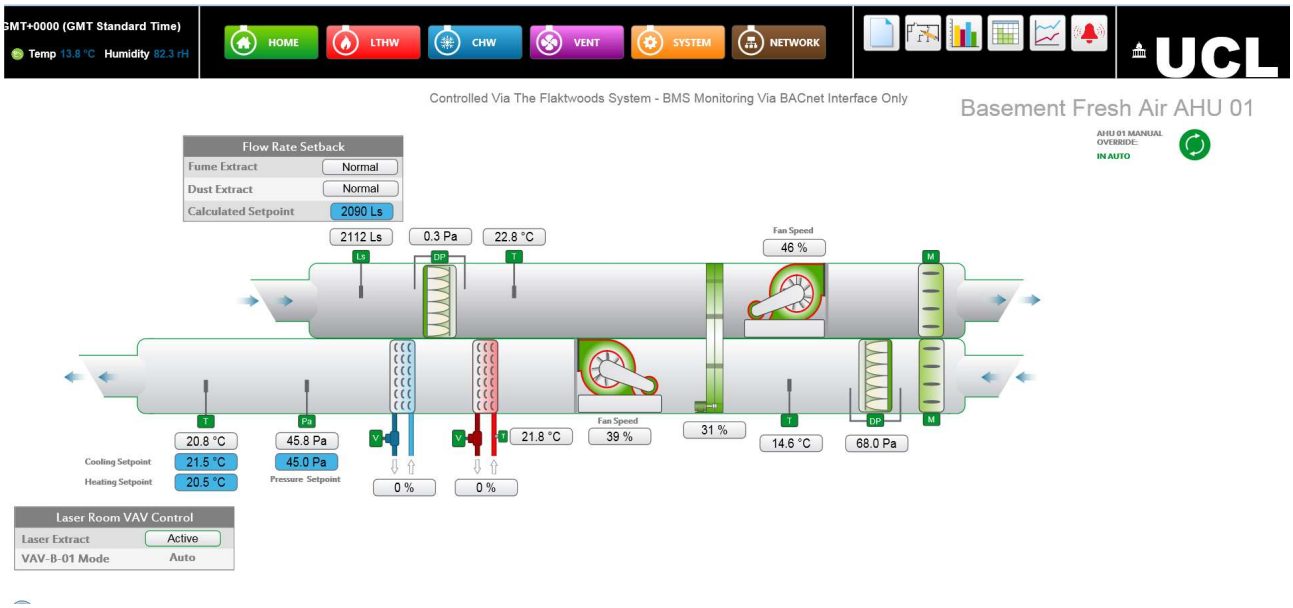
2.2.1.5 Level 4 Graphic detailing a 2D LTHW schematic



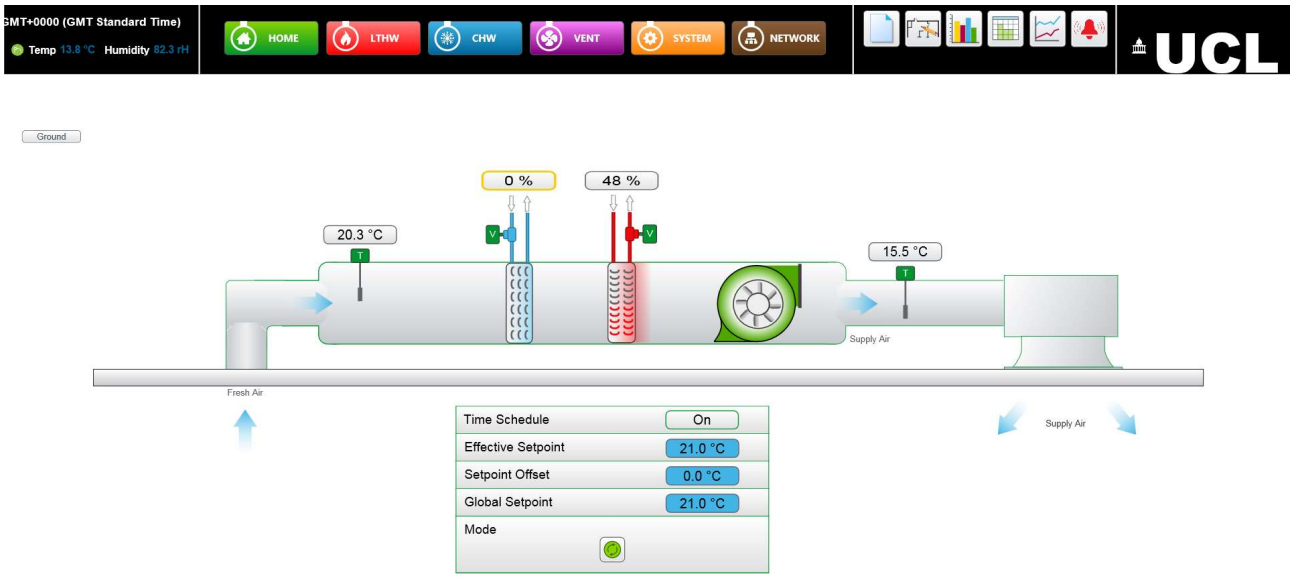
2.2.1.6 Level 4 Graphic detailing a 2D Chilled Water schematic



2.2.1.7 Level 4 Graphic detailing a 2D AHU schematic



2.2.1.8 Terminal Unit Graphic



2.2.2 Systems Logs & Reports

An operator shall be able to display system logs on any operator's station or print logs on any BMS printer. Logs as a minimum shall include:

- Critical alarm summary log
- Critical and general alarm summary log
- Summary of all current alarms
- Status logs which include a review of selected system points (e.g. a graphic display or logical group)
- Time schedules logs, which print all or selected time schedules

Trend logs, which display real time values of selected points in a graphical/graph format. Up to four points shall be able to be displayed on each trend log. These logs shall be capable of updating at one second intervals.

Historical trend logs, which log the value of selected points as recorded at predetermined intervals. Sample times for each point to be logged shall vary from 5 seconds to 24 hours. Hours run values for selected or all equipment.

Accumulated register values for selected or all equipment. Change of state conditions for selected or all equipment.

The BMS shall store the information in an SQL database, the date in which shall be available for export to other software packages (such as aM&T and dedicated metering packages) and up to Enterprise level software. The BMS shall also be able to export the data in a format compatible with Microsoft Excel software.

2.2.3 Information Redirection

It shall be possible for the system to redirect information to other (or future) operator's stations and/or printers on a time schedule basis (including holiday programming) or manual command basis. For example, all alarms may be re-directed from the BMS alarm printer to the security room alarm printer, after hours.

2.2.4 Response Times

The response times detailed below are the maximum acceptable response times.
Alarms: The time from activation of an alarm (at the source) to annunciation on an operator's station shall not exceed 5 seconds.

Graphic Displays: A graphic display shall be displayed complete with updated information from the field for all points, within 15 seconds of the operator request.

Once displayed all point information will be updated from the field and displayed at intervals not exceeding 30 seconds.

Global Program: The time from occurrence of an event from one controller or unitary controller to the activation of the output of another controller or unitary controller shall not exceed 10 seconds.

2.3 System Configuration

2.3.1 BMS Operator's Station

As there is a BMS central monitoring station all BMS will be relayed to this location at Medawar. No local monitoring PC's will be needed. Local viewing portals will be allowed on building's MCCP's fascia.

2.3.2 Extension to an Existing Client's BMS

BMS/Controls Specialist shall liaise with the Client to determine how the new works shall be integrated to the existing BMS, and interface requirements shall be detailed in the Tender.

2.3.3 Web Server Functionality

The BMS shall be provided with web server functionality which will enable remote access anywhere on the network. The web server shall support Internet Explorer or any of the browser equivalents. The web server shall have the facility to support a minimum of 20 consecutive client terminals at any one time and via any standard Internet Explorer package. The access shall include both text and graphical forms of information required. The system shall be configured to allow users/operators differing levels of access through password
s. Critical alarm configurations shall also be included to operate in the same manner as remote alarm printers.

2.3.4 Passwords

The system shall use encrypted passwords and shall use theses from active directories if connected to the client's IP network.

2.3.5 Web-Based Operator Workstations

Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. There will be no need for any additional computer based hardware to support the web-based user interface.

2.3.6 Network Addressing

It is preferred that all devices being attached to the IP Network shall manual IP addressing. A network addressing schedule/schema shall be created and shall include device name, location, MAC address, IP address, subnet mask, specific port addresses required for router configuration and connected switch reference.

If the BMS is to run over an existing IP network or a common IP infrastructure provided by others, then the network addressing schedule shall be coordinated with the Client's IT manager.

2.3.7 IP Version Support

All devices being attached to an existing IP network or a common IP infrastructure provided by others, shall provide support for both IPv4 and IPv6.

2.3.8 IP Device Communication Requirements

As a minimum, all devices shall comply with the following:

- Fully configurable in terms of IP address, subnet mask and default gateway settings
- Fully TCP/IP compliant
- Use a standard RJ45 or LC Fibre Optic connectors
- If wireless comply with IEEE 802.11g and 802.11n
- If supporting multiple speeds (e.g. 10 and 100 Mbps), shall support auto sensing for both speed and duplex settings

2.3.9 Active Directory

If the BMS is fully installed on the Client's IP network it shall support Active Directory technology for groups and users within its application. The BMS Specialist shall coordinate with the Client the required groups and the user access levels to be able to access the BMS Servers and software.

2.3.10 Master Time Clock Function

The BMS system shall support a master time clock function. The master time clock shall be based on a dedicated NTP (Network Time Protocol) time server.

The master time clock shall be used to synchronize all other real-time clocks on PCs, servers and controllers that make up the BMS. The master time clock shall automatically change times and dates throughout the system for changes due to daylight savings, leap years and any other global calendar/time adjustments.

2.3.11 Broadband Router/VPN Connection

Where BMS connection to the internet is required and is not available via the buildings IP infrastructure, a broadband modem or router (as appropriate) shall be provided.
The BMS internet connection shall comply with the client's IT/security rules.

2.3.12 Laptop

Where specified, a laptop shall be:

- Used to interrogate and program controllers and unitary controllers.
- Supplied with a case, power supply and all necessary software to allow for local interrogation and programming, whether it be a copy of the head-end software, a dedicated programming/interrogation program or else a terminal emulation program. This software shall be password protected.
- Able to either be plugged into any controller or unitary controller throughout the system, or else plugged into a network connection point and once connected to the network, shall be able to access all control devices on the associated network.
- All laptops should have their IP address and subnet mask issued via ISD and their MAC address be given to ISD.

2.4 Controllers

Controllers shall be complete with power supplies, a real time clock, input and output modules, memory, processors and all other items necessary for proper and correct interfacing and operation of the control functions described in the System Narratives.
All controllers shall have peer to peer communications. All controllers shall have a 'stand-alone' capability such that a failure of the operator's station shall still permit the plant and controls associated with the controllers, to continue to operate normally with the controllers continuing to communicate with one another.

In the event of transmission failure in the controller network, the controllers shall continue to operate with all sequence interlocks and control strategies operating normally excepting those, which require global information. Either user adjustable default values or the last sensed value (user selectable) shall then be assumed for these global parameters. An alarm shall be raised at the operator's station for each 'off-line' controller.
All necessary interfacing equipment shall be provided so that the controllers are fully compatible with all items of plant and equipment.
When installed internally within a building but not in a designated CE controller shall be enclosed in lightweight IP51 wall mounting cabinets. The cabinets shall be provided with a key-lock.

Controllers shall be capable of accepting digital inputs, analogue inputs, pulsed inputs and shall provide digital outputs and analogue outputs.

Each controller or controller location shall be provided with spare hardware capacity for future additions of at least 25% of each type of point. Universal inputs may be counted as either a spare digital or analogue point, but not both. Note that this spare capacity may be accomplished by the ability to add additional input/output modules provided space is available. Memory shall also be sufficient to allow all programs associated with these extra points to be run in the controller.

The controllers shall be provided with either non-volatile memory or else an internal battery back-up power supply, capable of maintaining all memory, including the real time clock, for not less than 72 hours. The battery shall be easily replaceable i.e. not soldered to the PCB.

Each analogue input device connected shall be calibrated (to compensate for non-linear characteristics of input devices, line resistance and similar items) to achieve an accuracy, of the displayed value on the operator's station, as detailed in this Specification for each sensing device.

Open or closed circuits on sensor inputs shall be recognised by the controller and annunciated as alarms on the system operator's station(s). If a sensor fails (open or closed circuit or out of range) then its associated control loop shall be programmed to default to a safe condition.

It shall be possible to characterise each analogue output to an actuator in order to obtain a near-linear response from the device the actuator is controlling. This may take the form of a look up table with a minimum of 6 co-ordinates, such that the linear output from a control loop is converted into a non-linear control signal to the actuator.

2.5 Intelligent Unitary Controllers (IUCs)

Where a controller is used to monitor and control VAV boxes, FCUs, chilled beams, heat pumps etc, they shall be classed as intelligent unitary controllers (IUCs).

IUCs shall be either small freely programmable controllers or firmware application specific controllers which shall be selected to meet the performance requirements of the Particular Specification.

Each IUC shall meet the specified requirements of a controller except where specified to the contrary as follows:

- Real time clock functions are not essential where these commands are generated by other controllers, which shall also control the transfer of information to, from and between IUCs on the same communications network.
- Only the inputs and output points necessary to meet the functional requirements of the particular Specification are required to be supplied. The spare capacity as detailed under 'controllers' is not required.

2.6 Remote Panel Facia Mounted Touch Pad/Display Panel

Where specified the touch pad/display panel shall:

- Incorporate a touch pad and liquid crystal display.
- Provide password protection and shall provide setpoint adjustment, plant command, system monitoring and alarm interrogation and acknowledgement facilities.

2.7 Uninterruptible Power Supply (UPS)

Where specified the UPS shall:

- Not allow the equipment supported to power down and reboot in the event of mains failure
- Be capable of maintaining, in a fully functional mode, its associated devices for a period of 20 minutes, and utilise sealed batteries

2.8 Controller Software

The BMS shall be programmed to achieve all functions described in the System Narratives. Adjustable software parameters for each process loop, including the setting of the proportional bands, integral times and derivative rates, shall be set up and tuned on site and the values recorded in the appropriate engineering units. All settings shall be such that each process loop performs within the required tolerances and that there is no hunting (cycling) of final control elements.

All software relating to plant control and monitoring detailed in the System Narratives shall reside at controller or unitary controller level. Only management software shall reside at the operator station.

All programs shall be scanned as a minimum every one second.

Software shall include diagnostic routines which check hardware for correct operation. All hardware faults shall be annunciated on the operator's station(s).

2.8.1 Password Access

Operators shall gain access to the system by logging on which shall be achieved by entry of a unique operator name and password combination.

Each operator shall be assigned a system access level which shall enable that operator, once logged on, to access only those command, monitoring and program functions which have an equal or lower access level. A minimum of eight access levels shall be provided. Only the highest access level shall enable assignment or reading of operator passwords. The system shall record (to the operator's station's hard disk and optionally on a selected printer) logging on/off activity. Terminals shall automatically log off after a pre-set time if no keyboard activity has occurred. In addition, operators shall be able to manually log off when leaving the terminal.

The configuration of system access levels shall be submitted for approval before commissioning commences.

2.8.2 Alarm Processing

Alarms shall be classified by their alarm type and priority. The facility shall be provided for enabling and disabling each individual alarm on the system.

Once generated, the alarm shall be processed by its associated alarm type and priority as defined in the Equipment Schedules. The alarm types and priorities shall be as follows:

Type	Description	Priority
1	Digital or Analogue	Critical
1a	Mismatch	Critical
2	Digital or Analogue	General
2a	Mismatch	General
3	Digital or Analogue	Low Level

2.8.2.1 Alarm Types

Digital, analogue and mismatch alarm are defined as follows:

Digital:
The alarm is associated directly with an external volt free contact (i.e. a digital input). The alarm may be generated by transitions from either open to closed status, closed to open status, or any change of state. A time delay shall be associated with the alarm such that the alarm does not occur until the required alarm state has existed for longer than the delay period.

Analogue:
The alarm is associated directly with an analogue input. The alarm is generated by the BMS due to a measured variable exceeding specified limits. It shall be possible to define the limits in two ways:

- Fixed limits. The point has fixed upper and lower alarm limits. If the measured variable rises above the upper limit, or falls below the lower limit, then an alarm is generated. e.g. high alarm limit = 30°C, low alarm limit = 8°C
- Floating limits. The point has an associated setpoint, and an alarm is generated when the measured variable deviates either above or below the setpoint by more than a given alarm limit value. If the setpoint is changed, the alarm limits are automatically moved to suit. e.g. setpoint = 21°C, alarm limits = Setpoint ±2K

The above alarm limits shall have associated hysteresis bands to avoid nuisance alarming. A time delay shall be associated with the alarm such that the alarm does not occur until the required alarm state has existed for longer than the delay period.

Mismatch:
The alarm is associated with an output command point and an input giving status feedback of the output command. The alarm is generated when the status feedback does not correspond with the output command status for longer than a defined time delay period.

2.8.2.2 Alarm Priorities

On occurrence, the alarm shall be displayed on the operator's station screen, the alarm shall be put in the alarm list and the relevant alarm message, including time and date, printed out on the operator's station(s) alarm printer(s). In addition, the following actions shall be taken dependent upon the alarm type.

Critical Alarms:

- The alarm printout shall be in bold text to clearly differentiate it from general or maintenance alarms
- Shall generate an audible alarm at the operator's station
- Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station

General Alarms:

- Shall generate an audible alarm at the operator's station

Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station.

It shall be possible, at the highest operator password level, to enable and disable the audible alarm feature of the operator's station.

Alarms shall remain active until acknowledged by an operator logged on with the appropriate password level, even if the alarm has physically cleared. Upon acknowledgement, the alarm shall be moved to the appropriate place in the alarm list and an alarm acknowledgement message sent to the printer(s) which shall include the time, date and operator's identity.

When an alarm is acknowledged, the audible alarm, if enabled, shall be muted unless another unacknowledged critical or general alarm exists on the system.
It shall be possible to acknowledge alarms on both an individual and group basis.
Upon clearance of an alarm, a clearance message shall be sent to the printer, which shall include the time and date.

All alarm events shall be included in the historical data program.
It shall be possible to view or print the contents of the alarm list in historical order, using the typical selection criteria as follows:

- All alarms in the alarm list
- Critical alarms only
- General alarms only
- Low level alarms only
- Acknowledged alarms only
- Selection of alarms associated with an individual drive or plant only

2.8.3 Alarm Inhibition

Consequential alarm suppression algorithms shall be provided to limit the alarms annunciated on the BMS to those associated with the source of the initial alarm condition e.g. boiler lockout shall not initiate flow and return water temperature alarms, fire alarms shall not initiate mismatch alarms, restoration of power following a power failure shall not initiate mismatch alarms etc.

Analogue alarms associated with plant shall be inhibited when the plant is commanded off by the BMS unless otherwise stated in the System Narratives.

2.8.4 Configuration

Configuration data shall be stored in the controllers or the unitary controllers. Configuration data shall include but not be limited to the following:

- The engineering unit applicable (°C, kPa, m3/s, etc.).
- The point identifier (minimum of 12 characters).
- The point alarm message if applicable (minimum of 80 characters).
- The point descriptor (minimum of 32 characters).
- Other miscellaneous information necessary for the correct operation of the entire BMS (e.g. trending run hours, accumulation, access levels etc.).

All configuration data shall be displayed in alphanumeric characters. Configuration shall include but not be limited to the following points:

- All system peripherals and remote controllers
- System inputs and outputs (binary and analogue)
- System alarms
- System calculation results (e.g. efficiency values)
- System parameters and timer.
- System programs (e.g. event initiated program)
- System points received via a data interface. Once configured, points shall then be assigned to colour graphic displays and/or logical groups

2.8.5 Response Times

The response times detailed below are the maximum acceptable response times.

- Alarms: The time from activation of an alarm (at the source) to annunciation on an operator's station shall not exceed 5 seconds
- Graphic Displays: A graphic display shall be displayed complete with updated information from the field for all points, within 15 seconds of the operator request
- Once displayed all point information will be updated from the field and displayed at intervals not exceeding 30 seconds
- Global Program: The time from occurrence of an event from one controller or unitary controller to the activation of the output of another controller or unitary controller shall not exceed 10 seconds

2.8.6 Transient / Spike Protection

All microprocessor based controllers and other electronic equipment such as unitary controllers, personal computers and peripheral equipment and communications equipment, must be capable of withstanding transient disturbances from the input power supply.

Suppressors shall be fitted to all controller input and output points for protection against voltage transients, spikes etc.

The controllers' copper communication network(s) shall be isolated against transient disturbances via optical couplers or other approved means. Where running between buildings, fibre connections are the preferred means of connection but if this is not possible, lightning protection devices shall be installed on the copper communications network at the point of entry to each building.

2.8.7 Electromagnetic Compatibility

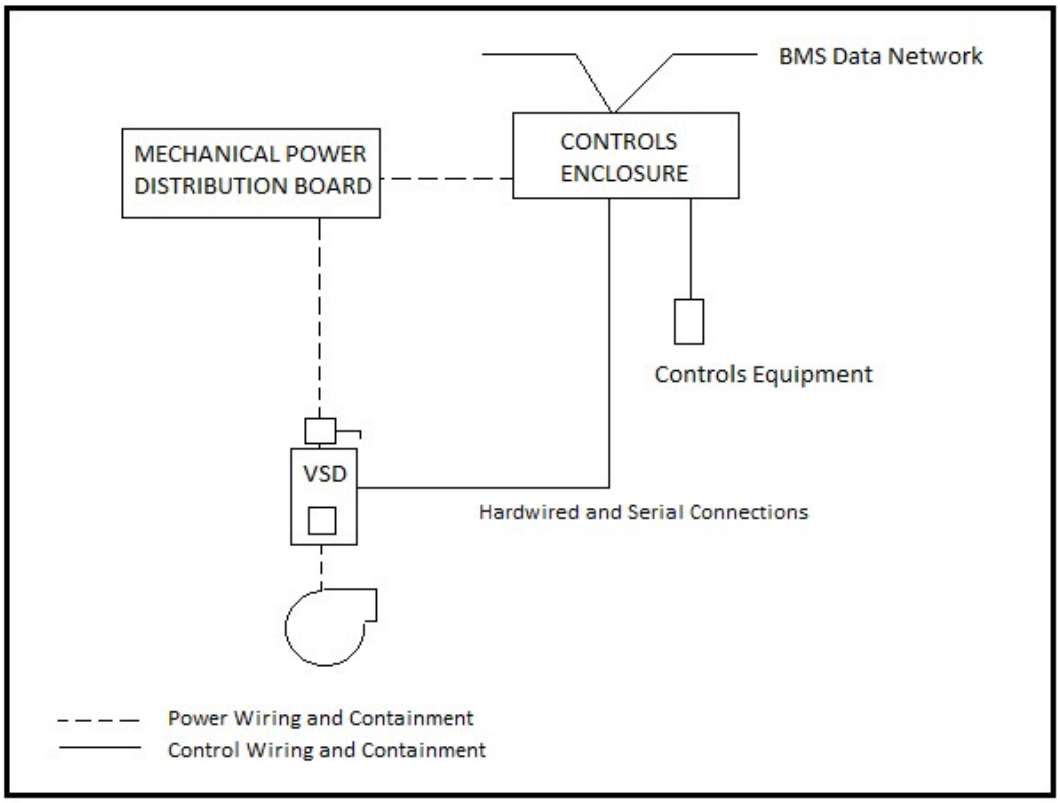
All BMS components and the complete BMS system shall comply with the requirements of BS EN 50081-1 Generic Emission Standard and BS EN 50082-1 & -2 Generic Immunity Standard.

In order to avoid corruption of the BMS equipment operation by electrical interference, all wiring shall be installed to minimise coupling of electromagnetic and electrostatic interference on low voltage signals and data wiring. The preferred method of achieving this shall be by ensuring a physical separation of greater than 50mm between the power supply cables and the signal and data cables. Where mixed wiring is unavoidable braided screen mains cable, dressed close to metalwork, is preferred.

The BMS shall be protected from interference by the operation of hand held radio transmitters, radio pagers, etc., at greater than 1 metre from the equipment.

2.9 Mechanical Power Distribution Boards

Provide Mechanical Power Distribution Boards in accordance with the Electrical Specification and Drawings.



2.10 Controls Equipment

Provide controls equipment in accordance with the Equipment Data Sheets.

2.11 Power and Controls Wiring

2.11.1 Configuration

Provide power and controls wiring and containment in accordance with the following diagram.

2.11.2 Wiring Requirements

Refer to Electrical Specification for general wiring requirements.

Within plant rooms all extra low and low voltage field control circuits associated with CEs and MPDBs shall be wired in LSF cables when contained in trunking or conduit and XLPE/SWA/LSF cable when installed on racking or tray.

Outside of plant rooms all extra low and low voltage field control circuits associated with CEs and MPDBs shall be wired in LSF cables and run in trunking or conduit.

Life safety related extra low or low voltage field control circuits associated with CEs e.g. fire interlocking, motorised smoke dampers, etc. shall be wired in category CWZ cable. All extra low and low voltage field control circuits associated with CEs and MPDBs shall have a minimum cross sectional area of 1.5mm2.

All BMS field wiring associated with analogue and universal inputs and outputs shall be run in screened twisted pair(s) LSF cable with a minimum cross sectional area of 0.36mm2. All field wiring associated with digital inputs and outputs shall be wired in LSF cable.

Adequate segregation shall be provided between power and control circuits, as necessary, to avoid mixed voltages and effects of interference. No BMS data cable shall be installed in the same conduit as any power cable nor affixed within 25mm if surface/tray mounted. Where cables are run in trunking or with others clipped to tray of a similar type, these shall be identified either by colour or labels every 2m.

No joints will normally be allowed in cables. Where these are unavoidable, the cables shall be joined using an approved housing, securely fixed and having cable securing clamps. Any such connecting boxes shall be shown on the record drawings.

Where cables are connected to sensors measuring extreme heat, the necessary thermal breaks and local connecting cables are to be supplied.

All field cabling shall be identified with an agreed code. Typically power cable identification shall include the CE reference, the plant reference, cable size and number of cores, e.g. CE2/SF1/4mm2 3c. Typical control cable identification shall include the CE reference, voltage and outgoing first terminal number, e.g. CE2/24VAC/32.

2.11.3 Wiring Testing

Test all BMS/controls and power wiring as described under Wiring Installation in this Specification and BS 7671.

Provide documentary evidence of all cable test results associated with BMS/controls and power wiring installation.
Report the extent of any failures identified during testing which may affect the installation programme.
Correct any wiring faults discovered during the testing and commissioning at no additional cost to the contract.

2.12 BMS IT Network Shared

2.12.1 Network

Utilise the provided Cat 6e IP network as the BMS communications backbone.

Liaise with the IT network manager (UCL Information Services Division) to confirm the required number and location of IT connection sockets, allocation of IP addresses if DHCP is not used, the set-up of any required VLans and if the BMS not using dedicated server platforms, the use and set-up of the BMS server software on virtual servers hosted by others on the IT system.
Allow to provide and install colour coded patch cables required to connect the BMS into the IP network. Liaise with the IT network manager for these cabling requirements.

2.12.2 Dedicated Network

Provide BMS network cable of equivalent rating to that used elsewhere in the building. A Cat 6e cable shall be assumed as the minimum standard.

Design, provide, install and test a CAT 6e IT network for use as the BMS communications backbone in accordance with the specification requirements.

Provide a full network schematic.
Provide detailed layout drawings for all wiring routes, including tray, trunking, conduit installation and cable installation details.

Provide, install and test all necessary copper and fibre cabling, patch leads containment, sockets, connectors, switches, patch panels, copper to fibre converters, cabinets, enclosures, UPSs and configuration software to form a fully functioning network.

2.12.3 Network Design

Design the system and cable routes in accordance with all the relevant standards for fibre and CAT 6e cabling, including maximum allowable cable lengths and minimum bend radii.

Where any distances between CAT 6e devices exceed the maximum allowable cable distance, fibre shall be used instead.

Fibre shall always be used when running external to a building or between different buildings.

The network topology shall be designed to be as robust as possible so that loss of power to a CE shall not cause a loss of communications between any other BMS equipment external to that CE.

Within each CE an Ethernet switch shall be used to distribute the signals to controllers and Interfaces of ISD. No unmanaged hubs within the BMS LAN will be allowed. All Ethernet final connections (patch Cat6e leads) will be to a single data point supplied by an recognized cable installer.

IP connections between CEs, BMS field panels, servers, etc. shall be made via switches located in dedicated ISD Ethernet switch closets and owned my ISD. Once two or more switches are required, at this level then they shall be managed type and a network shall be formed between all the switches at this level. The connecting cables shall be arranged so that no cable section takes the same physical route as another.

2.12.4 Network Installation

Each of the switch enclosures shall be fed from a dedicated local power supply and shall contain a UPS within the enclosure to provide a minimum of 20 minutes back-up in case of power loss. They shall contain a patch panel for all incoming and outgoing terminations.

A patch schedule shall be created for each switch enclosure and each termination port appropriately labelled.

All cables, fibre or copper, with the exception of patch cables, shall have an associated containment system of either tray, ladder, trunking or conduit.

Data Termination points shall be located next to CEs. These shall have twin outlets, one for the switch connection and the other one as either:

- A spare cable run back to a patch panel but not connected to a switch
- A patched connection allowing commissioning and maintenance/local interrogation of the system.

All cables shall be appropriately identified using a propriety identification label system to an agreed identification format.

The installation of fibre and CAT 5e cabling shall comply with BS EN 50174.
The fibre/cable installation shall be warranted by the manufacture for the application for 15 years.

2.12.5 Network Testing

2.12.5.1 Fibre Testing

The fibre, once installed, shall be fully tested using, as a minimum, the following tests:

- Fibre Length
- Losses
- Connector losses
- Splice Losses
- Fibre Defects

The Fibre testing tool shall provide a printout of the results for each segment.
These printouts shall be available prior to demonstration of the BMS and shall form part of the O&M manual.

Any Fibre found not to not meet the necessary standards shall be replaced at no cost to the Contract.

2.12.5.2 CAT 6e Cable Testing

The CAT 6e cabling once installed shall be fully tested using, as a minimum, the following tests:

- Pins connected correctly
- Cable Length
- Wire Map
- Open Pairs
- Shorts
- Reverse Pair
- Split Pair
- Attenuation
- Near End Crosstalk (NEXT)
- Power Sum NEXT (PS-NEXT)
- Far End Crosstalk (ELFEXT)
- Power Sum EFLEXT (PS- EFLEXT)
- Propagation Delay
- Skew
- Return loss

The network testing tool shall provide a printout for each cable installed. These printouts shall be available prior to demonstration of the BMS and shall form part of the O&M manual.

Any CAT 5e found not to not meet the necessary standards shall be replaced at no cost to the Contract.

2.13 Labelling

Supply and fix labels for all items of controls equipment in accordance with the reference numbers in the System Narratives.

2.14 Commissioning

Fully commission the installed BMS/Controls system once the software and operator's station graphics have been installed on site.

Arrange for all flow measurement devices to be commissioned/calibrated by the equipment manufacturer and provide documentary evidence of such testing.

Set up frequency inverters provided by the BMS/Controls Specialist and carry out the initial start self-tune procedure in accordance with the manufacturer's instructions. This shall include setting up of underload/time parameters to detect malfunctions.

The commissioning process is defined as the activity where the complete BMS/Controls system is moved from a condition of static completion to a state of dynamic operation to provide functional and environmental control of the process within the design parameters. The commissioning process shall be undertaken systematically through the following principle stages to meet the requirements of the contract programme:

- Pre-commissioning and setting to work
- Point to point testing
- System functional operation
- Setting and adjustment of system variables or control loop values

The installation shall be thoroughly tested in the course of commissioning by the BMS/Controls Specialist to ensure every point, control device and item of plant is being controlled and/or monitored correctly.

It is a requirement that the system is tested and commissioned by personnel who have gained an intimate understanding of the project throughout its design stages. These personnel must also have a minimum of at least three year’s experience in the DDC

controls field and have full product training. Should any commissioning personnel not meet these requirements the BMS/Controls Specialist must apply to the Appointed Person for approval prior to allowing the said commissioning person(s) on site. The Contract Administrator reserves the right to refuse such commissioning personnel from working on site.
All testing and commissioning shall be pre-planned and scheduled in order that it is fully co-ordinated with other relevant trades and shall be carried out in a safe and efficient manner with a minimum of inconvenience to all concerned.

The installation shall be tested progressively as construction progresses and then finally on completion to ensure that the installation complies with the Specification and operates correctly under normal, emergency power, fire, fireman's override and fault conditions. Control, protection and operative devices shall be checked for correct adjustment and rating. Throughout the commissioning period detailed records of all testing undertaken shall be kept and maintained on site and periodically submitted to the Contract Administrator for their information. The detailed records shall include calibration certificates of any instrumentation used during the commissioning process.

All equipment or materials found to be faulty during testing shall either be replaced or repaired free of charge.

Where work is being carried out in an occupied building, the building manager shall be kept fully informed regarding the nature of the testing and commissioning. Steps shall be taken to ensure that any possible hazards or inconvenience that may arise due to the testing and commissioning shall be minimised.

Pre-commissioning and setting to work shall include:

- Ensuring that field devices have been correctly located for the application
- Ensuring that control devices are correctly installed in accordance with the manufacturer's instructions and are so mounted that there is adequate clearance for their removal and for normal testing, maintenance and inspection
- Verification that the control device has the correct range for the application, the range is correctly entered in the controller and is correctly engineered on the operator's station
- Attendance during the initial start-up of prime movers and the checking of direction of rotation, hard wired safety interlocks and the suitability and settings of protective devices
- The functionality and operation of all hard wired safety interlocks
- Checking network availability and functionality
- Checking assignment of IP/Network addresses
- Point to point testing shall include:

- Correct operation of a controls device/interface, including any associated status and alarm text.
- Correct installation of each valve/damper actuator, and that each valve/damper actuator is stroked correctly when checked against the BMS output.
- Calibration check of the control device

Point to point checks shall be proven from the field device/interface operation to the controller and from the controller to the presentation of the point on the graphics in a single continuous operation. The results from the point to point tests shall be submitted on pre-defined schedules.

Point to point testing for all Copper & Fibre IT Network cables installed by the BMS/Controls specialist shall include testing from the data point termination to the patch panel in the associated data cabinet. The results from the point to point tests shall be submitted on pre-defined schedules. Submit a schedule of points to be checked in this manner for each data point termination.

System functional operation shall include:

- Functional testing of the software in accordance with the system narrative on a clause by clause basis to check system normal, emergency power, fire, fireman's override and fault conditions as applicable
- The functional testing of hard wired interlocks by simulation of their respective fault conditions and the subsequent operation of the system in accordance with the system narrative
- Functional testing of the synchronisation between hard wired interlocks and system software to suppress alarm conditions
- Setting and adjustment of system variables and control loop values shall include:
- Setting the correct operational value for delay on/off timers to provide the correct cascade control or dissipation functions
- Setting the correct operational value for delay timers associated with alarm inhibit functions
- Checking the correct temperature value for out of limit alarms that provide either a high, low or differential alarm function
- Setting the correct proportional, integral, or derivative values in control loops to maintain stable control at the required design conditions. This shall ensure that the loop is neither under-damped and therefore unstable, or over-damped and too slow to respond to changes in system conditions or setpoint

The graphics shall be verified as part of the commissioning process to ensure that they give a true representation of the installed plant layout, e.g. if heater and cooler batteries are swapped or a damper has been omitted. Sensors should be located in the correct positions with relation to other plant e.g. is the sensor before or after the pump?

2.15 Demonstration

Demonstrate fully to the Contract Administrator that the BMS/Controls system operates to the requirements of this Specification.
Prior to loading software into BMS controllers on site, demonstrate all software and head end graphics at works, by simulation of plant operating conditions using switches, potentiometers, volt meters and lamps etc. The BMS/Controls Specialist shall give the Contract Administrator seven working days notice of software test dates. The Contract Administrator may decline to test software off-site.

On site the graphics shall be utilised as a means to carry out point to point checking in a single operation from field terminal device through controller to operator's station prior to demonstrating the system functionality.

Demonstrate that the installed and commissioned BMS/Controls system functions and operates in full accordance with this Specification and the testing and commissioning procedures described elsewhere in the Contract Documents

Before any demonstration, sign a document stating that the system to be demonstrated has been fully tested and commissioned and complies fully with the Specification.
The following shall be demonstrated as a minimum:

- Each and every point on the system including calibration checks and the stroking of actuators
- All dynamic graphics comply with the Specification
- All system programs comply with the Specification

Make available a minimum of three hand held radio transmitters (complete with chargers, etc.) to be used during the period of the acceptance demonstration.

Calibration of all devices will be demonstrated using only a currently certified instrument. It will be the responsibility of the BMS/Controls Specialist to ensure all instruments and their calibration certification are available for inspection prior to the demonstration. These shall remain the property of the BMS/Controls Specialist.

Acceptance of the system does not absolve the BMS/Controls Specialist from his responsibility, to provide a fully operational system, should any defects appear during the warranty period, notwithstanding that a fault was not apparent at the time of commissioning.

2.16 Documentation General

Refer also to the requirements detailed in the Technical Introduction.

Collate, prepare, submit, alter and subsequently re-submit controls O&M documentation and drawings in accordance with the Contract Documents.
As some items described in 'Project Documentation' cannot be completed until the project is partially or fully completed the documentation shall be formally submitted at 3 stages in the project. These stages, their timing and their contents are described as follows:

i. **Stage 1** (Preliminary) - This documentation shall consist of a file which contains dividers for all sections.

Any sections of the document not submitted shall be marked as such with the date by which that section will be supplied.

This stage of the documentation shall contain sections i, ii, iii, iv, viii, ix and x as described in 'Project Documentation' and shall be submitted within 3 months of the commencement of the contract. This documentation stage must gain "approval" from the design team before construction of CEs and MPDBs may begin, and control valves, actuators and variable speed drives be ordered.

ii **Stage 2** (Construction) - This shall be as per the stage 1 document set, except it shall include the latest revisions of the sections for stage 1 plus sections v, vi and vii. Proposed colour graphic displays shall be submitted with this document issue. This documentation stage must gain approval from the design team before programming shall commence.

iii. **Stage 3** (As-installed) - This document set shall contain the latest revisions of all sections. These shall be supplied on a disc or set of discs (CD or DVD) and the specified number of disc sets shall be provided.

Documentation shall consist of three virtual ‘volumes’ of which 3 copies of each shall be submitted. The documentation shall be provided in disc format (CD/DVD) with an hyperlinked index for each volume. Documentation shall be provided in both PDF and the document’s native format e.g. .docx, .dwg, .xls.

Documentation shall only be provided in paper form if specifically requested in the Scope of Works or Contract Preliminaries.

The three volumes are:

BMS Project Documentation; BMS Operator's Manual and BMS Programmer's Manual

The BMS project documentation volume will be job specific and therefore is the most important volume of documentation. The following details the sections which must be included in this part of the documentation.

i. Index (per volume and per disc). Hyperlinks shall be provided to each document and all documents drawings and drawings shall be provided with plain English descriptions as well as any drawing or document reference number e.g. LTHW Schematic 1 of 3 M-003-01.

ii. Schematic Diagrams - This includes schematic diagrams of the BMS network complete with system numbering and controller locations. It provides a quick understanding of the network architecture. Also included in this section is a plan view (and elevation view, if required) of the site which combine to give a reader a quick understanding of the site's/building's layout.

iii. Functional Description - This section describes in detail, the program and hard-wired control sequences associated with the systems. It shall reflect any changes made during the Contract. It shall be written in an easy to understand format and include the following:

- Set points values, time schedules etc.
- Mnemonic tag references as detailed in the Specification schedules.
- Input/output point addresses.
- Software addresses where appropriate e.g. calculation points, global points, etc.
- Detail of required operator action in acknowledging and resetting alarms, etc.

iv. Input/Output Listings - A complete list of all BMS inputs and outputs including device type connected, location, point number and terminal numbers shall be provided in this section.

v. Strategy Diagrams/Program Listing - Strategy diagrams or a program listing shall be provided, dependent on the manufacturer's standard software production method, for each controller and unitary controller. The program listing shall include English Language descriptions of how the routines work. Both methods shall include the values of all setpoints, proportional bands, integral reset times, timers etc.

vi. Configuration Data - This section shall include a list of all English language point and alarm descriptors and other information as described under 'Configuration' in this Specification.

vii. Maintenance Instructions - This section shall include any specific items of maintenance which are necessary to ensure the safe and reliable operation of the BMS, the plant it controls and the CEs.

viii. Data Sheets - A data sheet for each item of equipment in the BMS and in the CEs shall be supplied, including all field devices.

ix. Drawings - A complete set of drawings shall be supplied. Drawings as a minimum shall include the following:

- Schematic diagrams of all systems, detailing the locations of each item of plant in the system and the control actuators and sensors, complete with cross-reference point and item numbers
- CE layouts and label details
- Equipment schedules (including all CE and field equipment)
- CE wiring diagrams
- Field wiring diagrams

x. Schedules –detailing evaluation criteria and selections for the following equipment:

- Control valves and actuators
- Mechanical power distribution boards
- Power cables
- Variable speed drives

If a deviation to the above is required it must first be agreed with the Contract Administrator. However, any such deviation would be in format or presentation only. All information described above must be included.

Copies of Application Software

Provide two sets of back-up copies of the latest application and configuration software to the Client, both at the time of Practical Completion and also at the time of Final Completion of the BMS/Controls system. This shall include all head-end graphics, configuration data and database, controller application software, IUC application software and interface configuration software.

This shall be in such a format as to allow a full restoration of the BMS/Controls system should any controller or head-end computer be replaced or its software require re-loading. All software shall be the versions resident in the head-end, controllers, IUCs etc. at the associated issue time.
Back-up software shall be provided on optical media, i.e. in CD or DVD format.

2.17 Training

Refer also to the requirements detailed in the Technical Introduction.

The BMS/Controls Specialist shall provide training in accordance with this Specification, for the Employer and his nominated representative(s) starting at the end of the Contract Period not later than two weeks after Practical Completion. This shall comprise of five days offsite training for four people and ten days onsite training for four people.

2.18 Warranty & Maintenance

The BMS/Controls Specialist shall warrant and maintain the entire installation (including all BMS hardware and software, CEs, discrete controls, valves, etc.) for 12 months following the issuing of the certificate of Practical Completion.

The BMS/Controls Specialist shall attend any call by the end of the next working day as part of the warranty requirements.

Maintenance shall include regular visits to site during the warranty period. As a minimum requirement the BMS/Controls Specialist shall visit the site for 8 hours per month, to conduct maintenance on the BMS.

Any time required for the rectification of outstanding and latent defects is not included in this maintenance period.

During these visits the operation of the system shall be checked, trend log data collected and any maintenance required shall be performed. The operation of control loops under different seasonal conditions shall be checked and adjusted to provide stable but responsive control.

Following each site visit, a report detailing any problems encountered and the maintenance carried out and shall be submitted. The collected trend log information shall be examined and analysed and a report detailing the building's performance and any recommendations for system improvement issued after each visit.

During the warranty period, notification shall be made of software updates or upgrades when they become available. As part of the notification process the content of the updates or the reason for the upgrade shall be advised so that an informed decision as to whether to proceed with the update/upgrade or not can be made.

2.19 Tender Requirements Tender Quantities

For Tender purposes all control valves shall be sized for line size as detailed on the plant schematic drawings.

The information detailed in the Electrical Specifications and Drawings regarding power ratings are to be used for Tender purposes only.

Information To Be Returned With The Tender
The BMS/Controls Specialist shall:

- Return with their Tender a full points list and unitary control schedule
- Provide an exceptions list of all specification clauses which the BMS/Controls System offered is not compliant, otherwise the system shall be deemed to be fully compliant
- Provide interface requirements if the works is an extension to the client's existing BMS. Description of Excluded Work

Clearly describe any work necessary for the proper completion of the Specialist works not included for in his Tender and which he may require to be executed and paid for by others; any such work not specifically stated and described shall be deemed to have been included in his Tender.

Tender Cost Summary
Submit as a minimum separate prices with the Tender for the following:

- BMS Application Software (Trend 963, StruxureWare Building Operation)
- Computer equipment
- BMS Hardware (Touchscreens, controllers, I/O modules, integration controllers)
- Unitary Controllers including associated control valves, actuator and sensors.
- Field Devices
- Variable Speed Drives
- Control Panels
- Power & control installation including necessary containment
- Commissioning
- Software engineering
- Project engineering
- Graphic creation/updates
- Project Management

3.0 BMS Standard Operations

3.1 Guidance

The section is for guidance only and should be read in conjunction with the tender particular specifications, drawings and relevant Contract Documents.

3.2 Control Panels

The below Control Panel types shall be provided and comply with BS EN 61439-2:2009 standards.

Additional at least 10% spare capacity shall be allowed in every panel for future installation of desired equipment on the back plate as well as on terminal connections and within any installed trunking. Any input/output modules required to utilise the spare points shall be provided. Expansion capacity shall include equal quantities of every point type; Analog input, Digital input, Digital output, and Analog output.

Control panels shall be constructed to suitable IP rating for their environment.
There should be a 13A double gang socket installed along with ventilation and heater units where necessary.
MCC's shall be provided in each plant space for local power distribution and for BMS control / monitoring of the building services installation.

Power feeds from the LV switchboards to the Control Panels will be provided by the electrical contract to single section field interface panels shall contain controllers, I/O modules, power supplies for sensors and interface relays requiring for field interface devices.

Power to drives are not to be mounted within this type of control panel.
Two section control panels with separate power and control sections for local power distribution and for BMS control monitoring of the building services installation.

3.2.1 Form4

Where added resilience of HVAC Plant is required Form 4 Type 4 Control Panels will be installed.

3.2.2 Control Panel Facia Test/Off/Auto Switches and Indications

Unless specifically described otherwise, the positions of panel fascia 'Test/Off/Auto', 'Test/Auto' or 'Off/Auto' switches shall have the following actions:

3.2.2.1 "Test" Switch Position

The 'Test' position is provided for commissioning and maintenance purposes and shall allow the plant to run out of normal automatic control provided all the associated hardwired safety interlocks are satisfied.

When a fan is selected for 'Test' operation, any associated fan isolation damper(s) shall be first driven open via a hard-wired interlock and that fan shall be prevented from operating until all associated isolation dampers have been proven open via hardwired interlocks from damper end switches.

If a pump has any associated circuit isolating valves that would normally be driven and proved open before the pump started under automatic control, then the pump shall be hardware interlocked with those same isolating valves and the minimum number of valves required to open under automatic control shall need to be driven and proved open before the pump is allowed to run.

Inverter controlled fixed speed fans or pumps shall be provided with 'test' positions, but inverter controlled variable speed fans or pumps shall not have a 'test' position but shall require their inverter to be put into a local mode whilst its switch is in the 'Auto' position.

3.2.2.2 "Off" Switch Position

When a selector switch 'Off' position is selected the associated plant shall stop. The 'Off' position shall not be overridden by either a fire condition or fireman's switch override or an inverter being put in a local mode.

Note that any subsequent plant failure alarms caused by turning the equipment off will have to be cleared before that plant will run again under automatic control.
When a fan is selected 'Off', any associated fan isolation damper(s) shall be driven closed via hard-wired interlocks.

3.2.2.3 "Auto" Switch Position

With a selector switch in its 'auto' position, the associated plant shall operate as described under the Automatic Control section in the System Narratives.
The switch shall be monitored by the BMS for ‘out of Auto’ status which shall be assigned to a specific alarm priority on the BMS so that a filter can be set to establish all status of switches.

3.2.4.4 Plant Indications

All indicators lamps are to be LED type and coloured green for normal or run status, and red for fail or fault status.

'Panel Live' indication shall be on the control panel fascia.
'Running' and 'Fault' indications on the control panel fascia shall be derived from volt free contacts on the variable speed drives and packaged units to indicate running and tripped conditions, normal and fault conditions, boiler lockout and high temperature faults, pressurisation unit fault, frost thermostat operation etc. as appropriate to indicate the status of all plant being controlled via the control panel.

Variable Speed Drives (VSDs) indications on the control panel fascia shall be provided by additional DDC outputs if the VSDs are interfaced to the BMS via serial link, or by relay contacts auxiliaries, if the VSDs are interfaced via hardwiring.

'Tripped' indication shall be derived from overload contacts on the motor starter.
The panel must also be fitted with a lamp test facility.

3.2.4.5 BMS Alarm Reset

Any software plant faults/alarms that prevent normal plant operation by those controllers within that control panel shall illuminate a common "BMS Fault" lamp at that control panel. BMS software alarms shall be reset at either the BMS operator's station or via the software reset button on the fascia of the control panel. The reset button shall only reset alarms generated by controllers at that control panel.

3.3 Equipment Interfaces

3.3.1 Inverter Local Mode Monitoring

Each inverter shall have a hard wired enable signal and high level interface for monitoring of the following points at the BMS Workstation:

Fault Status, Run Status, Control, Out of Auto & KWHr
If an inverter controlled variable speed fan has any associated fan isolation damper(s), these shall first be driven open and that fan shall be prevented from operating until all associated isolation dampers have been proven open via hardwired interlocks from damper end switches.

If an inverter controlled variable speed pump has any associated circuit isolating valves that would normally be driven and proved open before the pump started under automatic

control, then the pump shall be hardware interlocked with those same isolating valves and the minimum number of valves required to open under automatic control shall need to be driven open via a hard-wired interlock from the inverter 'local mode' signal and proved open before the pump is allowed to run.

3.3.2 Life Safety Fan Control Circuit Monitoring

Each supply and extract fan that has a life safety function (e.g. smoke extract fan, staircase pressurisation fan) shall have its control circuit monitored for a healthy condition by the BMS.

A relay shall be driven by the control circuit at a point downstream of all panel isolators, Test/Off/Auto switches, local isolators and control cable protection fuses/MCBs but this point shall be upstream of any controls switching circuits (so that if the fan is supposed to be off, no alarm is raised). That relay shall be monitored by the BMS.

In the event of a fan unable to run because of a loss of the control circuit, a critical alarm shall be raised on the BMS for that fan.

3.4 General Software Control Functions

3.4.1 Manual Off/On/Auto Software Selection Switches

Unless specifically stated otherwise, an "Off/On/Auto" software selector switch shall be provided for each system and also for the individual main items of plant within that system e.g. each pump, each fan, etc.

The software selector switch commands shall be overridden in software by other life or plant safety signals e.g. fire, fireman overrides, system pressure and frost shutdown Point Override.

It shall be possible to override all input and output points by use of the BMS manufacturer's standard software engineering pages or graphics. Any point in an override condition shall be clearly indicated as being overridden on the system graphics.

3.4.2 Rotational Point

A rotational point is any software point used to determine the sequence of operation of a number of items of similar plant such as duty/standby, lead/lag and lead/1st lag/2nd lag/standby.

The rotational point shall be set to automatically change the duty as specified in the particular system narrative, typically under one of the following circumstances:

- On a calendar basis (e.g. weekly, monthly).
- Once a predefined hours run total has been reached.
- Once a predefined time is reached.

In the event of a motor failure the lead/standby rotation shall be disabled.
Unless otherwise specified, an operator shall always be able to manually alter the rotational point value to select a particular sequence.

3.4.3 Run Time Totalization

A run time totalization program shall be provided for each drive or plant enable output. The system shall initiate an “hours run exceeded” alarm for that plant item whenever the preset limit has been exceeded for the particular item.

The run time total shall be accessible by command from the operator, who shall also be able to reset the limits or zero the count for each item.

3.4.4 Fixed Time Program

Each time program shall provide occupied and unoccupied period data enable in order to allow plant to start and stop, or change mode of operation as detailed in the particular specification at specific times for each day of the week. It shall be possible to specify a minimum of two occupied periods per day. Occupied and unoccupied periods shall be able to span from one day to another.

Where multiple systems are normally required to operate together, then either a single or a master time schedule shall be provided that covers the operation of all those systems. It is not acceptable that an operator has to individually adjust the times for each of those systems.

It shall be possible to program for up to twelve months in advance including holidays and to make temporary time adjustments which automatically reset once operated.

3.4.5 Optimum Start / Stop

Optimum start and stop programs shall be provided for energy conservation and shall calculate the optimal start and stop times for the HVAC plant, based on occupancy time, measured internal space and outside conditions. The programs shall be suitable for both heating and cooling operation as specified and shall be self-adaptive, i.e. they shall make corrections to the optimisation characteristics in accordance with the accuracy of their predictions. The program shall take account of the day of the week, occupancy patterns and holidays.

Unless otherwise detailed in the Particular Specification any heating or cooling optimum start 'boost' condition shall be terminated by either occupancy time being reached or by occupancy temperature being achieved whichever occurs first.

For both optimum start and stop operation, after the initial learning period, setpoint should be achieved within ±15 minutes of the start or end of occupancy.

The program shall incorporate facilities for maintaining the internal space temperature of the building or system above a predetermined minimum level, outside occupancy hours. For each optimum start program the following points shall be logged: Plant start time. Outside air temperature at plant start time.

The inside air temperature used for control at plant start time. Time optimum start terminated.

Lowest inside air temperature at optimum start termination time. Time inside setpoint achieved.

For each optimum stop program the following points shall be logged:

- Plant stop time.
- Outside air temperature at plant stop time.
- Inside air temperature used for control at plant stop time.
- Time inside setpoint achieved.

3.4.5.1 Optimum Heating Start

Optimum start heating shall be used for the optimisation of the heating system start time in all buildings. The optimum start heating operation shall utilise the adaptive, self-learning program detailed above, to achieve the pre-defined comfort conditions at the start of the occupied period in the shortest possible time, thus minimising fuel consumption.

Upon the average space temperature measured being [3]K or more below the occupied setpoint, the plant shall be started in heating boost mode. When the outside air temperature is below [8]K a boost signal shall be initiated. Upon receipt of a boost signal from the optimum start program the heating plant shall operate at maximum output consistent with safe and efficient operation.

3.4.5.2 Optimum Heating Stop

Optimum heating stop shall be used to optimise the stop time of the heating plant in all buildings.

Optimum heating stop control shall utilise the adaptive, self-learning program detailed above, to compute the earliest possible stop time on a particular day that is consistent with maintaining a minimum acceptable zone air temperature in the heated space by the end of the period of normal plant operation, i.e. usually at the end of the occupied period.

The purpose of optimum heating stop control is to reduce heating energy consumption by stopping the heating earlier than would otherwise be the case.

Upon the lowest space temperature measured being [1]K or more above the occupied setpoint, the heating plant shall be optimised to stop. The control program shall disable the normal operation signal so as to stop the heating plant as early as possible consistent with maintaining the related zone air temperature no more than [1]K below the pre-set occupied setpoint until the end of the occupied period.

The optimum stop program cannot be applied to ventilation systems which supply outside air to the heated zone if the outside air requires heating throughout the occupied period. Items of plant that serve separate zones may utilise individual optimum stop programs.

3.4.5.3 Optimum Cooling Start

Optimum start cooling shall be used for the optimisation of the cooling system start time. Optimum start cooling operation shall utilise the adaptive self-learning program detailed above to achieve the defined comfort conditions at the start of the occupied period in the shortest possible time, thus using the minimum amount of cooling energy to reach the zone cooling temperature setpoint.

Upon the highest average space temperature measured being [3]K or more above the occupancy setpoint, the plant shall be started in boost mode. Upon receipt of a boost signal from the optimum start program the cooling plant shall operate at maximum output consistent with safe and efficient operation.

3.4.5.4 Optimum Cooling Stop

Optimum cooling stop shall be used to optimise the stop time of cooling plant in intermittently occupied buildings with regular occupation profiles. The optimum cooling stop control shall utilise the adaptive self-learning program detailed above, to compute the earliest possible stop time on a particular day that is consistent with maintaining a maximum acceptable air temperature in the cooled space by the end of the period of normal plant operation, i.e. usually at the end of the occupied period.

The purpose of optimum stop control is to reduce cooling energy consumption by stopping the cooling earlier than would otherwise be the case.

Upon the highest space temperature measured being [1]K or more below the occupied setpoint, the cooling plant shall be optimised to stop. The control program shall disable the normal operation signal so as to stop the cooling plant as early as possible consistent with maintaining the related zone air temperature no more than [1]K above the pre-set occupation setpoint until the end of the occupied period.

The program cannot be applied to ventilation systems which supply outside air to the cooled zone if the outside requires cooling throughout the occupied period. Items of plant that serve separate zones may utilise individual optimum stop algorithms.

3.4.6 Night Cooling

Night cooling programs shall be provided to assist in offsetting the daytime heat gains that build up thus minimising or avoiding the requirement for air conditioning during the occupied period. Night cooling is achieved by ventilating the space using either passive or mechanical ventilation.

A night cooling control strategy shall be initiated should the measured average daytime zone temperature be above the predetermined maximum night cooling setpoint of [24]°C, and the average afternoon outside temperature is greater than the average outside temperature setpoint of [20]°C, at this point the decision should be made to initiate night cooling the following evening.

Interlocks shall be provided for both the natural or mechanical ventilation systems to:

- Prevent the ingress of air that is too cold
- Prevent night cooling occurring when the outside temperature is above the inside temperature
- Additional interlocks shall be provided for passive ventilation to prevent rain ingress

Ensure limited operation of the vents into a safe position in the event of high wind speed. Once night cooling has been initiated the natural ventilation system operates to allow air flow within the building. Night cooling shall continue provided the zone temperature remains above the outside air temperature. Mechanical ventilation should be limited in use to periods when the outside temperature is at least [4]K below the zone temperature or when natural ventilation is not feasible due to bad weather conditions (high wind or rain) and the outside air temperature is at least [2]K below the zone temperature.

The night cooling routine should be operated throughout the entire non occupied period, seven days per week. Where buildings are occupied Monday – Friday only night cooling will not occur on Friday and Saturday.

Unless otherwise detailed in the System Narratives any night cooling demand shall be terminated by either of the following whichever occurs first:

- Occupancy time being reached
- Optimum heating or cooling being initiated
- Night cooling setpoint being achieved

If one zone is cooled to setpoint then this zone should shutdown and the remaining zones continue to operate until their respective setpoints are reached. The night cooling setpoint should always be greater than the heating setpoint, as cooling below this level will conflict with the heating system. An interlock to stop night cooling shall be incorporated should the outside temperature fall below [12]°C.

For each Night Cooling Zone, the following points shall be logged:

- Night Cooling start time.
- Night Cooling stop time.

3.4.7 Fan/ Isolating Damper Interlocks

When the supply and extract fans are required to run in either ‘test’ or ‘auto’ they shall be hard wire interlocked with the end-switch on their respective isolation damper so that a fan shall be disabled until its respective damper has been driven open and is proven fully open.

Upon a mismatch between the BMS command to a damper and the damper end-switch status condition occurring, after a time delay sufficient for the damper to fully open, or loss of status, a damper mismatch alarm shall be raised on the BMS operator’s station.
In the event that the intake or exhaust damper fails, the AHU shall be configured as described under Plant Shutdown. The AHU shall not re-enter the normal automatic control sequence until the BMS operator acknowledges that the fault has been cleared and operates the fault reset at the BMS operator's station or operates the ‘plant alarm reset’ push button on the CE fascia.

3.4.8 Generation of Mismatch Failure Alarms for Motor Drives

When commanded to run from the BMS, a fan or pump specified as having an associated flow proving input shall raise a mismatch failed alarm on the BMS for that drive if a running status is not received within an [adjustable] time delay. This time delay shall be set long enough to allow the drive to run up to its design speed.

If the software allows two time delays, then once the drive has been proved running and the drive is still being commanded to run, loss of running status for longer than another shorter [adjustable] time delay shall also raise a mismatch alarm on the BMS for that drive. The method of obtaining drive status and the action taken upon a drive failure shall be as defined in the particular system narrative.

3.5 District Heating System

The District Heating Primary System that is distributed around the campus is controlled by the SmartStruxure system which is networked back to the server located within the UCL BMS room.

When there is a requirement within the particular specification for LTHW or DHW plate heat exchangers to be installed a dedicated control panel with StruxureWare controller will be installed to provide control and monitoring of plate heat exchangers (PHX) associated with the LTHW and DHW systems.

The primary to the plate heat exchanger is connected to the existing UCL MTHW district heating system. A Kamstrup Multical heat meter will be installed on the Primary Side of the PHX, the below M-BUS points will be mapped to a SIPe M-Logger that shall also be mounted within the Control Panel:

- Energy Total
- Flow Temp
- Return Temp
- Flow Rate
- Max demand

The secondary discharge side of the plate heat exchanger provides LTHW to the pumped circuits, the following points shall be installed per PHX:

- Secondary flow temperature
- Secondary return temperature
- Control valve actuator (Primary side return)

The secondary flow temperature sensor shall modulate the control valve located in the MTHW primary return circuit to maintain a discharge flow temperature of 80°C and return temperature of 60°C.

The external air temperature detector varies the water flow temperature via a 2-port valve on the MTHW return to maintain a pre-set compensated heating curve.

Outside Air Temperature 0°C - Calculated Setpoint Water Flow Temperature 80°C

Outside Air Temperature 20°C - Calculated Setpoint Water Flow Temperature 65°C

The plate heat exchangers will operate under the dictates of a dedicated plate heat exchangers demand signal from the BMS.

If required the BMS sequences the two equal plate heat exchangers to operate as lead/lag.

The lead plate heat exchanger control valve output is modulated, via a proportional control loop, to maintain the flow water temperature setpoint.

On increasing load the lag plate heat exchanger will be enabled when the loop output has risen above setpoint for a period of [3] minutes. On decreasing load, the lag plate heat exchanger will be disabled when the loop output has fallen below setpoint for a period of [5] minutes.

The duty plate heat exchanger will be rotated every [7] days at [0800] hours.

3.6 Mechanical Ventilation Systems

3.6.1 AHU Cold Start Interlock

Upon a demand signal being received by the AHU, should the outside air temperature be less than [6]°C, then a heating demand signal shall be sent to the LTHW plant and the AHU shall remain disabled. The frost or heating coil control valve shall be fully opened to coil.

If the unit has no frost coil, the heating coil shall be used. If the unit has a frost coil, the frost coil only shall be used.

Upon the CT circuit serving the AHU achieving a temperature of [60]°C or more and the frost or heating coil being open to their coil for [5] minutes, the AHU shall be free to start. Upon a fan running status being received this interlock shall be disabled for the remainder of the AHU occupied period.

During the Warm-Up period, an indication of ‘Pre-Warm-up Mode Active’ shall be shown on the AHU graphic.

These interlocks shall be active each time the system is required to start and shall be disabled once the AHU is running.

3.6.2 Supply Air Temperature Control

Refer to UCL Heating and Cooling Policy for guidance.

The mixing dampers, heater battery and cooler battery shall be modulated in sequence, via P+I control loop, in order to maintain the discharge air temperature at setpoint ±0.5K.

3.6.3 Supply Air Temperature Reset

The AHU discharge air temperature setpoint shall be calculated, via a P+I control loop, to maintain the average space temperature at setpoint ± 0.5K. The discharge setpoint shall be varied within limits of [14]°C and [24]°C.

3.6.4 Mixing Damper Temperature Control

The supply and exhaust dampers shall be modulated in parallel via 0-10Vdc signals. The recirculation damper shall be operated in opposition to the supply and exhaust dampers via a 0- 10Vdc signal.

During normal plant operation the mixing dampers will be modulated between their minimum outside air position and full outside air under the dictates of the control loop(s) described in the Particular Specification.

For temperature control purposes, the mixing dampers shall operate in cooling mode when the intake air temperature is less than the return air temperature by more than [1] °C, i.e. a greater demand for heating sees the mixing dampers move to allow greater amount of recirculation air supplied to the AHU and a greater demand for cooling sees the mixing dampers move to allow a greater amount of outside air to be supplied to the AHU.

The mixing dampers shall swap operation to operate in a heating mode when the intake air temperature is more than the return air temperature by more than [1] °C i.e. a greater demand for cooling sees the mixing dampers move to allow greater amount of recirculation air supplied to the AHU and a greater demand for heating sees the mixing dampers move to allow a greater amount of outside air to be supplied to the AHU.

If the difference between the intake and return air temperature falls in-between those limits, then the mixing dampers shall remain in their last mode of operation. On initial plant start, the mixing dampers shall assume a cooling mode.

The mixing dampers shall be controlled to the highest demand signal from either the temperature, CO2 or minimum outside air control loops.

3.6.5 Cooling Coil Frost Protection

The mixing dampers shall be modulated, via a P+I control loop, to maintain the average temperature upstream of the cooling coil at setpoint ± 0.5K.

3.6.6 Minimum Outside Air Control

For a fixed speed AHU, the correct minimum outside air position for the mixing dampers shall be determined during commissioning through independent measurement of the intake air volume.

For variable speed AHUs, the minimum outside air position for the mixing dampers will vary dependent on fan speed. Dependent on the method specified by the system narrative, a minimum fresh air volume shall either be obtained by use of direct volume measurement and a P+I override loop to maintain the airflow reading at or above the minimum airflow setpoint, or else by the use of a look-up table with a number of mixing damper positions against the range of fan speeds as determined during commissioning through independent measurement of the intake air volume at those set fan speeds. A minimum of five fan speeds shall be used.

3.6.7 Enthalpy Override

Where an enthalpy override function is required in the system narrative, the following shall occur:
When the plant is operating and the intake air enthalpy, as calculated from the intake duct mounted air temperature and humidity sensors, is greater than the return air enthalpy, calculated from the return air temperature and humidity sensors, the normal mixing damper control shall be overridden and the mixing dampers driven to their minimum outdoor air position. The system graphic shall provide an indication that an 'Enthalpy Override' is active.

The dampers shall revert to their normal control position when the return air is greater than the intake air enthalpy. A suitable switch over dead band shall be provided to prevent hunting between modes.

Note that enthalpy shall only override the position of the dampers as required under temperature control. If there is also a carbon dioxide override specified, this shall take precedence over the enthalpy override.

3.6.8 Carbon Dioxide Control

Where a carbon dioxide override function is required by the system narrative, one of the following two options (as specified) shall occur.

The specified controlling carbon dioxide value (space CO2, return air CO2 etc) shall be used by a P+I override loop to maintain the controlling carbon dioxide value at or below the maximum carbon dioxide setpoint.

The specified controlling carbon dioxide value (space CO2, return air CO2 etc) shall be fed into a proportional loop with an output of [minimum outside air position %] at the [low CO2 setpoint] and an output of [100% outside air] at the [high CO2 setpoint]. If the loop output requires a greater outside air amount than any other mixing damper control loop, then the mixing dampers shall be set to the carbon dioxide loop control value.

3.6.9 Mixing Damper Control Priority

The mixing dampers shall be controlled to the highest demand signal from the cooling coil, carbon dioxide, enthalpy override, minimum outside air and supply air temperature control loops in this priority.

3.6.10 AHU Face and Bypass Heat Exchanger Control

During normal plant operation, the face and bypass dampers shall be modulated in opposition via the same 0-10Vdc control signal to vary the airflow through the heat exchanger. The dampers shall be modulated via proportional and integral action control to achieve the desired system setpoint under the dictates of the appropriate control loop(s) described in the System Narratives.

For temperature control purposes the heat exchanger shall operate to recover warmth or coolth when the following conditions are met:

Warmth Recovery

The supply air heating setpoint is greater than the on plate heat exchanger air temperature. The return air temperature is greater than the on plate heat exchanger air temperature.

Coolth Recovery

The supply air cooling set-point is equal to or below that of the on plate heat exchanger air temperature.

The on heat exchanger air temperature is below that of the return air temperature.
If not in either of the recovery modes, then the bypass damper shall be opened with the face damper closed.

During plant operating periods the face and bypass dampers shall always be sequenced first in order to provide energy recovery to achieve the required temperature setpoint. Only when the dampers are being fully utilised or not available due to temperature restraints are the other items of plant to be operated in sequence for temperature control purposes.

The heat exchangers face and bypass damper actuator shall be software interlocked to the supply fan motor so that irrespective of the BMS operating signal the heat exchanger dampers can only modulate when the fan is operating. If the fan fails the face damper is fully opened and the bypass damper closed.

When the BMS is signalling a shutdown period, the face damper is fully opened and the bypass damper closed.
When the BMS is signalling a Night Cooling operation, the face damper is closed and the bypass damper is fully opened.

3.6.11 Thermal Wheel Mode Operation

Where an AHU has a single thermal wheel used just for heat reclaim purposes, the following description shall be shall be used to determine the mode of operation of the thermal wheel – heating mode, cooling mode or off. Note that if the AHU has no cooling capacity and thermal wheel is not wanted to operate in a cooling mode, then the cooling mode words shall be ignored and the thermal wheel operate in either a heating mode or shall remain off.

Heating Mode

- The thermal wheel shall be enabled in a heating mode only if both:
- The supply air heating setpoint is greater than the supply AHU intake air temperature by [1]K or more
- The on-extract thermal wheel temperature is greater than the supply AHU intake air temperature by [2]K or more
- Once enabled in a heating mode, the thermal wheel shall be turned off if:
- The supply AHU intake air temperature equals or exceeds the supply air heating setpoint
- The on-extract thermal wheel temperature equals or is less than the supply AHU intake air temperature

Cooling Mode

The thermal wheel shall be enabled in a cooling mode only if both:
The supply air cooling setpoint value is equal to or below that of the supply AHU intake air temperature.

The on-extract thermal wheel temperature is below that of the supply AHU intake air temperature by [2]K or more.

Once enabled in a cooling mode, the thermal wheel shall be turned off if:

The supply AHU intake air temperature falls below the supply air cooling setpoint by [1]K or more.

The on-extract thermal wheel temperature is equal to or greater than the supply AHU intake air temperature.

If not in either a heating or cooling mode, the thermal wheel shall remain off.
Once enabled to operate, the thermal wheel speed shall be controlled by either the heating or cooling control loop as appropriate. The thermal wheel speed shall always be either the first stage of heating or cooling.

If the thermal wheel remains off for longer than [4] hours whilst the AHU is operating, then the thermal wheel shall be put in a 'purge' mode and run at its lowest speed for [15] minutes after which the 'purge' mode shall be cancelled, the wheel turned off and the cycle shall be allowed to repeat as necessary. If the wheel is required to be operated in either a heating or cooling mode whilst a purge is taking place, purge mode shall be cancelled and the wheel shall operate as required under the dictates of the temperature control loop.
The system graphic shall display the operating mode of the thermal wheel, either 'heating mode', 'cooling mode', 'off' or 'purging'.

3.6.12 AHU Temperature Alarming

AHU control temperature sensors (e.g. supply air temperature or the off-frost coil temperature) shall raise an out of limit alarm is the sensors value varies excessively from the sensor's setpoint for longer than [5] minutes on critical plant.
If the sensor has control over a heating source only, then an alarm shall be raised if the sensor temperature falls below setpoint by more than [2]°C for the specified time period.
If the sensor has control over a cooling source only, then an alarm shall be raised if the sensor temperature rises above setpoint by more than [2]°C for the specified time period.
If the sensor has control over a both a heating and cooling source, then an alarm shall be raised if the sensor temperature rises above setpoint by more than [2]°C or falls below setpoint by more than [2]°C for the specified time period.
The alarm shall be inhibited for [15] minutes after plant start-up and whenever the AHU is shutdown

3.6.13 Duct Mounted Electric Heater Battery

Duct mounted electric heater batteries should not be employed except as a point of last resort.

Where an AHU has an electric heater battery used for temperature control purposes, the following description shall be used to determine its use.

The electric heater battery shall be used when the sequencing of the mixing dampers and thermal wheel do not meet the supply duct temperature control heating requirements. Once enabled, a thyristor shall modulate the output to the electric heater battery via a 0-10v control signal to achieve the supply duct heating set-point.

An automatic reset hi-Limit protection thermostat, located [5] metres downstream of the heater battery, on sensing a temperature of [40]°C or greater shall, via a hardwire interlock and latching circuit, disable the electric heater battery, and after a time delay of [10]minutes, shut down the supply and extract fans and close any associated intake and extract isolation dampers.

When the unit is shut down due to hi-limit protection by the thermostat, a critical alarm shall be raised at the BMS operator's station and the AHU 'Hi-Limit Protection Activated' lamp on the CE fascia shall be illuminated.
The Hi-Limit protection interlock shall operate when the fans are in the 'Test/Off/Auto' switch positions.

Following a hi-limit shutdown, provided that the thermostat is in a healthy state, the latched signal shall only be reset by the 'hi-limit Reset' button on the CE fascia, by operator command at the BMS operator's station or upon loss of power to the CE

All parts of the hi-limit thermostat shall be located inside the AHU.

3.6.14 VAV Supply Air Temperature Reset

3.6.14.1 Decreasing Load

If the most open VAV terminal box volume setpoint signal drops below [75]% then the supply air temperature setpoint shall be raised at a rate of [1]K per [15] minutes until either the supply air temperature setpoint reaches its upper limit of [xx]°C or the highest volume setpoint exceeds [80]% when the resetting action to raise the supply air temperature setpoint shall stop.

3.6.14.2 Increasing Load

If the most open VAV terminal box volume setpoint signal exceeds [90]% then the supply air temperature setpoint shall be lowered at a rate of [1]K per [15] minutes until either the supply air temperature setpoint reaches its lower limit of [yy]°C or the highest volume

setpoint falls below [85]% when the resetting action to lower the supply air temperature setpoint shall stop.

The facility to monitor and remove any of the VAV boxes from this reset routine via the operator's station shall be provided. The '% open' value of each VAV box shall be displayed on the operator's station system graphic.

3.6.15 Static and Differential Pressure Control Loops

Where a system has multiple static or differential pressure sensors, each sensor shall be given its own setpoint. The exact setpoints required to allow the system to work correctly without providing excess pressure shall be determined during commissioning.
Each sensor shall have a proportional plus integral control loop, and the loop with the maximum output shall be used as the selected control loop.

The speed of the associated fans or pumps shall be controlled, via a proportional plus integral control loop, in order to maintain the selected control sensor at its static or differential pressure setpoint. Thus one sensor should be maintained at its setpoint and the other sensors be above their setpoints.

Should a sensor fail, then it shall be removed from the control regime and control shall pass to the remaining sensor(s). Should all sensors fail, then the loop output shall defer to a fixed speed of [80]%.

3.6.16 AHU Return Fan Volume Control

The supply air and return air volume rates shall be measured.

The return fan speed, shall be shall be modulated, via a proportional plus integral control loop, to maintain the return air volume setpoint.
The return air volume setpoint shall be set to [90]% of the supply fan volume setpoint, except when the AHU operates outside occupied hours and the mixing dampers are set to full recirculation, when then the return fan speed shall be set to the same speed as the supply fan.

3.6.17 Filter Pressure Transducer

For each filter monitored by a differential pressure switch, in the event that the differential pressure across a filter is indicative that the filter requires replacement an alarm shall be raised at the BMS Operator’s Station.

3.6.18 Filter Pressure Transducer

For each of filters monitored by a Pressure Transducer, in the event that the differential pressure across a filter is indicative that the filter requires replacement an alarm shall be raised at the BMS Operator's Station.

For filters on variable air volume systems, the differential pressure threshold value for differential pressure sensor application shall vary in relation to the air velocity passing though the filter. Where air velocities are directly measured, the dirty pressure setpoint shall be determined by a look-up table based on the measured air velocity. Where only the fan speed output is known, the dirty pressure setpoint shall be determined by a look-up table based on the fan speed output.

3.6.19 AHU Frost Protection

An automatic reset frost protection thermostat, located immediately after the first unprotected coil, on sensing a temperature of [3]°C or less shall, via a hardwire interlock and latching circuit shut down the supply and extract fans and close any associated intake and extract isolation dampers. The software shall drive all associated control valves to the full flow to coil position.

When the unit is shut down due to frost protection by the frost thermostat a critical alarm shall be raised at the BMS operator's station and the AHU 'Frost Protection Activated' lamp on the CE fascia shall be illuminated.

The frost interlock shall operate when the fans are in the 'Test/Off/Auto' switch positions. Following a frost shutdown, provided that the frost thermostat is in a healthy state, the latched signal shall only be reset by operator command at the BMS operator's station or upon loss of power to the CE.

All parts of the frost thermostat shall be located inside the AHU.

3.6.20 Excessive Positive Static Pressure Limit

Where an excessive positive static pressure switch is specified for a fan, either within an AHU or on its own, a static pressure switch shall be located immediately on the discharge side of the fan concerned. In the event of an excessive positive pressure condition, that fan shall be stopped by a hard wired latching circuit, which shall be failsafe in operation, and a critical alarm shall be raised at the operator's station. This interlock shall be wired such that it cannot be overridden by the fan's 'Test/Off/Auto' switch. Action shall be taken in software as if the fan had failed.

The plant shall only re-enter the normal automatic control sequence upon an operator reset via a pushbutton on the fascia of the associated CE provided that the pressure switch is now in a healthy condition.

The failsafe circuit shall be arranged such that upon loss and subsequent resumption of power, the latching circuit is automatically reset, if the pressure switch is in a healthy condition. Once reset, the alarm shall be cleared and the plant can restart.

3.6.21 Excessive Negative Static Pressure Limit

Where an excessive negative static pressure switch is specified for a fan, either within an AHU or on its own, a static pressure switch shall be located immediately on the suction side of the fan concerned.

In the event of an excessive negative pressure condition, that fan shall be stopped by a hard wired latching circuit, which shall be failsafe in operation, and a critical alarm shall be raised at the operator's station. This interlock shall be wired such that it cannot be overridden by the fan's 'Test/Off/Auto' switch. Action shall be taken in software as if the fan had failed.

The plant shall only re-enter the normal automatic control sequence upon an operator reset via a pushbutton on the fascia of the associated CE provided that the pressure switch is now in a healthy condition. The failsafe circuit shall be arranged such that upon loss and subsequent resumption of power, the latching circuit is automatically reset provided that the pressure switch is in a healthy condition. Once reset, the alarm shall be cleared and the plant can restart.

3.6.22 Duty/Standby Fan and Pump Packaged Units

Monitor the packaged unit for its running status and fault status via volt free contacts on the package unit.

Upon receipt of a 'fault' signal from the unit, if the' running' status is still present, raise a single fan/pump failed alarm at the BMS.

Upon receipt of a 'fault' signal from the unit, if the 'running' status is not present, raise a both fans/pumps failed alarm at the BMS.

The unit shall not return to normal operation until the 'fault' signal has cleared, and the unit has been reset at the BMS. Software timers shall provide if required to ensure that the status is proved.

All packaged pumps are to be controlled by the BMS pressure sensor.

3.6.23 Fan Coil Units

3.6.23.1 Temperature Control

The IUC shall modulate the heating and cooling coil valves in sequence, via a P+I control loop, to maintain the space/return air temperature at setpoint [22]°C ± 0.5K. An adjustable deadband shall be provided between the heating and cooling coil outputs.
A supply air temperature sensor shall provide indication if each coil is operating correctly.
Where more than one fan coil unit operate together to serve a space they shall operate as master/slave. The room temperature control sensor shall be wired to the master IUC, and the master IUC shall broadcast the control signals to the slave IUCs via the network. Master/slave is not to be used across multiple areas.

Local temperature setpoint adjustment shall be provided where indicated, and shall be integral to the room temperature sensor. The IUC shall be configured, via the controller software, to limit the local setpoint adjustment to ± [1.5] K. Indication of setpoint changes on the wall unit shall take the form of 'warmer/cooler or + / -', and not indicate specific temperature values.

3.6.23.2 Plant Shutdown

On plant shutdown the fan shall be disabled and the heating and cooling valves closed.

3.6.23.3 Low Limit Protection

Low limit protection of the space shall be provided as a function of the optimum start program and shall operate the FCU.

During the unoccupied period, if the temperature at a sensor falls below [12]°C the associated FCUs shall be enabled, and once the temperature at a sensor rises above [14]°C the associated FCUs shall be disabled.

3.6.24 Variable Air Volume Boxes

3.6.24.1 Temperature Control

The IUC shall modulate the heating and air damper in sequence, via a P+I control loop, to maintain the space/return air temperature at setpoint [22]°C ± 0.5K. An adjustable deadband shall be provided between the heating coil and air damper outputs.

A supply air temperature sensor shall provide indication if the coil is operating correctly. Where more than one variable air volume box operate together to serve a space they shall operate as master/slave. The room temperature control sensor shall be wired to the master IUC, and the master IUC shall broadcast the control signals to the slave IUCs via the network.

Local temperature setpoint adjustment shall be provided where indicated, and shall be integral to the room temperature sensor. The IUC shall be configured, via the controller software, to limit the local setpoint adjustment to ± [1.5] K. Indication of setpoint changes on the wall unit shall take the form of 'warmer/cooler or + / -', and not indicate specific temperature values.

3.6.24.2 Plant Shutdown

On plant shutdown the VAV damper and heating valve shall be closed.

3.6.24.3 Low Limit Protection

Low limit protection of the space shall be provided as a function of the optimum start program and shall operate the VAV and associated AHU.

During the unoccupied period, if the temperature at a sensor falls below [12]°C the associated VAV boxes shall be enabled, and once the temperature at a sensor rises above [14]°C the associated VAV boxes shall be disabled. This interlock shall be overridden if the VAVs are required by the optimum start program.

3.6.25 Door Air Curtain Control

Where door air curtains are being utilised, the BMS shall provide a volt free contact output to enable each of the door air curtain heaters.

Where more than one air curtain supplies a doorway, the doorway shall be enabled by one BMS contact. This enables a set of air curtain heaters to be disabled if the specific doors are not in operation.

The air curtain heaters shall be enabled via dedicated fixed time program. Should the outside air temperature be less than [14] °C at the start of the occupied period, then the air curtain shall be enabled. The air curtain shall remain enabled to until the end of the occupied period or until the outside air temperature rises above a determined level.. Once enabled, thee air curtain shall have a setpoint of [18] °C ± [1] K. The BMS shall modulate any associated heating valves via P+I control loops to achieve the heating setpoint.

3.7 Natural Ventilation

Where natural ventilation control is installed, the natural ventilation shall be enabled upon the average space temperature rising above a natural ventilation space setpoint of [24] °C providing the following conditions are satisfied:

The outside air temperature is [2] K less than the measured space temperature
Once enabled the natural ventilation dampers shall be controlled via a P+I control loop to maintain a setpoint of [21] °C ± [1.5] K within the measured space.

Note: The BMS points list may detail an analogue control signal to control the natural ventilation, however the BMS Contractor shall liaise with the mechanical and or Facade Contractor to determine the interface requirements to the window actuators i.e. raise/lower type actuators or 0-10Vdc type actuators.
Any spaces using actuators to open windows, vents etc should have an adjustment limit to prevent frequent adjustment and potential user annoyance through noise.

3.7.1 Wind Speed and Direction Interlock

The wind speed and direction shall be measured via the weather station. In the event that the wind speed is in excess of [14] m/s and the direction is towards the facade dampers, then the dampers shall be limited to [10]% opening, to prevent cold drafts entering. Should the wind speed be above [18] m/s then the dampers shall be fully closed.

Note that it shall also be possible to override the damper positions via the BMS operator's station.

3.7.2 Rain Detection Override

If rain is detected by the weather station when the windows are open greater than the [60] % position, and the wind speed as sensed at the weather station indicates a wind speed of greater than [8] m/s, and it is determined that rain could be blown through the open windows towards which the wind is directed (also determined from the weather station) then all control routines associated with that space shall be overridden [20] % position.
A software switch shall be provided on the graphics so that 'rain detection override' functionality can be switched on/off. In the off position windows will be limited to [20] % position.

3.7.3 Wind Speed and Direction Override

If a wind speed of greater than [10] m/s is detected at any time via the weather station when the windows and louvers are open greater than the [20] % position towards which

the wind is directed then all control routines associated with that space shall be overridden and the windows shall be driven to the [20] % position.

A software switch shall be provided on the graphics so that 'wind speed override' functionality can be switched on/off. These are to be highlighted on the associated graphic.

3.8 Heating Systems

3.8.1 Boiler Sequencing (Two Stage Burner)

The following describes a sequence for two equal duty boilers, each with equal duty low and high fire stages, which operate as lead/lag.
The two boilers shall be sequenced, via a proportional low/high control loop, to maintain a primary return water temperature at full load of [70]°C with a nominal flow temperature of [82]°C.

The boiler enable setpoints shall incorporate a deadband of [3]°C between enabling stages ON and OFF to avoid cycling.

Return water temperature, C	Switching next stage ON	Return water temperature, C	Switching last stage Off
	Off	>[82]°C	Off
~ [79]°C	Lead Low Fire	>[79]°C	Lead Low Fire
~ [76]°C	Lead High Fire	>[76]°C	Lead High Fire
~ [73]°C	Lag Low Fire	>[73]°C	Lag Low Fire
~ [70]°C	Lag High Fire		

On increasing load the next boiler shall be enabled at low fire when the return water has risen above setpoint for a period of [3] minutes. On decreasing load, the last boiler shall be disabled at low fire when the return water has fallen below setpoint for a period of [5] minutes.

A software switch shall be provided on the BMS graphics to inhibit the boiler sequence routine. Boiler Sequencing (Modulating Burner)

The following describes a sequence for two equal duty boilers, each with fully modulating burners, which operate as lead/lag.

Full consideration of boiler manufacturers recommendations are to be adhered to.
The burners shall be enabled and the output modulated, via a proportional control loop, to maintain the common flow water temperature setpoint. The control loop output 0 - 33%, 33 - 66% and 66 - 100% shall be in direct proportion to each successive burner output, 0-100%.
The boilers and burners shall be sequenced as follows:

Flow temperature control loop output, (%)	No. of boilers enabled	Loop output to enable boiler, (%)	Loop output to disable boiler, (%)
0 - 50%	1	10	5
50 . 100%	2	60	40

On increasing load the next boiler shall be enabled when the loop output has risen above setpoint for a period of [3] minutes. On decreasing load, the last boiler shall be disabled when the loop output has fallen below setpoint for a period of [5] minutes.
A software switch shall be provided on the BMS graphics to inhibit the boiler sequence routine.

A manual reset thermostat, located in the boiler primary common flow pipework, shall on sensing a temperature of [93]°C or above, switch off the boilers via a hardwired interlock, raise an alarm on the BMS and the 'Common Flow High Limit Thermostat Tripped' lamp shall be illuminated on the fascia of controls enclosure.

The duty LTHW pump shall remain running for a [5] minute run-on period. At the end of this period, the duty LTHW pump shall then be shut down.

The system shall not return to automatic control until the high temperature thermostat has been manually reset.

3.8.2 Boiler Rotational Point Program

The duty boiler shall be rotated upon failure, either through loss of status or a fault condition, and on a time elapsed basis, every [7] days at [0800] hours. If the lead boiler fails, the lag boiler shall be enabled, and an alarm shall be raised at the BMS.

Once a failed boiler is reset at the BMS it shall not return as the duty boiler until required again by the rotational point program.

A software switch shall be provided on the BMS graphics to inhibit the boiler sequence routine.

3.8.3 Flow Temperature Control

The control valve shall be modulated via P+I control loop, in order to maintain the flow temperature at setpoint ±0.5K.

3.8.4 Weather Flow Temperature Compensation

The base flow temperature setpoint shall be reset with reference to the outside air temperature according to a schedule set in the BMS. Upon an outside air temperature of [20]°C the flow setpoint shall be at its minimum of [20]°C and at an outside air temperature of [0]°C and below, the flow setpoint shall be a maximum of [80]°C. There shall be a third, mid-placed co-ordinate in the schedule, initially set to a flow setpoint of [50]°C at an outside air temperature of [10]°C, to allow alteration of the shape of the slope if necessary.

During normal operation, the weather compensation shall be configured with a zone trim offset. Should the space temperature be above, the required space temperature setpoint, then the compensated flow temperature shall be reduced proportionally by a value of [2]°C every [15] minutes for every degree the temperature is above the required setpoint. Should the space temperature be below the required space temperature setpoint, then the underfloor heating compensated flow temperature shall be increased by [2]°C every [15]minutes for every degree the temperature is below the required setpoint to a maximum temperature of [80]°C as stated above.

During a radiator heating zone optimum heating start routine, the weather compensated setpoint shall be fixed at [80]°C for the entire boost time period.

During a underfloor heating zone optimum heating start routine, the weather compensated setpoint shall be fixed at [45] °C for the entire boost time period.

3.8.5 System Frost Protection

Outside air, return pipe work sensors and internal zone space temperature sensors shall form part of a program that will signal three types of low temperature demand conditions to prevent any damage due to freezing fluid in pipes, coils etc., due to either low external

ambient air temperatures, low return pipe work temperatures, and additionally a low internal ambient temperature which has the potential to damage the fabric of the building.

These demands shall have the following actions:

- Stage 1 Frost Protection
- Stage 2 Frost Protection
- Fabric Protection

3.8.5.1 Stage 1 Frost Protection

A low outside air temperature shall initiate a demand to the primary and secondary circuit heating and cooling pumps and all associated control valves to allow water to circulate fully throughout the respective systems. Valves should open to allow circulation through all emitters.

A ‘Stage 1 Frost Protection’ demand signal shall become active in the event that the outside air temperature falls below [1]°C. The demand signal shall remain present until the outside air temperature rises to [2]°C or above, or an operational heating demand is present, then the stage 1 frost protection routine shall be stopped. Primary and secondary heating and chilled water pumps operate.

When a stage 1 frost protection demand is active, a ‘Stage 1 frost protection operating’ status indication shall be provided on all associated heating plant graphics at the BMS operator’s station.

3.8.5.2 Stage 2 Frost Protection

A low common primary return water temperature shall initiate a demand to the heating circuit if the primary and secondary plant is operating in a ‘Stage 1 Frost Protection’ mode. A ‘Stage 2 Frost Protection’ demand shall become active, if the heating plant is operating in a stage 1 frost protection mode and the common return water temperature falls to [10]°C or below, then the heating plant shall be enabled. The heating plant shall remain enabled under normal control until the common primary return water temperature has risen to [50] °C. At this point the stage 2 frost protection mode shall be disabled.

If the heating plant is operating in a stage 1 frost protection mode and the common primary LTHW return water temperature again falls to [10]°C or below, then the stage 2 frost protection cycle shall be repeated.

If the outside air temperature rises to [2]°C or above, or an operational heating demand is present, then the stage 2 frost protection routine shall be stopped

When a stage 2 frost protection demand is active, a 'Stage 2 frost protection operating' status indication shall be provided on all associated heating plant graphics at the BMS operator's station.

3.8.5.3 Fabric Protection

A zone low inside air temperature alarm shall initiate a 'Fabric Protection' demand and start the necessary heating plant serving the zone that registers the low inside temperature condition.
The fabric protection routine shall activate when any zone temperature falls below a setpoint of [12 °C and shall remain active until the lowest temperature within the zone rises by more than [4] K or until the BMS signals a normal plant demand routine.

The fabric protection routine shall be completely independent of the system frost protection routines described above and shall take priority over 'Stage 1' and 'Stage 2' frost protection.

When a fabric protection demand is active, a 'Fabric Protection operating' status indication shall be provided on all associated heating plant graphics at the BMS operator's station.

3.8.6 Boiler Safety Circuit

All of the hardwired interlocks below shall form part of the boiler safety circuit. Operation of the safety circuit shall be hardwired interlocked to disable the boilers and shut the gas solenoid valve. All shall have their actions duplicated in software in order to prevent unnecessary alarms:
Panic Buttons activated
Gas detected at 20% LEL within the boiler room
Gas sensor common fault
Fire detected alarm (via the automatic fire detection system)
The safety circuit operation shall be fail-safe and latching and shall require the operation of the boiler safety circuit 'reset' button on the controls enclosure fascia to de -latch it, providing all associated circuits are healthy. The safety circuit shall be arranged for automatic reset upon loss and subsequent resumption of power at the controls enclosure via a delay-on-energise timer relay, providing that all the associated circuits are healthy. The delay time of the relay shall be set just sufficient to allow any self-testing period of the gas detection unit on power-up.

In the event that any of the above plant safety interlocks are enabled, indication of 'safety circuit operation' shall be provided on the fascia of the controls enclosure.

Once the safety circuit has operated, the duty LTHW pump shall continue to run for a further [5] minutes to dissipate heat in the boilers after which time the pump shall switch off.

3.8.7 Natural Gas Detection

A multi-channel natural gas detection unit shall be provided and shall be located adjacent to the local CE. The gas detection unit shall have a minimum of four channels and a sensing head with an associated collector cone located midway between (and above) each boiler' burner and associated gas booster.
The gas detection unit shall have three alarm VFC outputs; an alarm at 12% LEL (Lower Explosive Level) which shall be used for warning purposes, an alarm at 20%LEL which shall be used for system shutdown purposes and a unit fault alarm.
Detection of gas at 12%LEL shall raise a critical alarm on the BMS and a '12% LEL Gas detected' indication on the fascia of the local CE.

On detection of gas by any one of the gas sensing heads at 20%LEL or greater, the boilers shall be disabled and the gas valve closed via operation of the safety circuit, a critical alarm shall be raised on the BMS and a '20% LEL Gas Detected' indication shall be provided on the CE fascia. An audible alarm shall be activated on the local CE fascia and three flashing orange warning beacons shall be illuminated, one within the boiler plantroom and one outside each of the two plantroom entrances. The warning beacons shall be clearly labelled as to their purpose.

The audible alarm shall have an associated mute button, the operation of which shall mute the sound for the duration of that alarm.

The beacons and the audible alarm (unless subsequently muted) shall operate until the 20%LEL alarm signal clears.

The gas detection unit shall be fail safe and shall be monitored for a 'fault' condition. On detection of a system fault from the unit or any one of the gas sensing heads, the boilers shall be disabled and the gas valve closed via operation of the safety circuit, an alarm shall be raised on the BMS and a 'Gas Detector Fault' indication shall be provided on the local CE fascia.

The above hardwired interlocks shall be duplicated by the system software to prevent unnecessary alarms.

3.8.8 Panic Buttons

The boiler plant room shall be protected by 2 key release panic buttons, one adjacent to each of the plant room exits. Activation of the panic button shall disable the boilers and gas valve via the safety circuit, and raise an alarm on the BMS, and provide indication 'Panic Buttons Operated' on the local control panel fascia.

Operation of the panic button shall be a latching action. De-latching of the circuit shall be achieved by resetting the panic button and operating the safety circuit reset button on the fascia of the local control panel.

The panic buttons shall be clearly labelled (using labels located just above the panic buttons) as to their purpose and means of operation.

3.8.9 Gas Valve Interlocks

During normal system operation the main gas solenoid valve shall be maintained in its open position. The control system shall monitor the gas valve for its open and closed positions via valve actuator end switches.

Closure of the gas solenoid valve in any condition shall illuminate the gas valve 'Closed' indication and extinguish the gas valve 'Open' indication on the local CE fascia. A 'gas valve closed' alarm shall be raised on the BMS. The boilers shall be shut down via hardwired interlocks.

Once the gas valve has closed, the primary and secondary circuits shall be disabled and the remainder of the boiler plant shut down in a controlled way as detailed in Plant Shutdown and Run On.

3.8.10 Gas Booster Sets

Each packaged gas booster set will comprise all necessary control and compressor starter gear and shall be powered from a separate feed from the power distribution board.

For each boiler, in the event of a low incoming gas pressure fault occurring, a gas booster 'low inlet pressure' indication shall be illuminated on the local CE fascia and an alarm raised on the BMS.

A volt-free contact will be provided in each gas booster control panel for connection to the control system for the purpose of raising an alarm in a 'common fault' condition. In the event of a fault occurring, indication shall be provided on the local CE fascia and an alarm raised on the BMS.

3.8.11 High Limit Temperature Protection

A manual reset thermostat, located in the boiler primary common flow pipework, shall on sensing a temperature of [93]°C or above, switch off the boilers via a hardwired interlock, raise an alarm on the BMS and the 'Common Flow High Limit Thermostat Tripped' lamp shall be illuminated on the fascia of the controls enclosure.

The duty LTHW pump shall remain running for a [5] minute run-on period. At the end of this period, the duty LTHW pump shall then be shut down.

The system shall not return to automatic control until the high temperature thermostat has been manually reset.

3.8.12 Flow Proving Pressure Transducer

Pressure Transducer installed across orifice plates shall be provided for flow proving.

3.8.13 Underfloor Heating Systems

3.8.13.1 General

Where under floor heating manifolds are being utilised to heat a zone, to prevent occupant discomfort, and to avoid the risk of damaging the screed, the temperature must be controlled within the screed and within the space.

Temperature control of the system shall be either on/off control of the circuit valves or by modulating a mixing valve to control the water flow temperature to a setpoint compensated to the outside air temperature.

Optimum start heating shall be used for the optimisation of both the screed and space temperatures. The system which has the largest deviation from the required setpoint shall dictate the optimum start time.

The system shall be controlled to ensure that the screed temperature does not rise by more than [5]K above the occupied space temperature setpoint during normal operation Note that the manifold valves shall be controlled based on the maximum demand from the space and screed temperature control loops i.e. should the space temperature control loop require a higher screed temperature then the valves shall be controlled to achieve this.

3.8.13.2 Space Temperature Control

The underfloor heating zone valves shall be operated under the dictates of a proportional plus integral action control loop to maintain the space temperature at [21] °C ± 2K. It shall be possible to adjust the underfloor heating setpoints either in groups or individually via the BMS operator's station.

Note that the output to the underfloor heating manifold valves shall be time proportional based on the output of the heating loop, the minimum on/off time shall be [5] minutes. Upon the underfloor heating manifold valves being commanded open, the associated manifold circulating pump shall be enabled and a heating demand signal shall be transmitted to the CT/VT circuit as appropriate.

3.8.13.3 Screed Temperature Control

A minimum of two temperature sensors shall be installed in the screed for each underfloor heating manifold circuit.
The two sensors shall provide a level of redundancy. In the event that the difference between the two sensors is greater than [5]K an alarm shall be raised at the BMS operator's station indicating 'Screed Sensors Zone ** Calibration Error'.

Under normal circumstances, the average of the two screed sensors shall be used as the measured input to each manifold's screed temperature control loop. The manifold actuators shall be operated by a time proportional output under the dictates of the screed proportional plus integral action temperature control loop to maintain the average screed temperature at [5] °C ± 2K below the measured space temperature during normal operation.

Upon the screed temperature control loops being overridden by the average space temperature control loop output, then the screed temperature shall be limited to [5] °C above the current space temperature. Upon an average screed temperature rising to more than [10] °C higher than the space temperature setpoint, then the associated manifold valves shall be closed, the pump shall be disabled and the local valves and pumps shall be inhibited from further operation.

Upon the average screed temperature falling to less than [5] °C above the space temperature then the manifold shall valves and pumps shall be reinstated to operate under the dictates of the space temperature control loop.

During an optimum heating start routine, the screed temperature shall be set to the maximum temperature available for the system as detailed above in 'Weather Compensation'.

Upon an open or short circuit fault, the affected sensor shall be removed from the control regime and an alarm shall be raised at the BMS operator's station indicating 'Zone ** Failed Screed Sensor' The screed temperature control loop shall continue to operate using the remaining healthy sensor value.

3.8.13.4 Screed Night Setback

During plant shutdown period, the manifold valves and pumps shall operate as described under 'Screed Temperature Control' to maintain a minimum screed temperature of [18]°C ± 1K.

3.8.13.5 Underfloor Heating Demand Signals

Upon the underfloor heating manifold valves being commanded open, the associated pump shall be enabled and a heating demand signal shall be transmitted to the CT/VT circuit as appropriate.

3.8.13.6 Screed Hi-Limit Protection

Where a weather compensated temperature control circuit is being utilised, the common flow temperature shall be protected by an automatic reset immersion thermostat that on sensing a temperature of [50] °C or more shall via hardwire interlock and latching circuit, shut down the underfloor heating pumps and position the mixing valve for full divert.

When the underfloor heating system is shut down due to hi-limit by the immersion thermostat, a critical alarm shall be raised at the operator's station and the 'Underfloor Heating Hi-Limit Protection Activated' lamp on the control panel fascia shall be illuminated. Following a hi-limit shutdown, provided that the immersion thermostat is in a healthy state, the latched signal shall only be reset by the 'Underfloor Heating Hi-Limit Reset' button on the control panel fascia, by operator command at the BMS operator's station or upon loss of power to the control panel.

3.9 Domestic Hot Water Services

3.9.1 Cylinder Temperature Control

The control valve shall be modulated, via a P+I control loop, to maintain the stored temperature at [65]°C.

3.9.2 High Limit Temperature

The two-port control valve shall spring closed if the high limit thermostat rises above 70°C, via a hard wired latching circuit. Provided the sensed temperature is below 65C, reset of the latching circuit shall be via a pushbutton on the CE facia. The high limit shutdown circuit shall be fail safe and shall be arranged to reset automatically on resumption of power following power failure provided the sensed temperature is below 65°C.

3.10 Chilled Water

3.10.1 Chiller Sequencing (Bypass Flow)

The following describes a sequence for three equal duty chillers, each with integral capacity control, which operate as lead/first lag/second lag.

Full consideration of boiler manufacturers recommendations are to be adhered to.
The two chillers boilers shall be sequenced, using the bypass flow rate, to maintain a positive flow rate around the primary circuit, and ensure that the secondary flow water is always at design temperature.

On receipt of a cooling demand the lead chiller shall be enabled. On increasing and decreasing load the chillers shall then be sequenced a follows:

	Increasing Load		Decreasing Load	
Chillers Enabled	Primary Circuit Bypass Flow Meter Reading (kg/s)	Control Action	Primary Circuit Bypass Flow Meter Reading (kg/s)	Control Action
Lead				
	<[5]% for [5] minutes	Enable 1st Lag		
Lead + 1st Lag			>[120]% for [5] minutes	1st Lag off
	<[5]% for [5] minutes	Enable 2nd Lag		
Lead + 1st Lag + 2nd Lag			>[120]% for [5] minutes	2nd Lag off

The bypass flow meter reading shall be a percentage of a single primary chiller design flow rate.

3.10.2 Chiller Rotational Point Program

The duty chiller shall be rotated upon failure, either through loss of status or a fault condition, and on a time elapsed basis, every [7] days at [0800] hours. If the lead chiller fails, the lag chiller shall be enabled, and an alarm shall be raised at the BMS.
Once a failed chiller is reset at the BMS it shall not return as the duty chiller until required again by the rotational point program.

A software switch shall be provided on the BMS graphics to inhibit the chiller sequence routine.

3.10.3 Low Limit Protection

Low limit protection of the space shall be provided as a function of the optimum start program and shall only operate the FCUs.

During the unoccupied period, if the temperature at a sensor falls below [12]°C the associated FCUs shall be enabled, and if temperature at a sensor rises above [14]°C the associated FCUs shall be disabled. This interlock shall be overridden if the FCUs are required by the optimum start program.

3.11 Pump Control

3.11.1 Duty/Standby Pump Rotational Point Program

The duty pump shall be rotated upon failure, either through loss of status or a fault condition, and on a time elapsed basis, every [7] days at [0800] hours. If the lead pump fails, the lag pump shall be started, and an alarm shall be raised at the BMS.
If a duty rotation occurs when the pump is running, the lag pump shall be started and the pump ramped to its [minimum] VSD speed. Upon receipt of lag pump status, and after a delay of [5] minutes, the lead pump shall be stopped, and the lag pump shall operate under the dictates of the pressure control loop. If status is not received from the lag pump, then an alarm shall be raised at the BMS and the rotation shall be inhibited.
Once a failed pump is reset at the BMS it shall not return as the duty pump until required again by the rotational point program.

3.11.2 Duty/Duty/Standby Pump Rotational Point Program

The pumps shall operate on 2 duty/1 standby with duty rotation on an hours run basis.

Once enabled the pump VSDs shall be enabled and the speed of the pumps ramped to maintain the pre-determined set point.

On rising demand, if the speed output to the lead pump is [100]% for [5] minutes, then the lag pump shall be enabled and the speed gradually increased. When the speed of the two pumps is within [5]% of each other, both pumps shall be provided with the same control output signal.

On falling demand, if the speed output to two pumps is less than [40]% for [5] minutes, then the speed of the lag pump shall be gradually reduced, and when its speed has reached minimum [25]%, the lag pump shall be disabled.

3.12 System Pressure Monitoring Pressurisation Unit

3.12.1 Monitoring

The system pressurisation unit shall be monitored for a common fault via volt free contacts provided within the pressurisation unit control panel. The contact shall be such that if the pressurisation unit loses power, the contact shall make.

A ‘Pressurisation Unit Common Fault’ alarm shall be raised at the operator’s station and an indication shown on the associated graphics pages. Indication of the fault shall also be provided on the CE panel fascia.

3.12.2 Low Pressure Interlock

A dedicated low pressure switch shall be provided for interlocking purposes in the primary circuit common return pipework. The switch sensing line connection to the main pipework shall be located at least two metres away from any pump inlet/outlet.

In the event of a low pressure condition, the boilers or chillers shall be shutdown via hardwired interlocks. A ‘Low Pressure Shutdown’ alarm shall be raised at the operator’s station and an indication shown on the associated graphics pages. Indication of the Low Pressure Shutdown shall be provided on the CE panel fascia. A hardware timer shall allow all circulating pumps associated with the system to run-on for a period of [2] minutes before turning them off via a hardwire interlock. This interlock shall be hardwired into any associated pump inverter safety circuits to ensure these shutdown if they are running under local control.

The BMS shall mimic the action of the hardwire interlocks to avoid mismatch alarms being generated. The system shall remain shut down until the low pressure condition clears.

3.12.3 High Pressure Interlocks

A dedicated high pressure switch shall be provided for interlocking purposes in the primary circuit common return pipework. The switch sensing line connection to the main pipework shall be located at least two metres away from any pump inlet/outlet.

In the event of a high pressure condition, the boilers or chillers shall be shutdown via hardwired interlocks. A 'High Pressure Shutdown' alarm shall be raised at the operator's station and an indication shown on the associated graphics pages. Indication of the High Pressure Shutdown shall be provided on the CE panel fascia. A hardware timer shall allow all circulating pumps associated with the system to run-on for a period of [5] minutes before turning them off via a hardwire interlock. This interlock shall be hardwired into any associated pump inverter safety circuits to ensure these shutdown if they are running under local control.

The BMS shall mimic the action of the hardwire interlocks to avoid mismatch alarms being generated.

The system shall remain shut down until the high pressure condition clears.

3.13 Sitewide Controls

3.13.1 Heating Demand Signals

A heating demand signal shall be derived from each BMS output signal to a heating control valve e.g. AHU frost and main heating coils or FCU heating coils
When a heating valve reaches the [10] % open position a "heating required" demand signal shall be generated and sent via the BMS communications network to enable the associated heating system which directly serves that valve.

The heating demand signal shall remain active until that heating control valve closes and remains closed for a period of [10] minutes, at which point that heating demand signal shall be deactivated.

When a valve reaches the [10] % open position again, the cycle shall repeat.
That heating demand signal be de-activated when the plant is in a shutdown state and shall not be generated from the valve position other than if specified to the contrary in that valve's associated system narrative.

Where there are large numbers of terminal units in a building with heating coils, then the heating demand signals shall be arranged in logical groups e.g. floor by floor or floor sector by floor sector and only one heating demand signal shall be sent from that group to

the associated heating system to cut down on network traffic. However the individual heating valve demand signals shall be available to view on a controller by controller basis for fault finding purposes.

3.13.2 Cooling Demand Signals

A cooling demand signal shall be derived from each BMS output signal to a cooling control valve e.g. AHU cooling coils or FCU cooling coils.

When a cooling valve reaches the [10] % or more open position and remains that way for a minimum of [10] minutes, a “cooling required” demand signal shall be generated and sent via the BMS communications network to enable the associated cooling system which directly serves that valve.

The cooling demand signal shall remain active until that cooling control valve closes and remains closed for a period of [10] minutes, at which point that cooling demand signal shall be deactivated.

When a valve reaches the [10] % open position again and remains that way for a minimum of [10] minutes, the cycle shall repeat.

That cooling demand signal be de-activated when the plant is in a shutdown state and shall not be generated from the valve position other than if specified to the contrary in that valve’s associated system narrative.

Where there are large numbers of terminal units in a building with cooling coils, then the cooling demand signals shall be arranged in logical groups e.g. floor by floor or floor sector by floor sector and only one cooling demand signal shall be sent to the associated cooling system from that group to cut down on network traffic. However the individual cooling valve demand signals shall be available to view on a controller by controller basis for fault finding purposes.

3.13.3 Valve Exercise Routine

In order to maintain the water treatment chemicals in suspension, the BMS shall regularly exercise the system as follows:

When the BMS determines that any valve has been stationary (idle) for greater than [100] hours, an ‘exercise required’ flag shall be set for that valve.
If the flag is still active when the plant is in a shutdown state, the valve shall be driven fully open for [30] minutes.

The BMS shall start the associated system pumps (if not already running).
The status of the exercise routine shall be displayed on the associated graphic.
At the end of the exercise time period, the valve and pumps shall be returned to normal control. The idle timers shall automatically zero.

If the idle flag is still active for greater than [24] hours, thus indicating the plant is operating 24/7, an alarm shall be raised at the BMS Operator's station indicating that valve exercise could not take place.

3.14 Fire Control

3.14.1 Fire Alarm/Fireman's Override

Volt free contacts shall be provided to control the plant in a fire condition in the form of volt free contacts from a local fire interface unit (FIU) or a fireman's control panel. Upon receipt of a signal the plant shall be controlled via hardwiring as detailed in the System Narratives.

Operation after Power Failure Restoration or Clearance of a Fire Shutdown or Fireman's Override Condition Unless otherwise detailed in the System Narratives, full recovery from a power fail restoration, fire shutdown or fireman's override operation shall be fully automatic.

Plant that has been turned off shall restart in a controlled manner using the normal plant start sequences.

A controlled staggered start-up regime shall be implemented, with each system that has an item of plant with a drive over 5kW having an associated individually adjustable time delay that must first pass after power is restored or a shutdown signal has cleared before that system is allowed to start up again. Priority should generally be given to ensuring the boiler and chiller systems are operational before AHUs are allowed to run.

3.15 Miscellaneous Plant Monitoring

3.15.1 Trace Heating Circuit Monitoring

Where trace heating monitoring has been specified, the activation of the trace heating system shall be monitored via current sensing relays.

Should the trace heating system fail to activate the current sensing relay when the outside air temperature is at or below [3] °C ± [0.5] K for a period of [30] minutes, then a critical alarm shall be raised at the BMS operators' station

Should the outside air temperature be greater than [5] °C and a trace heating activation signal is triggered, then a critical alarm shall be raised at the BMS operators station highlighting the item of trace heating that is enabled.

3.16 Environmental Monitoring

3.16.1 Room CO2 Monitoring

CO2 monitoring is required in all lecture theatres, seminar rooms, multi-occupancy office space and where specified by BREEAM / LEED purposes.

Where room CO2 monitoring is required, a high limit alarm shall be associated with the CO2 value that shall be set at 10% above the maximum design CO2 limit for that space. Unless otherwise specified, this alarm limit shall be set to [1000] ppm.

This alarm shall be inhibited when the associated outside air supply plant is off (through its time schedule, not through failure) and for [15] minutes after the outside air supply plant has started.

3.16.2 AHU Outside Air Intake Volume Monitoring

Where the monitoring of the outside air intake volume on an AHU is specified for code purposes, a low limit alarm shall be associated with the intake volume flow sensor that shall be set at 10% below the minimum design outside air intake value for the AHU.

The same principle shall be applied where there is a common outside air intake duct and a common outside air intake volume sensor has been used where all the AHUs supplied by that common duct serve the same common area.

This alarm shall be inhibited when the associated outside air supply plant is off through time schedule, not through plant failure, and for [15] minutes after the associated plant has started.

3.17 BREEAM Standard Requirements Mains Water Leak Detection

The BMS/Controls Specialist shall supply sub-meters to the main incoming water feed and to the cold water storage tank room. Any power supplies required to meters shall be via the BMS/Controls Specialist.

Each meter shall be monitored via a pulsed volt free contact which shall be installed on the meter by others. Information with respect to the pulse frequency and duration shall be provided by the supplier of the meters. The BMS input shall be suitable for metering

purposes and capable of recognising and counting a pulse with a high frequency and short duration.

Each piece of meter data shall be displayed on a common water services graphic at the BMS operator's station.

In addition the readings from the main incoming water meter and the meter to the water storage tank room shall be compared. In the event that that a difference of more than [40] % of the total consumption is detected an audible and visual alarm shall be raised at the BMS operator's station indicating 'Possible Water Leak Detected'.

3.18 Energy Monitoring Requirements

3.18.1 Energy Metering

UCL currently has an ION Enterprise Power Monitoring system which collects electrical energy consumption data and power distribution information from power monitoring devices located throughout the campus.

As the ION Enterprise system is running on an older version there are plans under a separate project to upgrade the system to the latest StruxureWare Power Monitoring Expert platform.

Once this is complete it shall be possible to make this data available to SmartStruxure Solution using Ecostruxure Web Services. With access to data from Power Monitoring Expert, SmartStruxure Solution can be programmed to manage building systems in the most energy efficient manner possible. Facilities managers can automate energy curtailment procedures and quickly address power quality issues.

In the meantime, all Power Meters will be installed and networked to UCL's "EMON" ION Enterprise system. This must be configured and commissioned by the Schneider Energy Management Systems (EMS) contractor.

Where metering of water, air, gas or steam has been specified these shall be networked to the SmartStruxure Solution and the consumption from the meters shall be collated and recorded at the StruxureWare Building Operation Enterprise Server.

All heat and cooling meters shall be manufactured by Kamstrup complete with the following devices:

- Ultraflow static flow sensor based on the ultrasonic measuring principle

- Multical 602 energy calculator complete with data communication module which shall be M-Bus protocol for integration on the Trend BMS and BACnet for integration on the SmartStruxure Solution.
- PT500 Temperature sensor pair complete with sensor pockets.

The BMS shall use software values for the consumption calculations. The BMS graphics shall display the values for each period. Values shall be logged by the BMS to ensure continuity of historical data.

3.18.2 Degree Day Calculations

Where specified as required, heating and cooling degree day calculations shall be carried out by the BMS. Where the BMS does not have a standard degree day module, the calculations shall be carried out as follows.

The BMS shall use seven software values for the degree day calculation: Heating Degree Day

- Heating Degree Day Base Value
- Cooling Degree Day
- Cooling Degree Day Base Value
- Counter
- Yesterday's Heating Degree Day Value
- Yesterday's Cooling Degree Day Value

The heating Degree Day base value and the cooling Degree Day base value shall be independently adjustable.

At [00:00] each day, "Running Cooling Total", "Running Heating Total" and the "Counter" values shall be reset to zero.

A value for the outside air temperature shall then be taken every half hour. A calculation shall take place of (Heating Degree Day base value – current outside air temperature value). Any negative result shall be set to zero and the final result shall get added to the "Running Heating Total" value. Another calculation shall take place of (current outside air temperature - Cooling Degree Day base value). Any negative result shall be set to zero and the final result shall get added to the "Running Cooling Total" value.

Every time an outside air value is taken, the "Counter" shall be incremented (to cater for the controller being turned off for short periods and missing readings).

After each reading has been taken, the value of the "Running Heating Total" shall be divided by the "Counter Value" and the "Heating Degree Day" value set to the result.

Likewise the value of the “Running Cooling Total” shall be divided by the “Counter Value” and the “Cooling Degree Day” value set to the result.

After the last value for the day has been taken at [23:30], the day’s “Heating Degree Day” value shall be copied to “Yesterdays Heating Degree Day Value” and the day’s “Cooling Degree Day” value shall be copied to “Yesterdays Cooling Degree Day Value”.

The “Heating Degree Day” and “Cooling Degree Day” values shall be logged by the BMS once a day at time between [23:31] and [23:59] so that the trend log shows the correct date for each value.

The heating and cooling degree days shall be summated and stored for each calendar month.

The BMS graphics shall display the values of “Heating Degree Day”, “Cooling Degree Day”, “Yesterdays Heating Degree Day Value” and “Yesterdays Cooling Degree Day Value.

APPENDIX E – UCL MANAGEMENT OF INCUMBENTS

This Appendix is currently being developed. Any current queries relating to management of incumbents should be directed at the Deputy Director of Campus Experience and Infrastructure.

APPENDIX F – PIPEWORK AND LAGGING INSULATION GUIDELINES

This Appendix is currently being developed. Any current queries relating to pipework and lagging insulation should be directed at the Deputy Director of Campus Experience and Infrastructure.

APPENDIX G – STUDENT RESIDENCES SPECIFIC REQUIREMENTS

For requirements specifically related to projects within Student Residences, please refer to the following sections of this guide. Detailed proposals and requirements are to be agreed with UCL Residence Technical Services Manager.

INTRODUCTION AND GLOSSARY

- A.1 EXECUTIVE SUMMARY
- A.2 INTRODUCTION AND GLOSSARY
  - A.2.1 Employer's Requirements and Design Standards for Mechanical, Electrical And Public Health Services
  - A.2.2 Best Value
  - A.2.3 Objectives
  - A.2.4 Consultant Appointment
  - A.2.5 Responsibilities for design and information production
  - A.2.6 Glossary of terms
- A.3 PROJECT GOVERNANCE
- A.4 CONSULTATION AND ENGAGEMENT
  - A.4.1 Stakeholder Engagement
  - A.4.2 Background on UCL's Support structure
- A.5 DESIGN STANDARDS
- A.6 STAGE GATE APPROVALS
- A.7 WORK ON EXISTING BUILDINGS
- A.8 ENERGY CONSERVATION CONSIDERATIONS
  - A.8.1 Energy efficiency measures to be included in the Project
  - A.8.2 Regulatory Considerations
  - A.8.3 Passive Design – Minimising Services Requirements
  - A.8.4 Building Fabric
  - A.8.5 Natural Ventilation
  - A.8.6 Mechanical Ventilation
  - A.8.7 Space Heating
  - A.8.8 Water Heating
  - A.8.9 Electrical Services
  - A.8.10 Water Conservation
- A.9 PLANT LOCATION, ACCESS FOR MAINTENANCE, OPERATION AND REPLACEMENT
- A.10 METERING STRATEGY
- A.11 BUILDING MANAGEMENT SYSTEM
- A.12 BUILDING USER GUIDE
- A.13 COMMISSIONING AND TESTING

A.14 OPERATING AND MAINTENANCE MANUALS
A.14.1 General Requirements of the O&M's
A.14.2 Content and layout
A.14.3 Checking of Drafts
A.14.4 Final documentation
A.14.5 Copyright
A.15 RECORD DRAWINGS
A.16 PLANT AND SWITCHROOM DRAWINGS, SCHEDULES AND SCHEMATICS
A.17 BUILDING LOG BOOKS
A.18 HANDOVER
A.19 DEFECTS PERIODS NAMED MATERIALS/SPECIALISTS
A.20 LIFE CYCLE CARBON ASSESSMENT
A.21 WORKING WITH ASBESTOS
A.22 NAMED MATERIALS/SPECIALISTS
A.23 OTHER APPLICABLE UCL TECHNICAL DOCUMENTATION
A.24 HEALTH AND SAFETY
A.25 DESIGNING FOR THOSE REQUIRING SUPPORT AND ASSISTANCE (INCLUSIVITY)
ELECTRICAL SERVICES
B.1 ELECTRICAL DESIGN CRITERIA
B.1.1 HV Electrical System
B.1.2 LV Electrical Supplies
B.1.3 Electricity Generating Plant
B.1.4 General Lighting Systems
B.1.5 Emergency Lighting Systems
B.1.6 Power Systems
B.1.7 Fire Alarms, Detection and Suppression Systems
B.1.8 Mechanical Wiring
B.1.9 Lightning Protection System
B.1.10 Earthing Systems
B.2 GENERAL REQUIREMENTS
B.2.1 Decommissioning of Systems (applicable to existing buildings only)
B.2.2 HV Systems
B.2.3 Electrical Substations
B.2.4 LV Switchgear
B.2.5 Residual Current Devices and Arc Protection
B.2.6 Fuses and Disconnecting Links
B.2.7 Distribution Boards
B.2.8 Busbar Systems

B.2.10 Transient Voltage Surge Suppression
B.2.11 Harmonic Conditioners
B.2.12 Power Factor Correction Units
B.2.13 Electricity Metering
B.2.14 Earthing Systems
B.2.15 Small Power Services
B.2.16 Wiring Containment
B.2.17 Cable Types & Colours
B.2.18 Interior Lighting Levels and Zoning
B.2.19 Exterior Lighting
B.2.20 LED Colour Temperature Guide
B.2.21 Lamps and Ballast preference
B.2.22 Lighting Control Systems
B.2.23 Specialist Lighting
B.2.24 Emergency Lighting
B.2.25 Emergency Lighting Testing Systems
B.2.26 Fire Alarms and Detection System
B.2.27 Alarms & Services for those requiring Support and Assistance
B.2.28 Induction Loops
B.2.29 Ancillary Alarms
B.2.30 Intruder & Panic Alarms
B.2.31 Access Control & CCTV Security Systems
B.2.32 Communication Systems
B.2.33 Media Systems
B.2.34 Labelling of Services
MECHANICAL SERVICES
C.1 MECHANICAL DESIGN CRITERIA
C.1.1 Environmental criteria, External Conditions
C.1.2 Environmental Criteria, Internal Conditions
C.1.3 Ventilation Requirements
C.1.4 Filtration Standards
C.1.5 Internal Heat Loads
C.1.6 Water Services
C.1.7 Noise Criteria
C.1.8 External noise arising from installed plant and equipment
C2 GENERAL REQUIREMENTS
C.2.1 Utilities and Infrastructure
C.2.2 Pipework Systems
C.2.3 Heating, Boilers & Humidification

C.2.4 Cold Water Services
C.2.5 Hot Water Services
C.2.6 Above Ground Drainage
C.2.7 Chilled Water & Cooling Systems
C.2.8 Expansion and Contraction
C.2.9 Isolating Valves
C.2.11 Mechanical Ventilation
C.2.14 Controls
C.2.15 Continuous and Out-of-Hours Operation of Plant
C.2.20 Plant Maintenance
C.2.21 Water hygiene risk assessments/method statements
C.2.22 Plant and services adjacent to project site
C.2.23 Pressure gauges and thermometers
C.2.24 Electrical power supplies to pumps