RMIT UNIVERSITY

Property Services

Design Standard

Volume Six Mechanical Systems

Issue 7 2015

August 2015

Design Standards – Volume Six Mechanical Systems

August 2015

Version Control

This document will be updated and re-issues to reflect approved change to content, and is subject to version control. The version record and status is documented below

Document Change History [1]:

Version	Date	Author	Comments
7.0	31/07/2015		Complete review of standards

Owner

The overall responsibility for these standards resides with RMIT University Property Services

Review

This Document is reviewed every two years

[1] Printed copies of this document are considered uncontrolled and may not reflect the most recent revision

Table of Contents

1. Introduction

1.1 Background

This document details the minimum RMIT design requirements for hydraulic systems. It forms part of the suite of RMIT Design Standards set out below. Additional volumes may be added as developed with all volumes being available on the RMIT Property Services Design Standards web page.

- Volume One Introduction
- Volume Two Architecture and Planning
- Volume Three Electrical Systems
- Volume Four Fire Protection Systems
- Volume Five Hydraulic Systems
- Volume Six Mechanical HVAC Systems
- Volume Seven Vertical Transportation Systems
- Volume Eight Building Management Systems
- Volume Nine Electronic Security
- Volume Ten Communications
- Volume Eleven Audio Visual
- Design Standards Checklist

This document should be read in conjunction with *Volume One - Introduction,* which provides context on the organisational and governance arrangements that apply to the design and construction of new facilities and describes the key principles that underpin the requirements of the Standards:

- Safety
- Accessibility
- Innovation
- Student Experience
- Maintainability and Serviceability
- Modularity and Standardisation
- Reliability
- Compatibility
- Sustainability
- Heritage
- Life Cycle
- Precinct Wide Solutions

1.2 Purpose

The purpose of this brief is to set out the minimum requirements for the design of mechanical systems. The aim is to achieve the maximum possible consistency and standardisation across the mechanical systems on the RMIT University campuses.

Any design aspects not specifically addressed by this brief shall be identified by the consultant during the design process and shall be brought to RMIT University's attention for resolution.

1.3 Demonstrating Compliance with the Standards

Designers are required to confirm compliance and justify any proposed deviations by completing the Design Standards Checklist.

All deviations must be approved by RMIT prior to commencing design. Unless a robust justification is provided for deviations from the Standards, it is unlikely that approval will be given. Design Standards compliance is achieved through completion of the Design Standards Checklist and endorsement by RMIT of any proposed non- compliances.

2. Mechanical HVAC Systems Design Standards

2.1 Regulatory Compliance Standards

2.1.1	The specified maintenance requirements comply with the current version of the AIRAH HVAC&R Maintenance application manual DA19.
2.1.2	The specified commissioning requirements comply with ASRAE Standard 111 and or CIBSE commissioning Codes A,B,C,R and W (other than measurements of fan and duct air quantities which comply with ISO 5802).
2.1.3	The Mechanical Services design shall be carried out by a Registered Building Practitioner registered with the Victorian building Authority.

2.2 Mechanical Services Systems Selections

2.2.1	Carry out a mechanical services systems Options Study and provide recommendations on which system type to adopt based on the following: • Whole of life cycle costs based on the Net Present Value Method with the following parameters: • 25 year term, with appropriate and industry sourced cost escalation rates on electricity, gas and fuels • Reliable plant and proven technologies • Minimises complexity of operation and maintenance • Readily maintainable with product support and locally source spares • Minimises aesthetic, noise and environmental impact • High Quality functional and operational outcomes including comfort indoor climate control, Internal Environment Quality, zoning flexibility and the flexibility to accommodate fit out changes at relatively low cost impact.
2.2.2	Inspect and report on the condition of existing systems to determine suitability for reuse and compliance with current statutory requirements, Australian Standards and RMIT Design Standards and provide order of construction cost estimates to upgrade and or replace as required.

2.3 Design Requirements

2.3.1	The ambient design conditions used in the calculations comply with the current AIRAH Load Estimation application manual DA09.
2.3.2	The design criteria complies with the criteria as scheduled in the Table : Design Criteria By Type of Space table included at Appendix A.
2.3.3	Lighting loads are in accordance with the lighting design for the project.
2.3.4	The air conditioning and heating systems designs incorporates individual temperature control zones with common zones shared only by areas with similar functional requirements, similar occupancies and frequency of operating hours and with similar load profiles. No one single room should be served by two different air conditioning units.
2.3.5	The HVAC systems operating times are controlled via the Universities BACnet installation with local 0-4 hrs (adjustable) afterhours override time delay off facilities for each zone

2.3.6	The expected noise levels from the HVAC systems (including pipe work) designs, and mechanical plant selections do not exceed the current Australian Standard AS 2107 recommend noise levels and reverberation times for Building Interiors and the criteria as scheduled in the Table: maximum continuous noise intrusion levels and minimum noise separation for speech privacy.
2.3.7	The expected noise levels from the HVAC systems designs and mechanical plant selections do not exceed the EPA requirements for external noise levels and also the resultant noise levels will not adversely impact the amenity of adjacent buildings and functional outdoor spaces.
2.3.8	Where the HVAC Return Air, Makeup Air and Relief Air paths penetrate partitions bounding spaces requiring speech privacy, attenuation has been incorporated in the designs such that the acoustic performance of the attenuation measures exceed the minimum Weight Level Difference (Dw) as schedules in Table: maximum continuous noise intrusion levels and minimum noise separation for speech privacy and so that the overall Dw rating of the partition is maintained.
2.3.9	The design outside air mechanical ventilation flow rates selected to suit the design occupancies are greater than the current Australian Standard AS 1668.2 minimum ventilation flow rate requirements by a factor of 2.
2.3.10	The HVAC systems incorporate Demand Ventilation Control (DVC) systems and monitoring of CO2 levels in the occupied spaces. The DVC systems control the ventilation outside air flow rates to maintain 700 ppm CO2 levels in the occupied spaces.
2.3.11	CO2 is not used as an indicator for control of the DCV systems serving zones with indoor sources of CO2 other than people.
2.3.12	Carpark exhaust systems designs incorporate energy saving measures in accordance with the current version of AS1668.2 including Atmospheric Contaminant Monitoring Systems based on CO monitoring to control the exhaust systems operation and flow rates.
2.3.13	The Air Coils design criteria and selections complies with the criteria as scheduled in the Table: Air coil selection criteria and where active dehumidification control is provided the Air Coil selections and face velocities are designed to achieve the design moisture removal rates shown in Appendix B.
2.3.14	The design of filter plenums and filter system selections complies with the criteria as scheduled in the Table: Air filter selection criteria included at Appendix C and all filter media is of the disposable type.
2.3.15	Filter plenums for air handling units and ducted fan coil units are specified with local manometers filter gauges and pressure sensors connected to the Building Management System to provide indication of when filter requires replacement / cleaning.
2.3.16	Provide filter resistance pressure sensors across filter plenums connected to the Building Management System to provide indication of when filters require replacement / cleaning.
2.3.17	Flexible connections and vibration isolation mounts have been specified provide vibration isolation of HVAC systems and mechanical plant, selected to minimise, structure borne and airborne noise and vibration to comply with the recommended vibration levels set out in the current version of AS 2670.2.
2.3.18	Fan coil units proposed to be exposed within occupied spaces are to be provided with acoustic enclosures.
2.3.19	The level of redundancy and spare capacity incorporated in the HVAC plant is as scheduled in the Table: Level of redundancy and spare capacities.
2.3.20	Hydronic system designs comply with the Table: Hydronic pipes design maximum frictional loss and maximum design velocities and incorporated automatic dosing water treatment with corrosion inhibiters and microbial control.

2.3.21	Hydronic systems incorporate sludge and dirt separators and Vacuum de-aerating systems.
2.3.22	The HVAC systems have been design and equipment selected for a 25 year economic life cycle.
2.3.23	If new fan installed with fresh air loop a new filter box on fresh air duct is required.
2.3.24	The refrigerants used in the air conditioning plant specified have zero Ozone Depleting Potential.
2.3.25	The HVAC systems incorporate heat recovery system to treat outdoor air ventilation rates where the minimum outside air ventilation rate is greater than 15% of the of the supply air flow rate.
2.3.26	The mechanical services systems incorporate a Building Management System (BMS) to monitor and control all mechanical plant compliance with RMIT's Building Management Architecture Standard. The BMS will be integrated into existing RMIT owned Central Head End via the RMIT VPN utilising BACNet over IP. Refer to the applicable RMIT BMS design and Maintainability Standard.
2.3.27	HVAC temperature control systems incorporate set point set back energy saving strategies for partially occupied spaces and corridors.
2.3.28	HVAC control systems and plant are specified to be monitored and controlled by the University's BACnet Systems with all the controls operating on 0-10 Volt or 4-10 mA output signals.
2.3.29	HVAC plant that uses proprietary control systems incorporate a BACnet High Level Interface (HLI) to connect to the University's BACnet systems where this is optional from the equipment manufacturer, or if a HLI is not availed as a minimum a BACnet interface is specified with enable /disable functions and where proprietary sensors cannot be interfaced additional independent monitoring temperature sensor are specified.
2.3.30	All variable speed drives to be specified to incorporate the following minimum features: • Minimum IP54 rating for indoor installations wit out a secondary housing • Minimum of IP66 for outdoor installations without a secondary housing • Factory fitted pad locked mains disconnect switch for auxiliary status indications • Rated for full load currents of the connected motor when operated to a maximum ambient temperature of 45^0C and with continued operation at permissible reduced performance up to 55^0C • Min. efficiency of 96% at 100 % load and 94% at 50 % load, loads of 11 kW and >, min. full load efficiency shall be 98% • The VSD shall incorporate Dual DC link choke harmonic filter. It shall also incorporate suitable Harmonic filters so that the Harmonics generated by the Drive system shall not exceed the limits set in AS 61000 for a maximum 5% current distortion. • The VSD shall be CE marked in line with European Union EMC directive legislation and C-ticked marked in accordance with Australian Communications Authority regulations and include within the VSD enclosure a radio frequency suppression filter and comply with AS 61800.3 with 50 m motor cable (C1 category for <90 kW and C2 category for >90kW • High proven High level interface(HLI) capabilities with BMS using BACnet protocol.

2.3.31 Include the following minimum programmable I/O points:

- 6 x Digital Inputs
- 2 x Digital outputs
- 2 x Analogue inputs each selectable for voltage or current signals, direct or reverse acting, with the minimum and maximum range independently scalable from 0-10V DC and 0-20mA)
- 1 x analogue output (0/4-20mA
- Be capable to expand the I/O capability via expansion modules
- Be capable of control all Digital and analogue outputs including the I/O expansion modules via the BMS HLI
- Include a full 3-zone, 3 set point, 3 feedback PID controller as standard with the ability to auto-tune the PI terms and shall incorporate a flow compensation function to dynamically adjust the set point based on flow
- The VSD shall have three additional auto-tune PID controllers which can provide set point reset or control damper and valve actuators in the system.
- The output voltage to frequency ratio shall be suitable for fan and centrifugal pump control. An automatic energy optimization function shall be incorporated to dynamically optimize the voltage to the motor throughout the operating range.
- The VSD shall be able to automatically tune itself to the motor to optimise motor performance and efficiency, improve start capabilities and compensate for motor cable variances. This function shall be carried out with the motor at standstill (i.e. without spinning the motor) and without the need to decouple the motor from the driven load
- The VSD shall have a standard USB port for direct connection of a PC to the VSD
- The VSD shall be able to store application load profile data to assist in analysing the system demand and energy consumption over time.
- The VSD shall incorporate a keypad with LCD alpha-numeric and graphical backlit display providing the system parameters, meter displays , set point and feedback displays,
- Displays for each of the I/Os
- Display of faults and alarms.

2.3.32 Design to:

- Incorporate power fault protection including loss of power, phase failure, phase reversal, over and under voltage, short circuit and earth faults, overload and over temperature
- Fire mode functionalities including forced run to full speed and override other local controls
- Detect loss of running load indicative of fan failures and provide alarms via the HLI
- Detect no pump on flow and or dry pump conditions and operation off the end of the pump curve and alarm via HLI'
- Include back up date of all parameters and addresses on a removable device.

2.3.33 VSD shall be located next to mechanical switchboards where practical in fully accessible locations, not mounted on AHU panels and within weather proof enclosures irrespective of manufacturer's IP ratings and provide with shielded cables with isolator at the motor..

2.3.34	All pipework and mechanical plant, other than plant with standard proprietary coatings, is to be painted to comply with RMIT's painting standards. Metal pipework and or sheeting, conduits colour shall comply with AS 1345 to identify the contents and conform to the recommendations of AS 2311 sections 3,6 and 7 or AS 2312 sections 5,8, and 10 as applicable the systems shall be suitable for the local environment and for 10 years to the first maintenance re application
2.3.35	All mechanical plant, equipment, power and controls is to be labelled in accordance with RMIT's BMS standard and generally to identify the building ID being served, the floor level of the building being served, the type of plant/item and the item sequential designation . Labels to be Traffolyte or similar, UV stabilised, self-adhesive, 2 colours.
2.3.36	Air handling units will incorporate the following features: • Lights to each compartment • Compartments with adequate access for inspection, service and maintenance • Hinged access dors with heavy duty hardware and seals • Stainless steel or PVC condensate trays with 25 mm ID minimum sized bottom drains extending past headers and coil fin blocks • Sandwich panel modular construction or Double skinned modular construction galvanised sheet steel construction mounted on a concrete plinths • Removal plugs to measure air on and air off the coil temperatures • Fans selected to maximum of 1440 RPM at the design duty and fitted with high quality sealed bearings (i.e. SKF) • Fans motors with minimum of 2 x belt cog drives with adjusting screws to be opposing end and side of motor or direct drive type • External lockable drive motor power isolating switch • High efficiency motors
2.3.37	Balancing dampers, smoke dampers and valve motorised actuators will be readily accessible for service and inspection and will incorporate position indicators and self-lubrication bushes. All access panels shall be labelled to provide indication of type and location of dampers.
2.3.38	Air coils incorporate: • Mini ball valves air bleed valves on top of the coil • Drain valve fitted at bottom of coils • Coils connected with demountable fittings • Temperature and flow probes inserting points on both the supply and return side of the coils • Strainers
2.3.39	Provide drains to Main heating and chilled water pipework branches and automatic air bleed vents.
2.3.40	Air conditioning units serving communication rooms are to be stand alone, not on main circulated water system so as to avoid risk of water damage to communications equipment from potential leaks. If ventilation only needs to be provide must be with filtered s/a fan located in server/communication's room floor.
2.3.41	All condensate trays to be gravity type.
2.3.42	All exposed refrigerant and condensate pipework shall be provided with Proprietary Covers and or colorbond top hat sections to Shield insulation from UV exposure and provide mechanical protection.
2.3.43	Kitchen exhaust ductwork shall comply with AS1668.1, all ductwork joints to be sealed with chemical resistant sealants and provide with access panels every 2 m and at every change in direction.

2.3.44	All 3 phase plant shall be provided with phase failure protection to protect against power and phase failure, phase reversal, over and under voltage and be able to be auto reset on power restoration
2.3.45	Mechanical Switchboards are to be located within the Mechanical services plant rooms and within sight of mechanical plant.
2.3.46	Mechanical plant Switchboards/control panels to be provided, for all mechanical plant items, with auto/off/manual switches with run and fault (LED) lights, lamp test, fire alarm indication with auto rest. The Switchboards shall also incorporate a 15 A single Socket Outlet and be 001 keyed. Cable sizes shall suit the connected loads but be not less than 2.5 mm2. For spare capacity see electricity standard.
2.3.47	Essential systems including BMS systems, gas detection systems, smoke management control systems and the like shall be provide with battery power back up systems for a minimum of 2 hours of operation.
2.3.48	Retail tenants to be provide with Standalone HVAC Systems powered and metered from the tenancy electrical boards.
2.3.49	The Mechanical Services is specified to be commissioned by an independent commissioning agent qualified to a minimum certificate IV, except for specialised items of plant such us Chillers, boilers and the like which require commissioning by the Manufacturers qualified personnel.
2.3.50	The mechanical services designs have been coordinated with all other new and existing services and building structures.
2.3.51	All reheat coils need to have before and after access panels.
2.3.52	No HVAC equipment to be fed from light and power main switch boards.
2.3.53	Operation and Maintenance manuals have been specified to be provided with the following minimum requirement and information: • Installers and commissioning agents name and contact details • Detail plant descriptions, make and model numbers and design duties, • Operational and controls descriptions • BMS Functional Brief, Control and Operational details and points list • Design and commissioning data and certification • Statuary certificates • Manufacturers literature • Specified and recommended Preventative maintenance procedures and schedules • As built drawings • Fire matrices as per AS1851- 2012 Fig 14.1 • Filter list, fire/ smoke damper list as per AS1851- 2012 Fig 14.4.
2.3.54	The manuals will be specified to be provided in PDF and MS Word format with the drawings in PDF and DWG format to match the design drawings.

2.4 Ventilation Rates and Carbon Dioxide Monitoring

2.4.1	As part of the design team including any sustainability consultant, develop a design solution that maximises natural ventilation as a primary means of ventilating 95% of useable floor area, as defined by AS1668.2 2002. For mechanically air-conditioned spaces, 100% improvement on outside air rates as determined by AS1668.2 1991 is required.
2.4.2	For at least 95% of the useable floor area that is served by a mechanical system, CO2 sensing at all return air points has been provided to moderate outside air requirements for energy efficiency purposes. Where the mechanical system provides at least 100% outside air provision, CO2 sensing is not required.
	NB Useable Floor Area is defined by the Green Building Council of Australia as used in the Green Star rating tools.

2.5 Thermal Comfort

2.5.1	The occupied spaces achieve internal temperatures that are within 80% of ASHRAE Standard 55 – 2004 Acceptability Limit 1, during the Standard Operating Hours of Occupancy for 98% of the year.

2.6 Energy Sub Metering

2.6.1	The design incorporates energy sub metering that is connected to the BMS for all mechanical switch boards.
2.6.2	The design provides energy sub metering that is connected to the BMS for all main cooling source, main heating source, air systems and water systems.

2.7 Comfort Control for Unoccupied Areas

2.7.1	The design solution requires that all separately enclosed spaces have the ability to be shut down when not in use or have the ability to extend the control band by +/- 2°C when not occupied.
2.7.2	The BAS system should, with one switch have the capability to shut down a/c in individual rooms (per air handling unit/ fan coil unit)/ whole floors/ whole buildings.

2.8 Shared Energy Systems

2.8.1	Shared or precinct wide energy systems have been adopted.

2.9 Heat Rejection Water

2.9.1	No water based heat rejection systems have been incorporated.
2.9.2	Where water is used in a heat rejection system, the potable water use for such a system has been reduced by 90%.
2.9.3	Where water is used in a heat rejection system, water is not kept a temperature between 20°C and 50°C and meets the requirements outlined in AS/NZS 3666.1:2002 and AS/NZS 3666.2:2002 and AS/NZS 3666.3:2002

2.10 Refrigerant ODP

2.10.1	ALL HVAC refrigeration have and Ozone Depleting Potential of zero or no refrigerants are used

2.11 Insulant ODP

2.11.1	All thermal insulants used do not use ozone depleting substances in both manufacture and composition.
2.11.2	Protection from Legionella :No water based heat rejection systems have been provided.
2.11.3	Gas monitoring systems should be monitored by the BAS system and the security control room.

2.12 Maintenance and Safety Provision

2.12.1	Carry out Safety in Design assessment of the mechanical services systems risks to address safety, hazards and risks associated with the systems selection, design, installation, operation ,maintenance, decommission and disposal.
2.12.2	The design shall provide for the location, spatial requirements and any constraints of the installation of the mechanical services plant and equipment and the requirements for servicing, preventative maintenance and replacement throughout the life of the installations and the plant.
2.12.3	The designs shall comply with AS 3666
2.12.4	The design shall comply with the NCC/BCA including Part J8 " access for Maintenance and facilities for energy monitoring" and include provisions to enable maintenance of the mechanical services components to the NCC/BCA Part I2 "Energy Efficient Installations"
2.12.5	All plant and equipment is to be designed, arranged and specified with adequate space and clearances in accordance with the manufacturer's recommendations and to facilitate reasonable, ready able and safe access for commissioning, tuning, maintenance and servicing.
2.12.6	Split DX systems and Variable Refrigerant Flow systems shall comply with AS1677. Ensure compliance in cases where provision of DX plant to serve small rooms with large equipment loads such as computer/ communications rooms and the like without outdoor air and or relief air paths such that a complete refrigerant charge leak in to the enclosed room would exceeded the concentrations noted in AS1677 that may affect the safety of personnel.
2.12.7	Major indoor plant containing refrigerants are provided with a refrigerant leak detection system and alarms connected to the Building Management System.
2.12.8	Plant rooms containing refrigeration equipment are designed with ventilation to AS1677
2.12.9	Where Plant is proposed to be installed concealed in ceiling spaces, provide for adequate and labelled ceiling access panels 800 mm x 800 mm minimum size or large if required to fully access the plant and in locations that will not be impeded by current and future furniture locations. Where feasible incorporate trafficable plant deck in roof spaces and trafficable access walkways.
2.12.10	Ceiling access panels and the like are to be labelled with the plant / item designation to identify the plant/item being served and should not be key lockable.

2.12.11	Provide for adequate maintenance and service space around central chiller plant for inspection and removal of heat exchanger tubes in accordance with the equipment manufacturer's requirements.
2.12.12	Where outdoor roof mounted plant is proposed provide the following: • Roof walkway mesh and, if applicable, hand rails • A maintenance weatherproof 15 A Single Socket Outlet.

3. Appendix A - Design Criteria by Type of Space

Space	Summer room design temp. (^oC)	Winter room design temp. (^0C)	Room Humidity (RH)	Minimum Population density Persons/ m^2	Appliance loading allowance (w/m2)	Other
Administration offices	24	22	50%	1/10	25	
Lecture theatre	24	22	50%	1/10	25	
Post Grad space	24	22	50%	1/4	25	
Conference rooms	24	22	50%	1/1.8	25	
Tutorials	24	22	50%	1/2.8	25	
Computer labs	24	22	50%	1/2.8		2.5m2 per work station and 110 W/computer drive and screen
Science labs	24	22	50%	1/5	25	
Communications/ Computer server rooms	27				Project specific, 300 W/m2 min	

Notes:

1. Unless otherwise noted, no active humidity control is required, plant should be designed to achieve the above nominal humidity design criteria + 10% tolerance
2. The actual appliance loading to be coordinated with the architectural and electrical designs and to include all specific know space appliances loadings or the above minimum scheduled allowance, whichever is greater.
3. All temperature set points to be adjustable over the range of 18^0C to 28^0C with and adjustable dead band of 2^0C across the set point
4. Where natural ventilation or mixed mode operation is applicable, the internal space temperature conditions can fluctuate within a wider temperature band of 18C to 26C dry bulb. Appropriate behavioural and comfort adaptations policy/methods should be incorporated into the design and operation of naturally ventilated or mixed mode operated spaces.

4. Appendix B - Air Coil Selection Criteria

Application	Max air velocity through the coil face area	Maximum air pressure Drop	Maximum water side pressure drop	Maximum fin pitch	Factory applied corrosion protection coatings
Cooling coils	Does not exceed 2.4 m/s	Does not exceed 150 Pa when wet	Does not exceed 30 kPA	Does not exceed 480 fins/m	-
Heating coils	Does not exceed 3.4 m/s	Does not exceed 70 Pa when wet	Does not exceed 20 kPA	Does not exceed 550 fins/m	-
Condenser coils	Does not exceed 3.4 m/s	Does not exceed 100 Pa when wet	-	-	Included

5. Appendix C - Air Filter Selection Criteria

Application	Primary Filters type and rating to AS 1324.1	Secondary Filter type and rating to AS 1324.1	Max air velocity through the filter face area	Maximum initial air flow resistance for filter system
Air handling units	Extended media deep bed, G4	Extended media multi peak, F8	Does not exceed 2.4 m/s	Does not exceed 175 Pa
Fan coil units ducted with airflows not exceeding 1000 l/s	Extended media F5	-	Does not exceed 2.4 m/s	Does not exceed 60 Pa
Fan coil units non ducted	Complies with AS1668.2		Does not exceed 2.4 m/s	Does not exceed 25 Pa

Notes: for fan coil units not exceeding 1000 l/s and non-ducted units provide separate outside air filters and filter plenums.

6. Appendix D - Maximum Continuous Noise Intrusion Levels and Minimum Noise Separation for Speech Privacy

Typical Spaces	Maximum design noise levels	Acoustic privacy rating based on the minimum Weight Level Difference (D_w) of partition being penetrated by Makeup/Relief/Return Air paths	
	L_{qds} dB(A)	**Noise Rating (NR)**	
Lecture theatres, conference rooms, meeting rooms, libraries, Snr offices	35	**30**	45
Reader's offices, lecturer's offices, common teaching rooms. laboratories	40	**35**	40
Tutor's rooms. Stores, general offices, amenities	45	**40**	40
Corridors, services areas and the like	50	**45**	40 (at toilets)

7. Appendix E - Level of Redundancy and Spare Capacities

Application	Level of redundancy	Spare capacity for future use	Comments
Mechanical Switchboards	-	25%	Includes spare capacity in cable load capacity as well as physical space on the switchboards – all 3 phase equipment to be provide with phase failure, phase reversal and under/over voltage protection
Chillers	N+1	20%	
Boilers	N+1	20%	
Hydronic pipework systems flow capacity	-	25%	
pumps	N+1	25%	
HVAC plant serving Communication equipment rooms	N+1 or N air conditioning units + back up exhaust systems		
HVAC plant Data rooms	N+1		Include N+1 redundancy in power and controllers

N- Denotes the number of plant items required to meet 100 % of the design duty.

8. Appendix F - Hydronic Pipes Design Maximum Frictional Loss and Maximum Design Velocities

Application	Maximum velocities in Accessible locations	Maximum velocities in Inaccessible locations	Maximum frictional Loss
Chilled water pipework	3.5 m/s	2.5 m/s	1000 Pa /m
Heating and condenser water pipework	2.5 m/s	2.0 m/s	1000 Pa /m