MS03 Cooling & Chilled Water

UNIVERSITY OF LEICESTER

Document Control

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A	Jun'16	J. Hoare	Technical Review Update
B	Oct '17	J. Hoare	Technical Review Update
C	Dec 17	UoL	Sign off for release
D	July '18	J. Hoare	Technical Review Update
E	Mar'20	J. Hoare	March 2020 Issue
F	April 2020	A. Singleton	General update to tracker and other minors.
G	Feb 21	A Singleton	Thermal Insulation

Design Guidance

1. This document shall be read in conjunction with the University Guidance Document "GD" series of guides which give greater information regarding the philosophies of passive design and the need to try to avoid mechanical cooling where possible.
2. Reference should be made to the detailed University's mechanical technical specification. Where there are discrepancies between this document and the University standards clarification shall be obtained from the University before proceeding.
3. The University has declared a Climate Emergency and needs to reduce its carbon footprint. Buildings should be designed as passive modifiers with a view to negating or greatly reducing the need for mechanical cooling. This document is therefore to be used only where mechanical cooling is a process necessity or where passive means cannot maintain the summertime temperature overheating criteria the University wish to comply with.
    a. All design options should therefore be investigated in an attempt to negate the requirement to use mechanical cooling methods for building cooling. This should be through passive building fabric solutions and night purging of the exposed thermal mass. Only when these measures have been exhausted should mechanical cooling be considered.
    b. Refer to GD series of documents for thermal analysis considerations to determine summertime overheating.
4. Wherever possible the University wishes to minimise its use of refrigerants and therefore designs should achieve this by means of centralised plant solutions employing chilled water generating equipment in general preference to stand alone type DX systems.
    a. DX stand alone systems will however be required in various applications and their use is accepted when analysis indicates that they are the solution for a particular application.
    b. However see below for further details of life cycle analysis to determine the choice of either chilled water or DX solutions .
5. Life cycle cost appraisals must be undertaken in respect of the preferred mechanical cooling solution to determine whether centralised chilled water or stand alone type DX (or indeed a hybrid of the two) is the best solution for a particular application.
    a. Analyse various cooling system philosophies including centralised chilled water, stand alone various types of DX systems or hybrid solutions of the two.
    b. Consider where N+1 resilience is required.
    c. Where a building is connected to the Leicester district heating network consider the use of centralised absorption cooling using summer waste heat from the network. The University will supply the energy cost data required.
    d. For the various systems consider operating temperatures, coil sizes, COP etc, to allow decisions to be taken as to the best overall choice in life cycle terms. This is to include energy in use, carbon, capital and maintenance costs. Refer to GD series for further Guidance.

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Design Guidance

   e. Always remembering that decentralised solution will use greater amounts of refrigerants than centralised.
6. Prior to designing any mechanical cooling systems an analysis of refrigerant options must be undertaken. This should consider suitability for application, GWP, ODP and phase outs of present refrigerants with a view to making a refrigerant use recommendation to the University.
   a. Refrigerants to comply with F Gas regulations always considering a forward look.
7. Chilled water (CW) systems shall be implemented as a standard for larger cooling systems with stand alone DX or hybrid solutions being implemented for smaller systems or where they are of use to increase resilience. The systems shall carefully consider operating temperatures to increase COP and therefore to reduce carbon.
   a. Under no circumstances will the use of adiabatic cooling, evaporative cooling or spray system cooling be allowed.
   b. Under no circumstances will the use of heat rejection equipment using adiabatic cooling, including cooling towers or sprayed coil blocks, be allowed.
8. Systems shall be installed using traditional steel pipework and fittings as per the University standard specification. Pipework shall be screwed up to 50mm and welded 65mm and above. Pipework shall be painted prior to insulation as detailed later.
   a. Copper, thin wall steel, stainless steel or plastic pipework systems must not be used.
   b. Pressfit, pushfit, clamped or compression fittings and systems must not be used.
9. For all mechanical cooling equipment utilised
   a. If the individual piece of equipment is above 100kW cooling load then the equipment must incorporate an inverter for modulating load and start load operation.
   b. If the individual piece of equipment is above 100kW cooling load then the equipment must include integral power factor correction.
   c. Mechanical cooling equipment shall be monitored and controlled by the buildings BMS system.
   d. Ensure manufacturer's minimum chiller cycle times are met in all circumstances.
   e. Minimise energy waste.
   f. Maximise efficiency looking for best economic CoP.
10. For larger centralised water chillers then the use of free cooling should be analysed by life cycle analysis to include energy in use, carbon, capital and maintenance costs. .
   a. Only needs to be considered on systems requiring wintertime or mid season cooling eg fan coils within internal areas etc.
11. Minimum Chiller Energy Efficiency Ratio (EER) at peak load, calculated in accordance with building regulations to achieve:
   a. Eurovent EER Classification of A (>3.1 for air cooled chillers)
   b. Eurovent EER Classification of A (>5.05 for water cooled chillers)
   c. Eurovent EER Classification of A (>3.55 for chillers with remote condensers)
12. Minimum Chiller Seasonal Energy Efficiency Ratio (ESEER) at calculated in accordance with building regulations (and for use in iSBEM):
   a. 4.2(for packaged air-cooled chillers up to 500kW capacity)
   b. 4.3(for packaged air-cooled chillers between 501kW and 750kW capacity)
   c. 4.2(for packaged air-cooled chillers between 751kW and 1,500kW capacity)
   d. 5.8(for packaged water-cooled chillers up to 500kW capacity)
   e. 6.0(for packaged water-cooled chillers between 501kW and 750kW capacity)
   f. 6.4(for packaged water-cooled chillers between 751kW and 2,000kW capacity)
13. Chillers and DX cooling equipment shall comply with the following
   a. Winter start kits will be included to operate and test machines at ambient temperatures down to minus 8°C

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Design Guidance

b. All chillers and condensing units need to be fitted with high efficiency spring anti-vibration mounting to provide a vibration efficiency of at least 98%.
c. All water chillers require integral flow switches to monitor chilled water circulation. A hired wired auxiliary interlock will be provided as standard. The chillers shall be inhibited from operation unless flow is proven by interlock to the flow switch and pump starter.
d. Where chillers serve systems such as chilled beams, high ambient fan coil units or for applications where chillers are required to operate during the winter/shoulder months then free cooling shall be included and shall be available wherever the outdoor ambient condition ambient is 2°C less than the return water temperature.
e. All chillers above 50kW cooling load shall have a minimum of two refrigeration circuits using suitable compressor types to get the maximum efficiency out of the chilled water system. All compressors need to be provided with suction and discharge isolating valves.
f. Freeze protection shall be discussed with the University at the beginning of design to understand if glycol can be used on the system. Where this is utilised a 20% mix shall be introduced into the system. Where the use of glycol is not allowed in the system a combination of trace heating, and evaporator electric heaters will be utilised.
g. Crank case heater and panel mounted anti-condensation heater shall be included. These shall be powered from a separate power feed such that when the chiller is not operational, the heaters are permanently fed.

14. Variable speed pumps should be used on secondary circuits and coils should use two port control technology to all coils to reduce water flow rates and thus save energy. Variable secondary flow design principles should be adopted in line with CIBSE Knowledge series technical guidance notes and good industry practice.
15. The chilled water distribution networks should be designed based upon low pressure drop good practice. Spine circuitry should not exceed 200Pa/m at full load conditions and sub circuits down stream of differential pressure and flow control valves (DPV) to be typically 100 to 200 Pa/m to suit the DPV maximum differential pressure setting of 30 to 40 kPa.
16. Any pressure independent control valves (PICVs) shall not be operating within the upper 25% of their preferred maximum differential pressure.
17. System pipework sizing shall also be based on limiting water velocities in line with the requirements of CIBSE, whilst also considering the type of water:
    a. Steel Non-Corrosive Water Velocity Limits: <Ø50mm = 1.5m/s; >Ø50mm = 3.0m/s
    b. Steel Corrosive Water Velocity Limits: <Ø50mm = 1.0m/s; >Ø50mm = 1.5m/s
    c. Copper Pipework Velocity Limits (where permitted by exception) <Ø50mm = 1.0m/s; >Ø50mm = 1.5m/s
18. System pipework sizing should be proportioned to account for the heat gains of the network.
19. All chilled water systems must employ primary and secondary chilled water pipework circuits designed and based as follows.
    a. Each primary chiller circuit pumping system shall be designed to achieve flow rates to each chiller to match the greater of the following at all times
        - 110% of the manufacturer's recommended minimum chilled water flow rate for the chiller output capacity stage
        - or
        - the flow rate required to meet the system load at the design differential temperature required.
    b. Where multiple chillers are provided each chiller shall be provided with its own individual primary pump set pumping through the chiller and around the primary loop to the low loss header. These pump sets shall be separate and hydronic modules will not be allowed.
    c. Primary loops shall include buffer vessels to ensure that the chiller cycle times exceed the manufacturers minimum acceptable starts per hour whilst maintaining chilled water temperatures

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Design Guidance

within acceptable drift tolerances.

d. Variable speed pumps should be used on secondary circuits and coils should use two port control technology to all coils to reduce water flow rates and thus save energy. Variable secondary flow design principles should be adopted in line with CIBSE Knowledge series technical guidance notes and good industry practice.

20. Pumps shall be provided as follows.
    a. Single headed run and standby pumps should be provided on all heating circuits. Pump motors above 3kW shall be totally enclosed fan cooled (TEFC) whereas small micro systems less than 3kW may be canned rotor pumps.
    b. All pumps shall be CE certified and fully compliant with Commission Regulation EU No. 547/2012, 640/2009 and 641/2009 in terms of energy efficiency.
    c. Circulating pumps shall vary flow rate via differential pressure transducers and a proportional pressure control methodology. Small systems below 3kW may have integral inverters and pressure control. Larger systems above 3kW shall be provided with inverters that are separate from the pumps.
    d. Inertia bases shall be utilised on every end suction or multistage water circulating pump set.
    e. Inertia bases shall be utilised on every inline pumps set unless it can be demonstrated that these are not required on low duty pump sets which are typically pipeline mounted and do not warrant this level of vibration control.
    f. The inertia bases are to be provided with spring anti-vibration mountings with a vibration efficiency of 98% minimum to limit vibration transmission to the building.
21. For guidance purposes, the following flow and return temperatures shall be adopted for the various systems chilled water designs
    a. Dry fan coils 14/18c.
    b. Wet fan coils 8/14c.
    c. Active and passive beams 15/18c (see notes about temperatures being above room dewpoints)
    d. AHUs without humidity control 8/14c
    e. AHUs with dehumidification control 7/13c
    f. Heat pumps in cooling mode (serve dry fan coil systems and peak lop cooling)
22. As regards the above it should be noted that
    a. Fan coil units shall normally be designed to run in sensible cooling mode only or to ensure the fan coil unit sensible heat ratio is not lower than the room ratio that the fan coil unit serves (to avoid excessive latent cooling). Condensate drains shall be required even if the FCU is designed to run dry (100% sensible).
    b. Chilled beams shall be selected to operate using chilled water temperatures that are greater than the room dew point with at least 2-degree kelvin margin. Dew point shut off sensors shall be included on the BMS.
    c. Air handling units supplying air which needs to be dehumidified to ensure specific room dew point conditions or meet room condition (RH or moisture content limits) may need slightly differing water temperatures. Therefore the designer may need to adjust these values but these AHUs shall be fed from a different circuit from the rest of the chilled water circuits.
    d. The requirement is to keep chilled water temperatures at levels such that CoPs are maximised
    e. When using alternative technologies for providing cooling such as Hybrid VRF installations (Heat Pumps Condensing units) utilising R32 then chilled water temperatures may need adjustment to suit the manufacturers requirements.
23. External Ambient air conditions for condenser full load rejection operation shall be based on the following. This applies to any type of heat rejection equipment including DX systems. Note all heat rejecting equipment must be installed externally to the building.
    a. 35°C dry Bulb where chillers are freely exposed to good airflow

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Design Guidance

b. 40°C dry bulb if a chiller is located in a plant well.
c. High ambient set back controls to off load the chiller water circuit will be required to prevent high pressure duty cut out where the high ambient conditions are exceeded.
d. Chillers shall operate at least 5°C above the given ambient design conditions above by means of 'off' loading without tripping out but a loss of capacity at this conditions will be allowed.

24. External ambient air conditions for air handling cooling coil on conditions shall be taken as either the CIBSE outside summer design conditions allowing for some degree of future proof for global warming or 30c dry bulb and 22c wet bulb whichever is the greater.
25. All new chilled water installations should incorporate combined air and dirt separators to passively remove sludge and pipework corrosion and debris. For retrofit installations, the air/dirt separator shall be added back at the primary plant source. A continuous vapour barrier seal shall be applied to the units prior to installing the manufacturers matched insulation sets.
26. When it is intended to connect onto / extend existing chilled water installations, the designer shall carry out a full conditional survey of the chilled water installations. The designer shall issue a concise report to the University detailing their findings.
27. All new / refurbished / modified installations shall be flushed and dosed by a BSRIA accredited contractor. All work shall be carried out in accordance with the relevant governing documents, as a minimum they should comply with the following documents:
    a. BSRIA Application Guide BG29/2012 - Pre-commission Cleaning of Pipework Systems.
    b. Water Treatment for Building Services Systems (AG 2/93)
    c. Water Treatment for Closed Heating and Cooling Systems (BG50/2013)
    d. Sampling and monitoring of water from building services closed systems. (BS8552/2012)
    e. Code of practice and the European Biocidal products Regulation (528/2012), commonly known as BPR).
    f. When existing systems are found to be fouled by corrosion, scale or debris resulting from lack of or incorrect treatment, an on-line cleaning programme shall be implemented, where non-aggressive chemical cleaning technology in conjunction with the flushing and inhibiting procedures used in pre-commissioning cleaning.
    g. During the flushing and dosing process the appointed design engineer shall attend site to review works being undertaken. Water samples by the appointed specialist shall not be taken direct from the dosing pot, these shall be taken further down the system to give a better indication of the water condition.
28. All chilled water pipework shall be thermally insulated.
    a. Insulation to steel pipe systems shall be applied following the painting of the pipework with two coats of red oxide paint.
    b. The steel pipe insulation shall be bore coated phenolic foam closed cell with a foil faced class O aluminium foil external vapour barrier. It shall be alumnium clad within plantrooms or other areas where damage may occur.
29. All valve and flanges 15mm and above shall be adequately insulated utilising jackets.
    a. Valve boxes shall be avoided in all instances. The valve jackets shall be fixed over valves using Velcro straps with drawstrings at either end of the jacket. The jackets shall have a robust, waterproof fabric finish fully stitched with flexible thermal insulation that meets the overall thermal performance of the insulation applied.
    b. Prior to application of the jackets all valves shall be adequately vapour sealed. This shall prevent potential condensation forming on the valves if the jackets are removed in the future and not fitted correctly. All valves shall be provided with continuous vapour seal regardless of size. All covers shall be certified Class 'O' Building Regulation British Standard, conforming to BS 476 part 6 (fire propagation) and part 7 (Class 1 rating surface spread of flame).
30. Where DX refrigerant pipework is installed then insulation may be "Armaflex" closed cell. Where this runs

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Design Guidance

externally the insulation shall be protected from damage by birds and by ultra-violet light. This shall be achieved by either an external finish of aluminium sheet or alternatively by means of a weatherproof PVC or synthetic sheet.

31. UPS facilities shall be housed within dedicated positively pressurised switch rooms and shall be designed to maintain a maximum temperature of 24^{o}C within the space.

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Design Components

Item	Manufacturer	Comments
Chiller	Airedale Hitachi York Carrier Daikin Mitsubishi	External weatherproof units with frost protection and integrated controls with BMS interfacing. Additional features / standards required: 1. Refrigerant – choice to be made following discussions with the University. Needs to be low/zero GWP and ODP and have good forward availability. 2. BACnetIP controls for BMS interface. 3. Electronic expansion valves. 4. Head pressure control. 5. Winter start where operating throughout the year. 6. Free cooling where economic payback. 7. Soft start. 8. Power factor correction to 0.95 9. Trace heating tape & frost protection. 10. EC variable speed motors on all condenser fans. 11. Corrosion resistant coating to condenser coils. Copper tubes with corrosion treated aluminium fins, suitable anti-corrosion treaments are Bylgold, Chromium plating, polymer and plastic coating. (Industrial areas, high quality specification requirements) 12. Cooling stage / capacity control either multistage 0 / 25% / 50% / 75% / 100% or fully modulating from 30% to 100% by inverter. 13. Evaporator heaters where no glycol is specified.
Pumps	Grundfos Wilo Armstrong Lowara	All pumps shall be CE certified and fully compliant with Commission Regulation EU No. 547/2012, 640/2009 and 641/2009 in terms of energy efficiency

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Design Components

Item	Manufacturer	Comments
Pressurisation Units	Aquatech Pressmain GM Treble Flamco Grundfos	Generally glandless in line circular type. Individual run and standby pumps with individual means of isolation and 'short circuit' NRV prevention. Pumps shall be continuously rated to allow system fill via the unit. Tank fill rate must exceed pump duty. The make up break tank to be complete with ball valve to provide an air gap separation between the system and potable make up supply. The "air gap" means a visible, unobstructed and complete physical air break to meet regulations. The potable supply to the pressurisation unit must be considered as a "dead leg" and as such must be loop connected to a main with good normal flow and use to prevent stagnation. The tee connection must be a short as possible with an isolation valve. This leg should be less than 200mm total. A pressurisation unit bypass quick fill system will be allowed in order to fill the system quickly following a drain down. It should however be noted it is the Universities preference to fill via the pressurisation unit, and a bypass quick fill should only be considered in larger systems. The bypass quick fill should consist of a "tee" connection from the looped potable main with isolating valve and double check valve normally capped off, again this connection must be as short as possible, less than 200mm total including valves. A suitable WRAS approved pressure rated hose should be provided loose. In an emergency quick fill situation, and only in such situations and with written agreement with the University, this hose can be connected to the non-return valve on the potable supply and used to connect to a suitable valved connection on the heating or cooling system to give a quick fill from system empty. After use the hose must be disconnected and the two connections capped off. The hose should be stored locally for emergency use and sterilised prior to connection and use.
Commissioning Valves	Crane Hattersley Oventrop	All commissioning valves to be fitted with measuring ports for final balancing. Refer to MS01 for all other preferred vale manufactures and types / patterns of valves

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Design Components

Item	Manufacturer	Comments
Insulation		All steel chilled water pipework shall be painted with two coats of red oxide primer paint prior to phenolic foam insulation being applied. The Phenolic foam shall be bore-coated (impregnated) with a factory applied passive anti-corrosive agent and all insulation shall be complete with an external vapour barrier class O aluminium foil finish. All thermal insulation shall be responsibly sourced and where applicable evidence shall be provided to the project BREEAM assessor/s. All thermal insulation shall be low embodied impact relevant to their thermal properties determined by the 'Green Guide' by achieving either A or A+ green guide rating. Insulation must be provided to the appropriate ECA recommended thicknesses and not British Standard requirements to satisfy the energy criteria for each development. Under no circumstances shall phenolic foam be applied to copper pipework (which itself must not be used unless requested in writing by the University)
Trace Heating	Isopod, Raychem	Designed to BS 6351, parts 1 & 2. Prior to installation of trace heating the pipes shall be wrapped in aluminium foil. Trace heating tapes to have a minimum rating of 12W/m. First stage control by circulating pumps and second stage control by outside air temperature detection for trace heating.
Pipework and fittings		Reference should be made to the detailed the University's mechanical technical specification Part 2. Heavy Grade Mild Steel is the default material which shall be employed on all projects without exception. All to be painted two coats red oxide before insulation is applied. Copper, thin wall steel, stainless steel or plastic pipework systems must not be used. Pressfit, pushfit, clamped or compression fittings and systems must not be used.

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Design Components

Item	Manufacturer	Comments
Direct Expansion Cooling only or heating and Cooling System	Mitsubishi Electric Daikin Toshiba	Single / Multi Split systems shall be utilised where there are only a few isolated single/local spaces where cooling is required. The installations shall have the following characteristics: • Capability of providing both heating and cooling • High Sensible Characteristics • Incorporate inverter technology to provide high seasonal efficiencies. • Each system shall provide the required sensible cooling and heating during design external ambient conditions noted earlier and maintaining the room to 24°C. • Refrigerant choice to be made following discussions with the University. Needs to be low/zero GWP and ODP and have good forward availability. • If R32 used then must be ultra low quantities used within internal areas as considered slightly flammable. • Every system shall be designed and certified to have an EER compliant with the non-domestic building services compliance guide or to satisfy EPC requirements. • Selected to achieve an Energy Rating of 'A' for each system. • All installations shall be installed by contractors who are on approved installers schemes such as Dakin D1, Mitsubishi Business Solutions partners or Toshiba T7 Warranty Partner as a minimum

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Design Components

Item	Manufacturer	Comments
HVRF Direct Expansion Heating and Cooling System	Mitsubishi Electric	HVRF installations shall be utilised when chilled water cannot be utilised or is impractical and small scale split systems are impractical or there is a requirement for simultaneous heating and cooling is required. The installations shall utilise the following system characteristics: •Heat recovery simultaneous heating and/or cooling system • High Sensible capabilities • Continuous Heating during defrost cycles • Each system shall provide the required sensible cooling and heating during design external ambient conditions noted earlier and maintaining the room to 24°C. • Refrigerant choice to be made following discussions with the University. Needs to be low/zero GWP and ODP and have good forward availability. • If R32 used then must be ultra low quantities used within internal areas as considered slightly flammable. • Each unit shall be selected based on 100% diversity • COP and EER of circa 3.88 / 3.40 or greater as required to comply as required to achieve building regulations compliance. All equipment shall be selected to achieve an Energy Rating of A. All installations shall be installed by contractors who are approved of Mitsubishi Electric Diamond Quality Partners
Close Control Cooling Equipment	Airedale Denco Happel	Installations shall be utilised where high precision air conditioning is essential, including areas such as data centres cooling, medium and low-density server environments, telecom switching stations, medical operating theatres, clean room environments, laboratories containing sensitive equipment, reserve galleries etc. The Units by default shall utilise chilled water unless it is impractical to use a chiller.
Insulation Jackets	Thermotex	Inner finish - Silicone coated glass fibre Outer finish - Woven glass fibre Insulation - Mineral fibre Stitching - Polyester cotton Draw cords – Nylon All covers shall be certified Class 'O' Building Regulation British Standard, conforming to BS 476 part 6 (fire propagation) and part 7 (Class 1 rating surface spread of flame)

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Design Components

Item	Manufacturer	Comments
Air and Dirt Separators	Spirotech	Purpose made manufactures insulations sets to be utilised on all air and dirt separators.

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