10 – Mechanical Services

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1.1	19 October 2010	Solomon Elijah	
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3.0	15 January 2024	Guy Walpole, Inga Doemland and Keith Hickson	General Revision

Introduction

10.1. The Australian National University's (the ANU or the University) is committed to energy efficient design and low long-term maintenance & operational costs associated with mechanical (and other) services and systems within buildings and on the sites of ANU campuses.

10.2. The Campus and Buildings Requirements Manual (the CBRM, the Requirements or the Manual) documents the minimum design and construction requirements for new, refurbishment or repurposed building works, landscapes and engineering/infrastructure projects on buildings, facilities and campuses of the ANU. The Requirements are prepared for the direction of a Consultant, Designer or Project Manager in the preparation of project specific documentation and in the delivery of project works.

10.3. This section of the CBRM outlines the ANU minimum requirements for air-conditioning and ventilation systems and services.

10.4. Notwithstanding any Consultant's particular discipline or area of responsibility, each Consultant and/or designer shall consider the document in its entirety. The complete CBRM consists of the following Sections which may be referred to within this Section:

Campus and Building Requirements Manual	
Section 01	General Requirements
Section 02	Architectural Requirements
Section 03	Roads, Car Parking & Civil Works
Section 04	Soft Landscaping
Section 05	Roofing, Roof Fabric & Roof Safety
Section 06	Building Management Systems
Section 07	Electrical Services
Section 08	Fire Protection Systems
Section 09	Hydraulic Systems
Section 10	Mechanical Services
Section 11	Lifts, Cranes & Vertical Transportation Systems
Section 12	Security, CCTV & Access Control
Section 13	PV Systems

Design Requirements

10.5. Mechanical services system design outcomes shall support the objectives and strategies of the Below Zero initiative. Sensible and appropriate levels of technology and design should be applied to obtain the correct level of quality and reduce energy wastage and carbon dioxide emissions arising from the building operation without reducing the functional requirements. This includes the elimination of natural gas consumption for space heating.

10.6. Mechanical services and systems will need to be adaptable and flexible due to the changing needs of the ANU. Systems are to be designed and zoned to accommodate the building design, proposed and future users.

10.7. In as much as the design can be developed to be efficient, the future operation and management of the building and its systems will have a huge bearing on energy consumption. To this end the designers shall liaise closely with the Principal's Representative to ensure all design features are clearly articulated and understood and systems properly handed over for successful operation of the systems.

10.8. The quality aspects of the services proposed will be provided to the Principal's Representative for review at all project stages.

10.9. A peer review of the designs, at various stages, may be arranged at the discretion of the Principal's Representative.

10.10. Specifications provided by the designer must be tailored to suit the specific project requirements and must not include generic or non-applicable material.

10.11. In designing and specifying a system consideration shall be given to the following:

- Size or capacity of the system including peak and minimum loads;
- Performance requirements;
- Energy utilisation through seasonal cycles;
- Greenhouse gas emissions during lifecycle of equipment (e.g. energy consumption for operation, refrigerant leakage, etc.);
- Noise considerations;
- Location and space considerations;
- Owning and operating costs;
- Reliability;
- Redundancy
- Ease of maintenance;
- Capability of future expansion;
- Separation of process and comfort cooling systems to ensure reliability; and
- Project specific energy targets.

10.12. Refrigeration equipment such as chillers, heat pumps, packaged units shall use non-ozone depleting and low-GWP refrigerants.

10.13. Systems designed and specified must be fit for purpose for which they are designed and installed, must be technically sound and must meet the current requirements of the National Construction Code (NCC) and any other applicable Standards, Regulations or Acts in force at the time.

Energy Efficiency Considerations

10.14. The mechanical services designer shall undertake analysis of various system types during the concept design phase to identify appropriate energy efficient system selections and secondary energy efficiency measures to be incorporated into the mechanical services design.

10.15. System design should consider and utilise, for maximum efficiency and enhanced user comfort, features of the prevailing climate. For Canberra this includes a high diurnal range, a low wet-bulb temperature, low average wind speed and low average rain days.

10.16. All systems shall consider energy efficient design to maintain comfort and set indoor conditions following sustainable design principles such as:

- Reducing peak demand
- Incorporation of heat recovery where possible (for example local via air to air heat exchanger or run-around coils and at central plant level via shared condenser water system)
- Energy storage to shift peaks
- Optimum start
- Demand ventilation and economy cycles on air handling plant;
- Night cooling (e.g. night purge ventilation) where applicable and a benefit can be demonstrated
- Mixed mode active/passive systems using free cooling where suitable.
- Use of Variable Speed Drives (VSDs) on system components with variable demands:
  - Variable speed pumps and fans to lower energy consumption in part load
  - Variable speed compressors or inverters to lower energy consumption in part load
- Highest efficient equipment (pumps, chillers, heat pumps, air-conditioners, fans, motors, etc.)
- Ductwork and pipework reticulation designed for lowest pressure drop
- Thermal zones appropriately defined
- Local controls allow for disabling of cooling/ heating when not required
- Temperature resets such as the following:
  - Room temperature set point, particularly for laboratories during night time.
  - Supply air temperature set point, etc.)
  - Chilled and heating hot water flow temperature resets
- Field differential set point reset for chilled water and heating hot water networks.
- Variable air volume (VAV) systems with duct pressure reset
- If humidification is required adiabatic systems are preferred

10.17. Consideration shall be given to spaces with unseasonal load patterns or spaces which require 24/7 conditioning such as computer facilities etc. Where connection to the central system may compromise the efficiency of the central plant, decentralised system design solutions are preferred.

Calculations and drawings

10.18. A set of all design parameters in form of a return brief shall be provided to the Principal's Representative prior to issuing any design documentation.

10.19. Using the available architectural drawings, the mechanical designer should perform a heat load assessment at the earliest stage practical using an industry acceptable modelling software such as CAMEL or IES VE, to accurately inform the spatial requirements.

10.20. Detailed design calculations shall include but are not limited to the following:

1. Building fabric U-Values to support thermal modelling
2. Outside air rates for compliance with NCC requirements for ventilation
3. Ventilation systems air flow rates
4. Duct work and pipework sizing considering acoustics and the energy efficiency requirements of NCC section J.
5. Fan static pressures
6. Pump heads
7. Electrical loads (maximum demand calculation)
8. Psychrometric analysis for critical areas

10.21. Diversification of heating and cooling loads should be calculated before sizing any mechanical plant. Details of diversification figures to be included in design calculations are to be discussed and agreed with Principal's Representative.

10.22. The design drawings should include the following:

- Schematics for air, water, refrigerant and laboratory gas reticulating systems including all equipment, pipework/ductwork details, instrumentation, etc. Show control lines between controlling instrument (for example actuator) and controlled variable (for example temperature sensor).
- General arrangement drawings, sections and details showing service clearances for ease of reference.
- Mechanical-electrical switchboard load schedule

Occupancy, Ventilation Rates

10.23. Typically, minimum ventilation requirements shall follow requirements stipulated by the NCC. Occupancy shall be determined in collaboration with and agreed by the Principal's representative.

10.24. For specialised facilities such as IVC enclosures, laboratories or research facilities holding animals like rats, mice, birds, insects or other animals, minimum ventilation air flow rates shall be determined based on guidance by laboratory consultants or as recommended in agreed return brief.

Passive Design Considerations

10.25. The Project Team shall give consideration to the benefits derived from incorporation of passive design measures from the earliest stages of the design process. The Mechanical services designer shall refer to the CBRM section 2 Architectural Requirements for passive design features.

10.26. Informed by an ESD consultant and in collaboration with the Projects Team the mechanical services designer shall propose, analyse and incorporate passive design measures in the mechanical design to reduce thermal plant sizing and maximise energy efficiency over the lifetime of the building.

Centralised Thermal Energy Generation

10.27. The objective of this section is to realise ANU's aspiration to service new buildings with chilled water and heating hot water from a central plant to harness energy efficiencies at larger scales. ANU wants to avoid the decentralised installation of new heating and cooling generation equipment without prior consideration of centralisation.

10.28. The design should consider connecting the buildings to an existing central thermal energy system. Utilising accessible service corridors is the preferred approach.

10.29. If a new building cannot be connected to an existing system, then it should house a thermal energy system designed for future connectivity to precinct central thermal energy system.

10.30. At the minimum, all new buildings on the Acton campus with a heating or cooling capacity of 300 kW and more must have the physical provision to connect to centralised thermal energy plants in the future. This requires full sized CHW and HHW pipework mains to be reticulated outside the building and capped within a services pit.

Electric Heating

10.31. In line with the ANU Acton Campus Energy Management Strategy, the mechanical services designer must design heating systems which utilise electricity using heat pumps as the input energy. Gas heating hot water generators (boilers) will not be accepted. This will have multiple follow-on requirements for the mechanical services designer:

- Reduced HHW design flow and return temperatures and lower ΔT between flow and return, and potentially revised air-side coil selections.
- Requirement for spare capacity in the central heating plant to cover low ambient de-rating and potential de-icing
- Waste/low grade heat should be utilised when possible to increase heating system efficiencies. For example, waste heat from data centres or chillers to be used as condenser water for a water cooled heat pump.

Value engineering and economics

10.32. A value engineering analysis shall be undertaken during the concept design phase to assess appropriateness of the potential system types and energy efficient design measures to validate the final systems selections. Total life cycle cost analysis shall be calculated for 5, 10, 15 and 20 years for the Principals Representative's.

10.33. The value engineering analysis, including detailed life cycle costing, shall incorporate as a minimum the following elements:

- Capital expenditure;
- Recurrent maintenance and repair costs;
- Payback periods;
- Replacement at end of economic life; and
- Energy usage costs.

10.34. The value engineering analysis shall be based on the building's operating schedule and take into consideration areas and systems with extended hours of operation (i.e. the economic service life of equipment serving a 24 hour facility will be significantly shorter than for a typical weekday office type application).

Hours of Operation

10.35. Hours of operation of air-conditioning systems are to suit the application and user requirements. For comfort air-conditioning of small spaces, the preference is for operation via BMS time-schedules with over-ride push-button functionality set initially for two hours.

10.36. A number of research laboratories, libraries, computer facilities and other areas may require 24 hour operation. Detailed requirements for the operation of air-conditioned spaces must be clarified with the Principal's Representative at an early design stage.

Design Conditions

Outdoor Design Conditions

10.37. Consider ambient temperature operating limits for equipment selection i.e. at what extreme ambient does the equipment fail to operate rather than derate.

Summer

10.38. Design ambient conditions for selection of air-conditioning equipment, chillers, cold room, constant temperature room and freezer room equipment and the like shall be as follows:

ANU campuses	Summer Design, comfort	Summer Design, Critical 24/7	Average Daily Range, °K	Average Yearly Range, °K	Elevation, meters above MSL	Latitude, South
ACT-Acton, Gowrie Hall, Spring Valley Farm	34.3°C DB/ 19.6°C WB	37.6°C DB/ 21.4°C WB	14.0	33.5	565	35°27'
ACT-Mt Stromlo	36.5°C DB/ 19.5°C WB	37.5°C DB/ 20.0°C WB.	15.0	33.5	742	35°19'

NSW-Kioloa	28.5°C DB/ 17.0°C WB	29.0°C DB/ 17.5°C WB	10.0	26.0	12	35°32.7'
NSW-Coonabarabran, SSO	36.3°C DB/ 22.3°C WB	39.2°C DB/ 24.7°C WB	18.0	34.5	1,164	31°16.5'
NT-NARU	34.5°C DB/ 27.7°C WB	35.0°C DB/ 28.0°C WB	7.0	16.0	30	12°28'

Notes to Table:

- Dry Bulb Temperature (DB), Wet Bulb Temperature (WB), Relative Humidity (RH),Mean Sea Level (MSL).
- Siding Spring Observatory (SSO), North Australian Research Unit (NARU).
- For all research facilities' cold rooms and freezer rooms the condenser 'air-on' condition to be used for sizing and selection of air-cooled condensing units is 43°C DB.

Winter

10.39. Design ambient conditions for selection of heating equipment, heating boilers, constant temperature room equipment and the like shall be as follows:

ANU campuses	Winter Design, comfort	Winter Design, critical 24/7
ACT-Acton, Gowrie Hall, Spring Valley Farm	-2.2°C DB, 80% RH	-4.0°C DB, 80% RH
ACT-Mt Stromlo	-3.0°C DB, 80% RH	-5.0°C DB, 80% RH
NSW-Kioloa	5.0°C DB, 80% RH	3.0°C DB, 80% RH
NSW-Coonabarabran, SSO	-3.5°C DB, 80% RH	-5.0°C DB, 80% RH
NT-NARU	18.0°C DB, 85% RH	17.0°C DB, 85% RH

Indoor Space Design Conditions

10.40. Unless stated otherwise, room design conditions for assessment of cooling and heating loads shall be based on the following:

Comfort applications	Internal design temperature
Offices, Libraries, Study Rooms, and the like	22°C DB +/- 2°C DB; RH uncontrolled
Auditoriums, Conference Rooms, Exercise Rooms and the like	22°C DB +/- 2°C DB; RH uncontrolled.
Machinery Workshops	24°C +/- 2C DB; RH uncontrolled
Critical/process applications (e.g. laboratories)	As determined in consultation with the user and recorded in the user brief
Passive/Naturally ventilated areas	As determined in consultation with the user and recorded in the user brief
Entry air-locks, foyers, break-out spaces, circulation spaces (including waiting areas that are part of such spaces), break-out rooms and the like	21°C DB +/- 3°C DB
Shower rooms, Change/Locker rooms, Cleaners	21°C +/- 3°C DB

Rooms and the like – source of heated make-up air from circulation space.	
Large store rooms for distributing items of equipment that are likely to be occupied for 30min or more	21°C +/- 3°C DB
Toilets	Unconditioned

10.41. Cooling load calculations to determine cooling capacity to be carried out to higher bound of internal design temperature set point. Heating load calculations to determine heating capacity to be carried out to lower bound of internal design temperature set point.

Laboratories and Critical Applications

Laboratory Design

10.42. Design of air-conditioning and ventilation systems to laboratory areas is to take into consideration the impact of localised effluent removal systems at the source of contaminant generation and the resulting reduction of outside air flow rates required, rather than be based on generic air change rates.

10.43. Physical Containment levels and pressure differentials for laboratories shall be determined in consultation with the users based on the individual case and approved by the Principal's representative.

Fume Cupboards

10.44. All fume cupboards shall be of a type that is currently operating at ANU with a proven record of operation. For conventional application, "Dynaflow", "Labsystems", "Labaire" or approved equal shall be used.

10.45. All components requiring maintenance shall be readily accessible.

10.46. Variable Speed Drives (VSD's) to be installed on all fume cupboard exhaust fans.

10.47. Automatic sash closing systems are preferred to save energy subject to user approval.

10.48. Where discharges could impact other building intakes or the general public, a plume CFD study shall be completed to assess impact.

10.49. Manifolding of fume cupboard exhausts shall be considered on a project by project basis and only implemented with written approval from Facilities & Services.

10.50. The supply and exhaust air flow control valves that form part of fume exhaust system shall be carefully controlled such that exhaust and makeup air systems respond to changes in fume hood sash position. Ensure fume hood capture velocities, lab pressure setpoints and pressure differentials are maintained at all times. Consider use of "AccuValve" or fast response actuators.

10.51. Where air flow control valves are required, these shall be a linear type and shall operate with a minimum turndown ratio of 8 to 1. Accuracy of the air flow valve shall be 5% of reading in the 8 to 1 range of the damper. The airflow control valve speed of response shall be <1 second. The air flow control valve shall be capable of being mounted in any position in duct work without the need for recalibration. The pressure drop through the air control valve must be kept to a minimum, in accordance with manufacturer's recommendations.

Critical Areas

10.52. Resilience and redundancy requirements are to be derived via user requirements brief and/or workshop and are to be agreed on and approved by the Principal's Representative.

10.53. Critical areas, including laboratories where applicable, shall be supplied with essential services including power, chilled water, condenser water, humidification, heating, ventilation and controls. The systems shall be designed so the appropriate load shedding occurs.

10.54. Single point of failure analysis is to be completed for critical areas with agreement of solutions with the Principal's Representative.

Cleanrooms

10.55. The Principal's Representative shall liaise with users in determining the production requirements of the cleanroom to ensure the design process is followed to be able to achieve sign off and shall include design, installation and commissioning qualification processes.

10.56. Cleanroom redundancy details shall be referred to the Principal's Representative for review.

Equipment Requirements

Chillers

10.57. Cooling load profile should be calculated the design phase to determine the most suitable type of system for the installation. When considering different system, at a minimum, the following factors must be considered:

- Air-cooled vs water cooled systems; Preference is to be given towards centralising loads sufficient to justify water cooled systems where possible, as detailed in the previous sections.
- Multiple chillers vs single chiller; Preference is to be given towards multiple chillers of unequal capacities, as maximizing turndown ratios of the system are important, as is additional redundancy. Consider low load operation (e.g. oil return, hot gas bypass)..
- Variable speed primary only pumping vs primary/secondary pumping; Either approach is acceptable, however in the case of multiple primary/secondary/tertiary circuits, there should be no hydraulic separation unless absolutely necessary. This should avoid unnecessary pressure loss and temperature losses associated with using heat exchangers to separate circuits. The preferable means of coupling a primary and secondary circuit is through a common chilled water buffer tank

- Chiller installation configuration and staging. Equal sized, low load chillers, Series pipework, Parallel pipework, Series-Counterflow pipework etc. Any configuration should be considered that can lead to a lower total life cycle cost, including new or novel approaches.

10.58. Given the low proportion of time that the chiller will run at full load in Canberra, the analysis must be weighted toward low load efficiency and minimum turndown capability. The analysis and recommendations shall be provided to the Principals Representative for review.

10.59. Chillers serving process cooling and other constant load applications year round must be fitted with a free cooling mode of operation that can run simultaneously with mechanical cooling.

10.60. All chillers should be optioned with CHW temperature reset functionality, and demand limit capacity control.

10.61. Chiller operating parameters shall be readily accessible for monitoring, directly via the chiller native BACnet HLI controls.

10.62. All chillers must feature variable speed compressors.

10.63. Any chiller operating in a standalone configuration must feature twin independent refrigerant circuits and compressors.

10.64. For the purpose of commonality, the ANU prefers Carrier, Trane, York or Daikin (or approved equal) central chilling equipment. These brands are preferred in terms of the ready availability of technical support and moderate cost of spare parts; although other brands will be given due consideration. Based on the life cycle cost analysis method earlier. Written applications with supporting documentation shall be submitted to the Principals Representative for approval to use alternative brands of plant.

10.65. Chillers and efficiencies to be AHRI and/or Eurovent certified.

10.66. Protect chillers from hail by using internal v-configuration such that heat exchanger is protected.

10.67. The below table outlines the minimum efficiencies that any chiller must achieve in order to be considered for installation at the ANU:

Chiller Type	Air cooled under 500kW	Air cooled over 500kW	Water cooled under 500kW	water cooled over 500kW
Operating Conditions	CHW F/R 6/12 ° @ ambient of 37.1/21.6 DB/WB	CHW F/R 6/12 °C @ ambient of 37.1/21.6 DB/WB	CHW F/R 6/12 °C @ CDW F/R 25/31°C	CHW F/R 6/12 °C @ CDW F/R 25/31°C
Minimum Chiller Efficiency at 100% Design Load	3.1	3.3	6.0	6.5

Minimum Chiller Efficiency at 75% Load (AHRI)	4.2	4.3	8.0	9.0
Minimum Chiller Efficiency at 50% Load (AHRI)	5.4	5.6	9.8	10.1
Minimum Chiller Efficiency at 25% Load (AHRI)	6.3	6.5	11.0	11.0
Minimum Integrated Part Load Value (AHRI)	6.0	6.2	8.0	8.6
Minimum Turndown Achievable	25	20	25	20

Electric Heat pump (Heating Hot Water Generators)

10.68. Heat pump and heat recovery heating hot water systems shall be analysed during the design phase to determine the most suitable type of system for the installation. A cost benefit analysis is required comparing, at a minimum, the following factors:

- Heat pump vs heat recovery: Preference to be given towards centralising the load and use of heat recovery chiller when there is simultaneous heating and cooling exist.
- Multiple vs single unit; Preference is to be given towards multiple heat pumps of unequal loads as maximizing turndown ratios of the system are important, as is additional redundancy.

10.69. Heat pump operating parameters shall be readily accessible for monitoring, directly via native BACnet HLI controls.

10.70. For the purpose of commonality, the ANU prefers Carrier, Trane, York or Daikin (or equal equivalent) equipment. These brands are preferred in terms of the ready availability of technical support and moderate cost of spare parts; although other brands will be given due consideration. Based on the life cycle cost analysis mentioned earlier.

10.71. For hail protection of heat exchanger fins provide hail guards

Pumps

10.72. Pumps shall be selected to achieve the lowest practical power absorbed at the specific operating conditions. Pumps shall be selected to operate at calculated duty point with operating speed of 45 Hz.

10.73. Pumps shall be of vertical in-line centrifugal type for smaller systems or back pull out (end-suction) long-coupled centrifugal type for larger pumping systems. Pump sets shall be complete with mechanical seal. All pump sets shall be mounted on concrete plinths and have sufficient space for service, maintenance and installation of connected pipework and fittings. All pump sets should be installed with flexible connections, strainers and test points on the inlet and outlet pipework

10.74. Strainers shall be fitted with stainless screens and all 65mm diameter and larger strainers shall also be fitted with a 25mm ball valve.

10.75. Non-return valve shall be provided at each pump discharge.

10.76. Pumps and motors shall be assembled on a common bedplate on a inertia block, the whole mounted on concrete plinth and arranged for ease of maintenance.

10.77. All pump sets should be provided with variable speed drive (VSD) motors.

10.78. Empirically derived pump curves shall be supplied with each pump in technical submittals and provided in Operating & Maintenance Manuals.

Fans

10.79. Fans shall be selected to achieve the lowest practical power absorbed at the specific operating Conditions. Fans shall be selected with 20% spare capacity in airflow.

10.80. EC fans should be the standard fan used when selecting AHU's or FCU's. Centrifugal and axial fans will only be accepted where EC fans are not available or viable.

10.81. Total isolation through a flexible connection must be provided for fan connection to duct work. All flexible connection shall be minimum of 50mm long and specified in accordance with the fan manufacturers recommendations.

10.82. Empirically derived fan curves shall be supplied with each fan in technical submittals and provided in Operating & Maintenance Manuals.

Ductwork and Pipework Reticulation

10.83. Duct and pipework runs within the building are to be preferably run in risers or ceiling spaces for minimum aesthetic impact and must be adequately supported.

10.84. Main risers (air and water) must be sized to handle an increase of 20% in air/water quantity, and fans and motors must be selected with this in mind.

10.85. Hail protection of external ductwork for corrosive gases: Preference of stainless steel duct over plastics.

10.86. Ductwork penetrations to walls and floors must be flanged on both sides of the penetration. No ductwork is to be connected into wall openings. When penetrating a Fire Wall, the penetration must comply with Australian Standards.

10.87. All pipe headers shall be provided with at least one spare flanged and valved connection for future use.

10.88. Automated deaerators shall be provided for all closed circuit chilled, heating and condenser water systems in the building. All pipe risers shall be provided with dirt legs and drains at the bottom of the riser.

10.89. All drains points are to be fitted with a valve suitable for hose connection. Sufficient drains, isolation / by pass valves shall be provided to allow the whole or any part of a pipe system to be drained or chemically cleaned.

10.90. All condensate drain pipework shall be UPVC or Type C copper. Where subject to mechanical damage such as in plant room, all drains shall be in Type C copper and insulated the full length. All condensate drain pipe work inside buildings must be insulated to prevent condensation.

10.91. Gravity drain is the approved way for condensate drain. Use of condensate pumps is not permitted.

10.92. Automatic air bleeds shall be provided at all localised high points of the system and all other points where air may collect.

10.93. Isolation valves shall be used at connections to all items of plant and equipment. Connection shall allow the removal of the plant without removing section of pipework or draining the system.

10.94. Isolating valves shall be ball valves in sizes 15 to 50 mm and either “Lugged” type butterfly or wedged type gate valves for sizes 65mm and above

10.95. Binder cocks shall be provided on all chilled, heating condenser water headers, flow and return lines at all air handling units, fan coil units and all equipment requiring temperature and flow measurement.

10.96. Binder cocks must be extended a minimum of 15 mm beyond the outside surface of the insulation. All fittings to be fitted with removable caps to avoid leaking event with the valves closed.

10.97. Binder cocks must be located next to all BMS hardware points.

10.98. At least one balancing valve shall be provided at each item of equipment. If necessary, additional valves shall be provided to facilitate balancing between groups of items clustered together as module. Main branches shall include balancing valves.

10.99. Preference should be given to pressure independent control valves (PICV) over a STAD and control valve arrangement. Ensure that sufficient isolation capabilities are installed to isolate the equipment and the PICV. Where balancing valves are used, these shall be located on the return lines from each item of equipment, and a straight distance of at least 5 pipe diameters upstream, and 2 pipe diameters downstream of the valve.

10.100. All chilled water valves located in ceiling spaces shall be insulated.

10.101. Any condenser water or other water or air lines or valves that operate in the environment below dew point shall be insulated.

10.102. Chilled water systems serving research or critical facility must incorporate suitably sized quick coupling to the main flow and return with isolation valves to facilitate temporary chiller connection in the event of plant failure.

10.103. Extend of sheathing: All hydronic pipework external and within plant rooms and/or trafficable spaces must be sheathed. Foil faced sheathing only acceptable inside risers or in ceiling spaces.

Thermal Energy Meters

10.104. All chilled and heating water generation plants outgoing pipe work shall incorporate thermal energy meters.

10.105. All building incoming pipe work from centralised chilled and heating water generation plant shall incorporate thermal energy meters.

10.106. Flow meters shall be non-invasive such as magnetic or ultrasonic type.

10.107. The thermal energy meters shall be Class 2 as per European standard EN1434 and either “Kemstrup” or “Siemens”.

10.108. BMS integration protocol needs to be BACnet MSTP, BACnet IP or Modbus serial or IP. The university must have the ability to change all communication setting eg. IP, baud rate and address.

10.109. Ensure to coordinate thermal meter naming convention with the ANU BMS Team who will assign the name.

10.110. Inlet temperature (°C), outlet temperature (°C), Flow rate (l/s), thermal energy (MWh) should be monitored and displayed on the BMS.

10.111. The thermal meter error codes like communication error, wrong flow direction, low battery level, Air in the system should be monitored by the BMS and alarm raised.

10.112. Commissioning sheet shall be supplied along with LAN schematic, flow meter, and flow temperature sensor and calculator calibration certificates, in technical submittals provided in Operating & Maintenance Manuals. NOTE: ANU will arrange for third party verification.

10.113. All calculators shall be located at an easily accessible location and at the height not greater than 1700 mm above FFL.

Air Handling / Fan Coil Unit

10.114. Large built up central air handling units (AHUs) are to be avoided. Packaged type AHUs are preferred. Air handling units shall incorporate heating coils. The use of terminal re-heat shall be avoided for the purpose of energy conservation unless dictated by the application.

10.115. Packaged AHUs should be readily disassembled to enable ready removal of fans, coils, trays and filter frames.

10.116. The outside air / return plenums shall be provided as part of all main air handling unit. Consider feedback capable actuator for O/A for large and critical environment AHUs.

10.117. If plant room is used for outside air intake, then plant room air intake louvers should incorporate accessible roughing filters.

10.118. Complete each AHU/FCU with dedicated air plenum, heating and cooling coils (as required), motorised outside air damper, outside air pre-filters and filters and supply air temperature sensor.

10.119. Provide lighting within air handling unit if unit can be accessed by personnel.

10.120. Provide filter differential pressure sensor with high limit alarm to BMS for all AHUs (smaller FCUs are exempt).

10.121. Install fan status indication on all FCUs/AHUs via current switches or pressure switch/ transducer as applicable.

Cooling Towers

10.122. Where cooling towers are used, strict adherence to *AS/NZS 3666:2011 Air-handling and water systems of buildings* shall be followed.

10.123. Careful consideration must be given to the sighting of cooling towers with respect to adjacent exhaust system discharge points and adjacent ventilation openings and acoustic constraints.

10.124. A minimum 100 mm diameter drainpipe connection shall be installed for quick draining. Ladders, handrails and maintenance access platforms for cleaning and servicing of components on the top of the tower must be provided. Ladder, handrails, platforms and kick plates shall comply with the requirements of statutory authorities.

10.125. Platforms shall be provided around the entire top of each tower. Submit details of stair and platform arrangement to the Principals Representative for review. Access ladders and restricted platforms will not be accepted.

10.126. Side stream filtration shall be incorporated into the condenser water systems sized to suit the application. Provide basin sweeping piping with inductor nozzles to effectively prevent sediment from collecting in the cold water basin, with pipe for connection to the side-stream filtration system.

10.127. Where cooling towers are appropriate for heat rejection of specialist laboratory cooling water systems, closed circuit cooling towers are to be considered.

10.128. Water treatment shall be provided by the incumbent water treatment specialist of ANU (Hydro Industries Pty Ltd).

10.129. Provide water treatment controls including monitoring of water quality and filtration side stream pump operation on time clock.

Condenser Water

10.130. Condenser water systems should be designed based on Canberra's specific ambient conditions, measured empirically. It is expected that condenser water design temperatures (inlet/outlet) of 26/32.5°C should be achievable for design day ambient of 20°C wet bulb.

Storage Tanks

10.131. Both chilled and heating water system shall incorporate a storage tank with minimum storage capacity of 8 litres per kW of diversified peak chilled/heating system capacity.

10.132. All storage tanks shall feature the following fittings and features as a minimum:

- A bolted and flanged gasketed manhole of at least 450 mm clear internal diameter;
- Flanged pipe nozzles; suitably sized for the maximum flow rate;
- A half coupling at the bottom of the lower dished end for draining purposes;
- A half coupling for air venting and a safety valve near the highest point of the top dished end;
- A half coupling for vacuum break purposes at the highest point of the top dished end;
- A half coupling connection near the highest point for a temperature gauge; and
- Two or more lifting lugs of Carbon Steel to *AS 1548:2008 Fine grained, weldable steel plates for pressure equipment*; with 60 mm diameter holes.

10.133. Ensure that the storage tanks are provided with water distribution headers and/or baffles in capacities larger than 2000 L water volume storage capacity. At least two strategically located manholes shall be provided for tanks of 10,000 L or more in capacity. Tanks shall be etch-primed and painted; suitable for application of thermal insulation on site.

10.134. Storage tanks shall be connected to the load (heating or cooling demand and heat generation source (chiller or heat pumps) according to their function in the system. Refer to Figure 1.

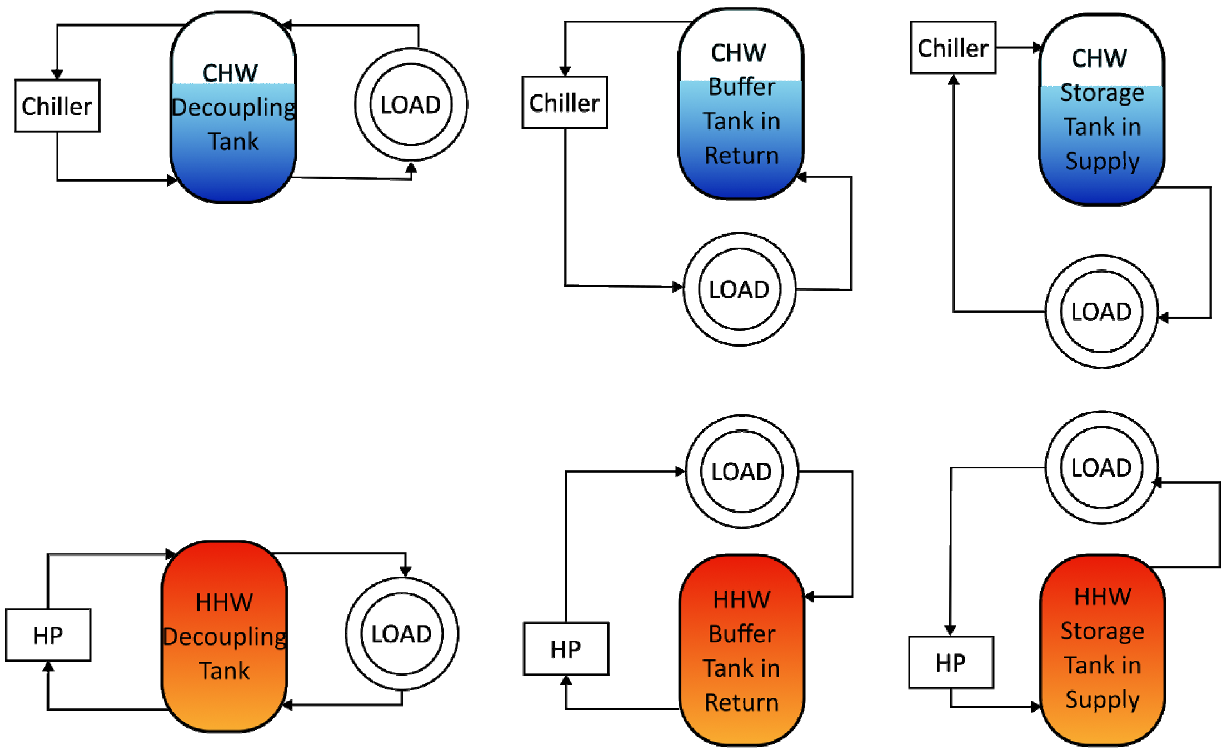

Figure 1: Storage tank hydraulic connection details, HP=heat pump, CHW=chilled water, HHW=heating hot water

10.135. For primary/ secondary systems the preference is to locate the storage tank as decoupler between primary and secondary circuits. Care should be given to degradation of supply water temperatures where flow rates are different.

Expansion Vessels for Water Reticulation Systems

10.136. Provide closed expansion vessel, sealed and to be used to provide make-up water to all chilled, heating and process water recirculation systems. These shall be located so as to provide make-up on the low pressure side of a recirculating water system. For heating water systems these should provide make-up water to the return line, upstream of the boiler inlet port. Such vessels shall be sized to take up the contraction/expansion volume of the system.

Water Treatment Systems

10.137. Chemical dosing systems shall be provided for all heating and cooling recirculating water or glycol systems. These shall consist of vertical cylindrical dozing pots fabricated of AISI 304 stainless steel. Vessels shall be complete with the following:

- Charging funnel for introducing chemicals;
- Air venting port with pipe having a reverse 'U' bend;
- Inlet and outlet pipe connections in the same vertical plane;
- Drain port at lowest level;
- Minimum of three legs, each with feet for fixing to the floor slab of the plant room; and
- Isolating valves for the tail pipe of the funnel, each inlet and outlet pipe connection and drain connection.

10.138. Condenser water system will utilise bromine as the primary biocide where feasible, being delivered through a dedicated dosing station, and interfaced with the BMS via a HLI. Oxidant feed from the dosing system will be based on monitored ORP (oxidation reduction potential) levels. PH levels will also be monitored and controlled in order to ensure ionization rates of the biocide are optimised.

10.139. The standalone dosing controlled controller will also control the bleed down rate out of each cooling tower basin based on a conductivity sensor reading total dissolved solids (TDS) in the condenser water. The cycle of concentrations set point will be established on site based on the specialist advice of the water treatment contractor.

10.140. Consideration should be given to engaging the company currently contracted to the ANU (Hydro Industries Pty Ltd) for the treatment of existing cooling towers (against legionella), condenser water, heating water, PCW and chilled water systems, as well as to conduct the required servicing during the defects liability period.

10.141. Water treatment chemical composition should be compatible with all materials installed within the CHW/HHW system, with particular emphasis on the materials used within the heat pump heat exchangers.

DX Air Conditioning Systems

10.142. VRF systems are not preferred due to the large refrigerant volumes and limited availability of low GWP refrigerants.

10.143. DX systems should not be installed if central CHW/HHW plant can be utilised. If a DX system is to be installed in lieu of a central CHW/HHW system, then written approval must be received from the Principals Representative, for example for 24/7 operated spaces.

10.144. The DX plant and equipment shall be provided on a separate electrical control panel. All control and indication points shall be available via a native Bacnet HLI.

Electric Steam Boilers and Steam & Condensate Reticulation Systems

10.145. Use electric steam boilers

10.146. Where possible sterilisation and humidification equipment shall be capable to internally generate steam.

10.147. On the Acton campus the need for steam boilers is generally associated with research activities which are generally critical as far as building operation is considered. Boiler selection shall be based on assessment of the peak load that the facility is likely to cater to, with adequate allowance for future additions. Steam demand charts shall be included in the design documentation. This should show the steam demand plotted during a day's duty cycle of the boiler. A list of steam consuming equipment stating dry steam usage (Kg/hr) at start-up and during normal operation as well as pressure required at the inlet to the equipment (kPa) should also be included.

10.148. Selection of boilers shall be based on the maximum steam demand. The extra allowance on capacity shall be as follows:

- Boilers that operate during normal working hours: 20%
- Boilers that operate on a 24/7 year round basis: 10%

10.149. In sizing the boiler, it may be noted that normal steam consumption of equipment operating simultaneously shall be used rather than summation of the maximum steam consumption figures; unless otherwise dictated by equipment operation.

Weather Protection

10.150. All plant and equipment should be installed internally to the building where practically possible. Roof top mechanical plant should be installed in roofed enclosures with louvered walls.

10.151. In the event that plant, pipework or ductwork must be installed externally, the installation must the weatherproof. This requires cross-fall to all ductwork, covering and sealing all ductwork flanges, proving roof sections to all AHUs and pumps, and enclosing VSDs fully (including ventilation).

10.152. Provide sheathing/ trunking to external pipework (e.g. refrigerant and hydronics) and cabling.

10.153. Outdoor equipment shall be protected from hail damage.

Colour Schedule for Plant and Equipment

10.154. All pipework and/or sheathing in plant rooms and exposed to view must be painted complying with AS 2700. The colorbond equivalent can also be provided. The nominated colours shall be:

- Chilled water pipework – Jade
- Heating water pipework – Emerald
- Condenser water pipework – Apple Green
- Drains – Black
- Compressed Air – Aqua

10.155. Where colours are not specified for particular items of plant, the Principal's Representative shall be consulted before colours are nominated.

10.156. All pipework, valves and fittings must be colour banded. Pipework identification must be achieved throughout using Safetyman pipe markers and labels to indicate content and flow.

Labelling and Bar Coding of Equipment

10.157. All equipment service access panel and ceiling tiles shall be labelled identifying the name of the plant.

10.158. Standardise naming convention and apply consistently on drawings, schedules, specification and equipment labels. Include the equipment designation (FCU, etc.), floor number, zone (if applicable), equipment number. The following equipment designations shall be used:

- FCU: Fan Coil Unit (chilled water or heating hot water)
- AC: Air conditioner (indoor units as part of direct expansion systems, for example VRF indoor unit)
- AHU: Air Handling Unit
- ASHP: Air-sourced Heat Pump
- WCHP: Water-cooled Heat Pump
- CH: Chiller
- CU: Condenser Unit
- CT: Cooling Tower
- OAF: Outside air fan
- TEF: Toilet exhaust fan
- KEF: Kitchen exhaust fan
- KEH: Kitchen exhaust hood
- GEF: General exhaust fan
- FC: Fume cupboard
- SAF: Supply air fan
- RAF: Return air fan
- FEF: Fume exhaust fan
- HX: Heat exchanger
- P: Pump
    - Liquid type: CW: condenser water, HCW: heating condenser water, HHW: heating hot water, CHW: chilled water
    - Circuit type: P: Primary, S: Secondary, T: Tertiary

  MSSB: Mechanical Services Switchboard
- VAV: Variable air volume box
- FD: Fire Damper
- SD: Smoke Damper
- CRAC: Computer Room Air Conditioner
- IRC: In Row Cooler
- COMP: Air Compressors
- NED: Nederman arms
- RAD: Radiator
- EVAP: Evaporative cooling units

Example 1: FCU-GF-A-01: fan coil unit on ground floor in zone A number 1

Example 2: CU-R-01: Condenser unit on roof number 1

Example 3: OAF-2-01: outside air fan on level 2 number 1.

Example4 : PHCWP: Primary Heating Condenser Water Pump

10.159. All electrical equipment, motors and the like shall be fitted with rating plates to ensure easy identification.

10.160. . All equipment, plant, switch rooms and controls shall be identified using engraved Traffolyte labels (black engraved letters/numerals on a white background) fixed in a suitable and approved manner using adhesive, rivets or screws.

10.161. All Identification markings should comply with AS 1345. Ensure that label identifies function, number and, where appropriate, circuit number and contents of pipes/conduits/ducts. All temperature, relative humidity and pressure sensors/controllers, CO2 sensors, gauges, remote sensing points, control valves, pressure gauge tappings, electrical isolators and the like, must be labelled to indicate their function.

10.162. A valve schedule shall be provided in each plant room indicating valve number and function. Labelling of control valves, balancing valves, etc. shall be by means of stamped brass tags identifying valve function, size and number tied to each valve by wire or chain.

10.163. In addition to labels used for identification purposes, ANU applies asset tags to equipment. The following provides the location for asset tags for specific types of equipment to be asset captured and the location where the asset / barcode label shall be placed:

Asset	Bar Code Location
Chiller	Chiller control panel
Air Handling Unit	Next to manufacturer nameplate or unit number
Fan coil Unit	Next to manufacturer nameplate or unit number
Fan + Motor Assembly	Fan housing next to unit number or nameplate
Fume cupboard	Next to manufacturer nameplate or unit number
Fan = Motor Assembly	Fan housing next to unit number or nameplate
Damper + Motor Assembly	Damper body next to linkage arm
Curtain Type Fire Damper	Damper body flange
Package A/C	Next to manufacturer nameplate or unit number
Split System A/C	Next to manufacturer nameplate or unit number
Computer A/C	On indoor unit control panel
Air Compressor System	Next to manufacturer nameplate or unit number
Calorifier or Holding Vessel	Next to manufacturer nameplate or unit number
VAV Boxes including Controller	Next to manufacturer nameplate or unit number

BAS Control Boards	Top right hand corner of front panel
MSSB	Top right hand corner of front panel
Cooling Tower	Next to manufacturer nameplate or unit number
Pump + Motor Assembly	Next to manufacturer nameplate or unit number