23 00 00 Heating, Ventilating, Air Conditioning (HVAC)

1.0 General

.1 Mechanical equipment schedules shall appear on the drawings including all performance, sizing and selection data.

.2 All new construction and major renovations shall include full air conditioning.

.3 Ground mounted equipment shall not be permitted. Any ground mounted equipment that cannot be avoided shall require Facilities Engineering approval, and if approved, will be placed in a lockable architectural enclosure to hide it from view and protect it from damage.

.4 Major mechanical equipment, with the exception of condensing units and fume hood exhaust, shall not be located outdoors or on the roof. All major equipment shall be located in mechanical rooms.

.5 Heating equipment shall be placed on emergency power to protect buildings from freezing during power outages. This includes all equipment required to keep the heating systems active while on emergency power.

.6 System redundancy shall be built into heating and cooling systems;

- All pumps shall be installed in duty / standby pairs.
- A minimum of two (2) boilers shall be installed to meet peak demand.
- A minimum of two (2) chiller compressors shall be installed to meet peak demand.
- A minimum of four (4) central heat pumps shall be installed in geoexchange systems including one redundant heat pump (N+1).

.7 No mechanical services are to run through electrical rooms unless specifically serving the electrical room.

.8 Equipment located on mezzanines or on the roof that require maintenance is to be accessible by stairs or elevator, fixed ladders are not permitted.

.9 In alignment with Queen's University's Climate Action Plan, transitioning away from fossil fuels is mandatory for all new capital, renovation, and deferred maintenance projects. Queen's Facilities team, external consultants and engineers must evaluate existing systems (age, condition, and outlook) and prioritize low-carbon alternatives, such as air-source or ground-source heat pumps, for any heating or cooling equipment upgrades.

To prevent "stranded assets," the university prohibits independent, like-for-like replacements of chillers or boilers that would delay a full low-carbon transition for 5–10 years. No equipment shall be replaced like-for-like without a comprehensive life-cycle cost and technical analysis. This analysis must account for energy costs, carbon emissions, internal carbon pricing, and the requirement that all fossil-fuel-based systems be phased out by 2040.

For residential buildings used for University purposes or student housing, when renovating those buildings envelope upgrades to improve thermal performance is required. Also, only heat pump technology is acceptable for heating and cooling purposes.

2.0 Mechanical

.1 Main mechanical rooms shall have a wash sink with hot and cold water.

.2 Mechanical rooms shall have floor drains.

.3 Mechanical rooms should not be located adjacent to or over classrooms, theatres, libraries, offices, or study areas.

.4 Mechanical rooms shall be provided with double doors with removable mullions.

.5 Mechanical rooms shall have both mechanical supply and exhaust ventilation systems and shall be maintained at a negative pressure with respect to adjacent rooms and corridors.

.6 Noise from mechanical equipment shall be attenuated within the mechanical rooms as necessary to achieve the recommended noise criteria range for conference rooms, classrooms, theatres, libraries, study areas and bedrooms.

.7 Mechanical rooms shall have sufficient space to allow for replacement and proper servicing of equipment. Clear paths must be maintained to all doors. Provisions must be in place to remove major equipment such as chillers and boilers such as roof hatches or removable roof or wall sections.

.8 Mechanical rooms not located on the lowest level shall have waterproof floors.

.9 Provide 110v outlets for portable service equipment.

.10 Provide adequate lighting for servicing.

.11 Roof mounted equipment, and the path leading to the equipment, must be protected from the roof edge with guardrails when within 3 metres (10 feet) of the edge. Ladders are not permitted to access roof mounted equipment.

3.0 Valving - General

.1 Sufficient valving should be provided to isolate the services on each level, and each major branch.

.2 Drain valves shall be provided at the bottom of all building risers, storage tanks, heaters, and system low spots. Drain valves shall consist of a hose bibs with a cap on a chain or shall be piped to drain. Drain valves shall be located to provide maximum effectiveness. Preferred manufacturers: Jenkins, Crane, or Zurn.

.3 Isolation (shut-off) valves shall be provided for servicing pressure reducing valves, major components of the systems, individual floor mains, risers, and fixtures. Isolation valves 100mm (4") and smaller shall be ball valves. Preferred manufactures: Jenkins, Crane, Victualic, Zurn or Watts.

.4 Hot water, chilled water, and steam control valves shall be sized for 100%, and not 33% and 66%.

.5 Kitz valves are not permitted.

4.0 Ventilation

.1 Outdoor air requirements for ventilation shall comply with ASHRAE Standard 62 "Ventilation for Acceptable Indoor Air Quality", and the Ontario Building Code.

.2 Operable windows shall not be used to meet fresh air requirements.

.3 Return air shall be ducted to the return fan. Ceiling return plenums shall not be used.

.4 Emphasis is drawn to the University's requirement for quiet operation of all mechanical heating and air handling systems. With respect to this requirement careful attention should be given to the selection and design of equipment, in particular: air velocities, fan design and selection, unit ventilators, unit heaters, pumps etc.

.5 In existing installations with steam coils; Ventilation systems shall use steam preheat coils with integral face and bypass dampers. Where possible, steam coils shall be piped vertically.

5.0 Heating and Cooling

.1 For new construction and major renovations, geothermal shall be used as the primary source of building heating and cooling unless shown not to be technically feasible. Geothermal system to be sized to meet peak cooling load.

.2 A single geothermal loop shall contain no more than 5 boreholes, or no more than 10% of the boreholes in the field, whichever is lesser.

.3 When central heating plant steam is used to heat the building it shall be brought into the main mechanical room and immediately converted to domestic hot water and heating water for distribution throughout the building. Steam shall only be used in main mechanical room. All steam equipment in the mechanical room shall be rated for 150 psi and include a CRN number.

.4 Residences, private offices and rooms occupied by only a few individuals shall have thermostats that are adjustable by users and that indicate the set point and room temperatures. Thermostats in lecture theatres, classrooms and public areas shall have thermostats that are not adjustable by users.

.5 Chilled beam cooling and chilled floor cooling shall not be used.

.6 Buildings with poor envelope performance, wall insulation less than R12, or windows that are not a minimum of dual pane thermal windows shall include low level perimeter heat.

.7 Distributed heat pumps shall not be permitted.

.8 Heat pumps shall be floor mounted and are not permitted above a ceiling.

.9 Four pipe systems with central heating and cooling equipment shall be used for heating and cooling. Provisions shall be in place for heat recovery when simultaneous heating and cooling is required. Provisions for free cooling shall be in place when winter cooling is required.

.10 Hydronic heat supply water temperature shall be a maximum of 120 F.

.11 New builds and major renovations to include full size heating and cooling water stubs in basement near an appropriate exterior wall for future connection to a district system. These stubs can also be used for emergency hookup of temporary heating and cooling sources.

6.0 Piping, Valves and Fittings - Heating & Cooling

.1 Valves shall meet the requirements of the Manufacturers Standardization Society: iron gate valves to MSS-SP-70, iron globe and angle valves to MSS-SP-85, iron swing check valves to MSS-SP-71, and bronze gate, globe, angle and check valves to MSS-SP-80.

.2 Piping should be located so as not to require heat tracing.

.3 Flow balancing valves shall be installed at each hot water heater, convector and radiator. Tour & Andersson model STA or Armstrong model CBV flow balancing valves are preferred. If other valves are used a flow balancing meter to be provided.

.4 Dielectric or brass couplings shall be used when pipes of dissimilar metals are joined.

.5 The attachment for flexible hoses shall be made with the hose manufacturer's recommended jointing system.

.6 Where possible, pipe expansion should be accommodated with "U" bends rather than mechanical expansion compensators.

.7 Sufficient valving shall be provided to isolate the services on each level or wing, each piece of equipment and individual coils and convection heaters. Valves shall be either a ball or butterfly valve.

.8 Frequently insufficient drain valves are provided. Drain valves shall be provided at the bottom of all building risers, main ventilation system coils, convertors, pumps, cooling towers, expansion tanks, storage tanks, water chillers and system low spots.

.9 Drain valves shall be provided with a hose bib or piped to drain.

.10 Drain valves shall be located for maximum effectiveness and convenience.

.11 Air vents shall be provided at the top of all building risers, system and equipment high spots, coils convectors, heaters, expansion lines, pumps and storage tanks.

.12 Isolation valves shall be provided for pressure reducing valves, major components of systems, individual floor mains, risers, entrance heaters, force flow heaters and fan coil units.

.13 Strainers shall be installed ahead of PRV's, pumps, and control valves.

.14 In general, hot and chilled water piping shall be threaded or welded. Grooved pipe joining methods shall only be used on: Condenser water; Chilled water within mechanical rooms; Hot water within mechanical rooms.

.15 Grooved pipe joining methods should be used at water chiller evaporator and condenser ends to facilitate disassembly.

.16 Cooling coils shall have fittings to allow compressed air to be blown through coils for winter lay up.

7.0 Water Specialties - Heating and Cooling

.1 Heating and cooling system expansion tanks shall be equipped with water level gauges that are conveniently located and easy to read, and a bladder to separate the air from the water. Tanks shall have bottom connections and have full acceptance bladders.

.2 Cooling coil drain pans shall be all welded and constructed of stainless steel.

.3 Cooling coil bases and supports shall be protected against corrosion.

.4 Pipe system filters shall be installed across pumps in closed loop heating, cooling and condenser systems. Filter housings by Filterite (model LM0) and Filterite filter cartridges (model RL0A10T) are preferred.

.5 Chilled water and condenser water pumps shall be started by chiller control systems and not by the BAS.

.6 Cooling towers shall have stand-alone controls. They shall not be controlled by the BAS.

8.0 Piping Valves & Fittings - Steam & Condensate

.1 Valves shall meet the requirements of the Manufacturers Standardization Society: iron gate valves to M55-SP-70, iron globe and angle valves to M55-SP-85, iron swing check valves to M55-SP-71, and bronze gate, globe, angle and check valves to M55-SP-80.

.2 Steam piping and fittings shall normally be seamless and schedule forty (SCH.40) black steel to ASTM A106 Grade B.

.3 Condensate piping and fittings shall normally be seamless and schedule eighty (SCH.80) black steel to ASTM A106 Grade B.

.4 Strainers shall be installed ahead of PRV's, traps, and control valves.

.5 Drain valves shall be provided at condensate tanks and shall be located for maximum effectiveness and convenience.

.6 Isolation valves shall be provided for pressure reducing valves, major system components and building mains. The main line isolation valve, as it enters the building, shall be double block and bleed. On high pressure lines, a warming line should be installed in parallel with the downstream "double block and bleed" valve to slowly build pressure and prevent water hammer.

9.0 Steam Specialties

.1 All steam fed tube bundles, coils and heat exchangers shall be equipped with vacuum breakers.

.2 Steam condensate from steam modulated equipment shall not be lifted by steam pressure.

.3 Condensate pumps shall not be greater than 1800 RPM.

.4 Pressure reducing valves shall be sized for 100%, and not 33% and 66%.

.5 Safety relief valves and condensate tank vents shall be separately piped outside to a safe location. If they terminate on a roof, terminate 2.2m above roofline with a 45 degree angle out on top of the pipe. Vents for condensate tanks shall not be combined with vents for safety relief valves.

.6 Condensate pumps shall be duplex and equipped with alternating switch.

.7 Pumped condensate shall be metered, not the steam feed. All condensate tanks to include a condensate meter GWF model MTH.

.8 All steam traps shall have a 12 mm (1/2") or 19 mm (3/4") test valve, located downstream of the trap, to allow maintenance personnel to observe trap operation

.9 Condensate tanks shall be cast iron or stainless steel and shall not use plastic multi-level float switches.

.10 Flanged steam pressure reducing valves shall be supported close to each flange to reduce gasket failures.

.11 All steam traps on steam modulated equipment shall be located 300 mm minimum below the condensate outlet of the equipment. All Packaged Air handling Units shall be mounted at heights that allow for a minimum of 300 mm of head at the inlet to steam traps.

.12 Steam control valves serving steam converters to be normally closed and fail closed in a power outage to avoid boiling the water side of the system.

10.0 Pumps - Heating and Cooling

.1 Circulating pumps shall have gauges to indicate both low and high side pressures. Pressure gauges should be provided with pressure snubbers to protect gauges from pulsations in pressure.

.2 Heating and cooling pumps shall be duplex type and equipped with automatic pump change over controls.

.3 Vertical in-line pumps 1 HP (0.75 KW) and larger should have a split type spacer coupling and have seal flushing connections complete with filter, sight flow indicator, and quarter-turn shut-off valves.

.4 When size & pressure permit, in-line pumps with mechanical seals are preferred. Mechanical seals should be of the outside type and should be Durametallic or equal.

.5 Circulating pumps should have flexible connections to limit the transfer of vibrations to the piping system.

.6 All 0.5 HP and larger pumps shall be provided with auxiliary contacts for monitoring of run times by the BAS.

.7 All pumps should run at 1800 RPM or less.

.8 Approved Pump Manufacturers: Armstrong, Grundfos, Bell and Gossett, Xylem.

.9 All circulating pumps shall have air vents.

.10 Flo-Trex suction guides and check/balancing/shut-off combined valves shall be installed on circulating pump inlets and outlets, respectively. As part of commissioning, ensure all three-way valves are balanced to achieve a minimum of a 20 degree difference between the discharge and return flow.

.11 Pressure gauges shall be properly sized and installed such that all pump inlet and outlet pressures can be measured quickly and accurately.

.12 With multiple pumps, provide mounts (either anchors or a monorail system) to service the pumps.

.13 VFDs are not to be integral to pump.

11.0 Testing, Adjusting and Balancing for HVAC

.1 Prior to startup of any pump, or fan, all construction debris shall be removed from the system.

.2 Pipe systems shall be thoroughly flushed prior to the startup of circulating pumps.

.3 The locations of Pitot tube test ports in ducts should be specified by the designer and not left to the contractor.

.4 Pumps shall not be started without a strainer on the suction line.

.5 All ducting shall be inspected to confirm that they are sufficiently clean for operation.

.6 Air distribution systems shall be balanced to design volumes ± 5%.

.7 Liquid handling systems shall be balanced to design volumes ± 15%.

.8 The functionality of all systems shall be verified and confirmed to Queen's University before final acceptance of the work will be considered.

12.0 Pneumatic Control System for HVAC

.1 A refrigerant dryer is required for control air. The dryer should be mounted in a cool place and should not be mounted above the compressor(s). The preferred supplier is Hankison

.2 Control air and laboratory air systems shall be separate.

.3 Control air compressors are required to be duplexed and should be sized to provide a run-time ratio of 0.3:1 to 0.5:1. Two separate electrical feeds from different sources shall be furnished for each compressor.

.4 Control air compressors shall be provided with auxiliary contacts for monitoring of run times by the BAS.

.5 Control air compressors shall be provided with auxiliary contacts for monitoring low air pressures by the BAS.

.6 Control air compressors shall have air-cooled intercoolers and aftercoolers. Coolers shall not use once-thru water.

.7 Control air piping shall be Type "L" hard copper. All common pipe shall be copper. Plastic pipe shall only be used for short runs from the main copper pipe to the equipment. Any tee in a chase should be accessible in case it needs to be repaired.

.8 Compressed air receivers shall be equipped with automatic blow down.

.9 Control air compressors shall be on emergency power.

.10 Control air is to be used in main mechanical rooms only. Control air is not to leave mechanical room that houses the compressor. Electrical controls are to be used outside the mechanical rooms.

.11 Preferred manufacturers: Gardner Denver, Quincy, Ingersoll Rand, Omega.

13.0 Refrigerant Piping

.1 All installations require best refrigeration practices.

.2 All piping system must be pressure tested to 1 ½ times operating pressure.

.3 All piping system must be evaluated to 500 microns.

.4 All piping systems must have TSSA Certification.

.5 All systems must be designed and installed to allow for serviceability.

.6 All brazing must be performed by TSSA certified trades person.

.7 All systems are to be installed by license trades persons.

.8 Licenses and certificates must be provided prior to start of installation. Licensed HVAC technician must be on site while installation is performed.

.9 TSSA inspection is required for all installs including completed refrigerant charge.

.10 To assist in tube cleaning, centrifugal chillers shall have marine water boxes on the condensers.

.11 Refrigerant vapour detection systems shall be provided with auxiliary alarm contacts for monitoring by the BAS.

.12 Vessels shall be provided for the storage of the full refrigerant charge of the largest chiller.

14.0 HVAC Water Treatment

.1 Water treatment shall be provided for all closed water systems. Systems shall include water filters. Queen's University currently engages CHEM-AQUA with contact information given below:

CHEM-AQUA
Brent Patterson
Area Manager
Mobile: 613-808-8037
Email: Brent.Patterson@chemaqua.com

.2 Pipe system filters shall be installed across pumps in closed loop heating, cooling and condenser systems.

.3 Water treatment systems for cooling towers shall use the conductivity method of control.

.4 Piping System Flushing & Cleaning Chemical
   a. To remove oil, mill scale, and oxides from piping and equipment, all new piping to be pre-operationally cleaned using Ferroquest FQ7103.

.5 Closed Heat Transfer System Treatment (Heating and Chilled Water Loops)
   a. Chemical Treatment: Corrshield NT4207, nitrite-based corrosion inhibitor for mild steel and yellow metal corrosion inhibition. For systems containing aluminum, use Corrshield OR4407.
   b. Enameled steel or cast-iron by-pass feeders. Neptune BF-2/BF-5 or equivalent.
   c. By-pass filter with flowrate of 3-5% of the total system flow rate.
   d. Mild steel corrosion coupon rack.

.6 Cooling Tower System Treatment
   a. Chemicals and chemical feed equipment to control scale, corrosion and microbial fouling in open evaporative cooling tower system.
   b. Chemical feed equipment:
      i. RediFeed RF-500 solid product dissolver
      ii. Water treatment controller: Walchem W100/W600 or TrueSense Ready,Set, Go II. Must include flow switch and conductivity probe.

iii. Chemical dosing pumps: Walchem EZB Series or Prominent Beta/B including foot valves, injection quills and required tubing.
iv. Make-up water meter.

c. Treatment Chemicals:
   i. Solid products: Continuum AT901 (scale & corrosion inhibitor) and Biobrom C-100G (biocide).
   ii. If liquid products are required: Gengard GN8142 (scale & corrosion inhibitor), Spectrus OX1205c (oxidizing biocide), and Spectrus NX1100 (non-oxidizing biocide).
d. Mild steel corrosion coupon rack.

15.0 Heat Exchangers for HVAC

.1 For building perimeter heaters, hot water heating shall be used rather than direct steam heating.

.2 All water lines into and out of heat exchangers shall have thermometers located in a convenient position for reading from the floor

.3 Hot water heating systems to be designed for 120 F supply water temperature.

.4 Steam/hot water heating converters do not require a backup or standby. However, 100% backup capability is preferred and a minimum of two converters are required to meet peak demand.

.5 Sufficient clearance shall be provided in mechanical rooms for the removal of tube bundles.

.6 Building entrances shall be heated with electric heaters.

.7 Tube bundle baffles in shell and tube heat exchangers shall be constructed of brass, stainless steel or other corrosion resistant metals. Carbon steel baffles are not acceptable.

.8 For steam fed heat exchangers the steam shall enter the shell clear of the tube bundle. Increase the length of the shell to suit.

16.0 Water Chillers

.1 Approved Chiller Manufacturers;

a. Air or Water Cooled: Carrier, York, Daikin

b. Modular Chillers (Must receive Queen's approval): Multistack, Aermec, Waterfurnace

.2 For loads of 200 ton and larger; Multiple compressors are required to meet peak demand.

17.0 Condensers, Coolers and Cooling Towers

.1 Tower basins are to be stainless steel construction or composite material.

.2 Motors are to be variable frequency driven.

.3 Float / level sensors are to be electronic.

.4 Towers will include sump heaters for shoulders season operation.

.5 Towers to include vibration sensors and seismic isolation springs.

.6 Towers to include factory approved access ladders and platforms where required.

.7 Galvanized material pre cleaning and Passivation is to be performed according to the manufactures specification complete with documentation of the process and verification upon completion.

.8 Approved manufacturers: BAC, Evapco.

.9 Open loop cooling towers are not permitted.

18.0 Air-To-Air Energy Recovery Equipment

.1 All air handling equipment 8000 cfm and larger to include energy recovery.

.2 Enthalpy wheels are not permitted in areas where cross contamination between air streams is a concern.

.3 Glycol run around loops and HRV cores are the preferred method of energy recovery due to their robustness and complete separation of air streams.

.4 If enthalpy wheels are to be used they must be segmented, and serviceable.

.5 RotorSource wheels are not permitted.

19.0 Air Handling Units – 30 ton and Smaller

.1 Where possible, packaged air handling units should be shipped to the job in one piece, factory assembled.

.2 All air handling equipment 8000 cfm and larger to include energy recovery per Section 18.

.3 Design basis equipment to be Daikin with ROC controls and terminal strips for connection to BAS.

.4 Units to be controlled by BAS and hardwired to air handler using factory supplied terminal strips. Air handler to provide protection of compressors.

.5 The use of curb adaptors is to be avoided.

20.0 Air Handling Units – Over 30 ton

20.1 General

.1 Where possible, packaged air handling units should be shipped to the job in one piece, factory assembled.

.2 Packaged air handling units should have an electrical disconnect.

.3 All units should have stainless steel data plates

.4 All units shall be located indoors.

.5 Design basis equipment to be Haakon Industries.

.6 High velocity air distribution systems are not permitted.

.7 All air handling equipment 8000 cfm and larger to include energy recovery per Section 18.

.8 Two level air handlers to include service platforms that run the entire length of the upper level and ladders supplied by the air handler manufacturer.

.9 Air handlers to include an I Beam with roller extension to facilitate motor replacement.

20.2 Unit Construction

.1 Unit casings should be a minimum of 16 gauge (1.6 mm) galvanized metal.

.2 A perforated galvanized metal liner of 24 gauge (0.70mm) minimum should be provided over insulated areas in fan, coil, mixing and access sections. A solid galvanized metal liner of 22 gauge (0.85mm) minimum should be provided over insulated areas in filter sections.

.3 Access doors should be provided at the following locations: mixing sections; damper sections; upstream and downstream of heating and cooling coils; humidifiers; cooling compressors; and fans and motors.

.4 Access doors for air stream sections should be hinged, insulated, lined, with bulb gaskets and with a minimum of two handles openable from both sides. Access doors should be mounted in welded steel frames. Whenever possible, access doors to areas of negative pressure should open out, and to areas of positive pressure should open in. where space constrictions require the use of outward opening doors to an area of positive pressure, a warning label should be affixed. Access doors should incorporate a glass viewing window.

.5 All units should be internally insulated with a minimum of 2" (50mm) thick 3 lb./cu. ft. (48 kg. / cu.m.) density acoustic insulation. Drain pans and floor areas should be insulated on the underside.

.6 Unit casing floors in walk in sections should be fabricated with a minimum of 14 ga (2.0mm) checker plate steel with grip coating.

.7 Cooling coil and steam humidifier drain pans should be all welded and constructed of stainless steel with stainless steel drain connections. Drain pans should be sloped and pitched such that there is no standing water.

.8 Integral service corridors should be insulated with a minimum of 2" (50mm) thick 3 lb. / cu. ft. (48 Kg / cu. m) density acoustic insulation and be fully lined with a solid galvanized metal liner. Floors should be fabricated with a minimum of 14 ga (2.0mm) checker plate steel with grip coating. Corridors should have a minimum of one duplex service receptacle.

.9 Access doors to service corridors should be lockable.

.10 Marine lights with switch and pilot light should be provided in all air handling unit and compressor sections with access doors and in service corridors. Lights should be located either on ceilings or on sides opposite access doors. All wiring should be in EMT conduit. Raintight connections should be used in humidifier sections.

.11 Air handling units should incorporate "low leak" construction details.

.12 Sufficient room should be provided for the installation of pneumatic damper operators.

20.3 Fans

.1 Centrifugal fans should be rated in accordance with AMCS. Where possible, centrifugal fans should be of the airfoil type.

.2 Forward curved fans greater than 18" (450mm) in diameter, should be equipped with greaseable pillow block bearings, supported on rigid steel frames.

.3 Airfoil and backward inclined fans should be equipped with greaseable pillow block bearings, supported on rigid steel frames.

.4 Bearing grease fittings should not be extended to the outside of casings.

.5 Motor mountings should be adjustable to allow for alignment and variations in belt tension.

.6 Belt guards should be provided on fans with walk in sections. The front face of guards should be constructed of expanded metal to allow for visual inspection and cooling.

.7 Fan-motor assemblies should be provided with vibration isolators.

.8 All fan motors should be of energy efficient design.

.9 Fan scrolls should have drain plugs or access doors.

.10 One set of spare drive belts should be provided.

.11 Fans are frequently specified with excessive rotational speeds. Emphasis is drawn to the University's requirement for quiet operation of all air handling systems. Therefore, speed and type of fan must be given careful consideration.

.12 Fume hood and fume exhaust fans shall be roof mounted. All fume exhaust ductwork must be under negative pressure within the building envelope. Basis of design to be direct-drive Strobic with sealed motor bearings. All fume exhaust to include a glycol run around loop for energy recovery. Fume exhaust systems to include a minimum of two (2) fans on a common plenum to provide some level of exhaust air flow in the event of a fan failure. Plenum to include a blank for a future fan and ductwork is to be sized to accommodate a minimum of 50% additional air flow for future expansion. Motorized dampers to be included under each fan to allow service to individual fans while others remain in operation. Critical exhaust systems, such as animal care applications, must include N+1 redundancy.

.13 All exhaust fans shall have backdraft dampers.

.14 All 0.5 HP and larger fans shall be provided with auxiliary contacts for monitoring of run times by the BAS.

.15 Use centrifugal fans or silencers on axial fans where exterior noise is a problem.

.16 In-line fans are difficult to service and should not be used, unless with the permission of Facilities Trades and Engineers.

.17 Fans with either A, B, or C belts are preferred.

20.4 Coils

.1 Coils should have a galvanized steel casing.

.2 Where subject to freezing temperatures, hot water heating coils should be glycol-water coils. Only propylene glycol shall be used. Steam heating coils to be face and bypass (Retrofit coils only, new coils to be hot water or glycol.).

.3 Coils should be removable from the unit. Piping unions or flanges should be provided to facilitate coil removal.

.4 Refrigerant coils with multiple compressors should be alternate tube circuited to distribute the cooling effect over the entire coil face at reduced load conditions.

.5 Heating coils should have double pole discharge air low limit thermostats (freezestats) requiring manual resetting. Freezestats should be installed as per manufacturer's instructions.

.6 All steam traps on steam coils shall be located 300 mm minimum below the condensate outlet of the coil. All Packaged Air Handling Units shall be mounted at heights that allow for a minimum 300 mm of head at the inlet to steam traps.

.7 It is the responsibility of both the controls contractor and equipment suppliers to insure the proper operation of valves, dampers and linkages.

.8 Damper operators shall not be mounted in the air stream. Damper operators shall be easily accessible for adjustment, maintenance and replacement.

20.5 Dampers

.1 Outdoor air dampers should be thermally insulated. Basis of design to be: TAMCO Series 9000 dampers.

20.6 Refrigerant Compressors

.1 Compressor sections and electrical control panels should have hinged and gasketed access doors.

.2 Each compressor should have "rotalock" service valves on the suction and discharge lines for easy removal.

20.7 Filters

.1 Final supply air filters to have a MERV rating of 14 or higher.

.2 Filters shall be placed upstream of supply fan preheat coils.

.3 Filters shall provide a minimum atmosphere dust spot efficiency of 35%.

.4 Manometers similar to the Dwyer Photohetic style shall be provided across filter banks to show the resistance to air flow through the filters. Gauges must have capability to be remotely monitored.

.5 Manometers shall be provided with auxiliary contacts for monitoring of high pressures by the BAS.

.6 Bag filters shall be rigid and shall not be constructed of glass fibre. A plastic filter is preferred for easy handling. A Camil - Durafil 2V is a good product. Units with bag filters shall be designed with a 2" pleaded pre-filter.

.7 Where possible filters shall be front loading.

.8 Replaceable media filters should be enclosed in permanent galvanized metal frames with metal retainers on both sides.

.9 One set of spare filters should be provided.

.10 Filters must be easily accessible and serviceable.

21.0 Air and Water Source Unitary Heat Pumps

.1 Heat pumps shall not be located in the ceiling space. All heat pumps to be located in mechanical rooms or mechanical closets mounted on the floor with adequate service clearances.

.2 Fans to have quick connect pig tail for ease of changeout.

.3 Heat Pumps to have a dedicated drainage system for cooling coil condensate which is not directly connected to sanitary sewer. Drainage system to drain to sewer inside a mechanical room with an air gap to avoid sewer smell in the event of a dry trap.

22.0 Fan Coil Units

.1 Fan coil units may be mounted in the ceiling space at a maximum of 10 feet above the floor level. Fan coil units may not be mounted above sloped floors.

.2 Fans to have quick connect pig tail for ease of changeout.

.3 Fan Coils to have a dedicated drainage system for cooling coil condensate which is not directly connected to sanitary sewer. Drainage system to drain to sewer inside a mechanical room with an air gap to avoid sewer smell in the event of a dry trap.

23.0 Humidifiers

.1 The campus Central Heating Plant steam shall not be used for HVAC humidification.

.2 Humidifiers that use canisters are not permitted.

.3 Preferred suppliers are Dri-Steem and Neptronic.

24.0 Split DX Systems

.1 When winter cooling is required for IT or electrical rooms and an appropriate central system is not available, ductless split DX systems may be used. Preferred suppliers are: Mitsubishi, Daikin.

.2 VRF systems are not permitted.