Introduction

The following are the University of Toronto Mechanical Design Standards. The information contained within these standards must be followed unless:

1. They cannot be applied to the specific design work planned. The design consultant must present the information to the Project Manager to point out the problem and receive permission to implement the alternative solution.

2. If an alternate product or system is available, which is the recommended standard of the consultant for the project, approval may be requested for such an alternate through the Project Manager.

3. If there is a conflict between the standards and codes, such issues should be brought to the attention of the Project Manager for a decision on what to use.

4. If there is a substantial cost savings to be realized by changing from a particular standard and the consultant is recommending such a saving, the Project Manager will consider such a request. The consultant might be requested to substantiate the cost savings.

5. The consultant must point out any problems with the standards, and provide alternates that may be more appropriate. The consultant is also encouraged to comment on the appropriateness of the standards as compared to general industry standards.

6. Should there be a discrepancy between products or models stated in the text of this standard or in Appendix A – “List of Mandatory and Preferred Manufacturers”, Appendix A shall have priority.
# MECHANICAL DIVISION 15 PART 2 SECTION B

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- C) Diagram 15.2: Control Air Filtration Station p.92
- D) Diagram 15.3: Sample Condensate meter installation p.93

Basic Mechanical Design Guidelines

1. All work on pressure vessels, boilers and power piping shall only be done by companies that are registered and certified by the Technical Standards and Safety Authority (TSSA) of Ontario.

2. Due to the capacity and hydraulics limitations of the Mechanical utilities from the Central Heating Plant (17 Russell Street) and the Central Cooling Plants (North-West Chiller, Bahen Centre and Medical Sciences), verify the addition of new loads onto these systems with the Director, Utilities and Building Operations.

3. Metering:
   - Provide monitored (connected to building DDC system) flow, temperature and energy meters on all central cooling water, steam and high temperature water.
   - Provide volume metering on all irrigation system supplies, cooling tower city water makeups and bleeds and swimming pool makeup. Provide shutoff valves and a bypass connection as necessary to allow continuous service when maintenance is performed on the meters.
   - As it is often the case that the construction activities will require the use of University-generated heating or cooling energy prior to the University’s takeover of the new facilities, the above metering must be fully installed, operational and commissioned prior to the University allowing the opening of any shutoff valves for the heating or cooling systems.

4. Lifts or removable ladders shall not be relied upon for access unless approved by University representative.

5. Provide pedestrian waterproof traffic topping system over entire mechanical room floor including over housekeeping pads under air handling units etc (see architectural finishes section).

6. Consultant shall include a statement in the specifications to the effect that all components of the mechanical systems (e.g. fans, ducting, insulation, sound attenuators, air terminal boxes, pumps, VFD drives etc) must be kept clean and dry as manufactured, delivered, stored and installed before operating the mechanical systems.

7. The abandonment of existing equipment and material in place is not acceptable. Abandoned systems can become a serious liability since it cannot be easily determined what is active and what is not. The correction of existing mechanical problems and removal of abandoned mechanical equipment while maintaining the proper operation of the building, all need to be addressed in the contract documents.

8. These standards are intended to be cost effective standards. The consultant, however, should understand that the University strives to achieve sustainability, operability, more permanence and lower long term maintenance costs incurred in the products that are purchased and installed. The standard therefore, might be slightly higher than the normal commercial standard.
Mechanical Design Standards - Checklist

The Design Team is required to read and comply with the full Design standard as it applies to this project. A completed copy of this checklist must be submitted by the Design Team to the University’s Project Manager at the end of the Design Development Phase. In all cases, if a “does not comply” has been noted, please indicate why. Attach additional sheets as necessary.

15xxx MECHANICAL

### 15000 Placement of Equipment

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1. **General:**
   - 1.1. Do not locate equipment in areas which are difficult to access and maintain. [ ] [ ] [ ]
   - 1.2. Do not locate equipment in window wells, etc. that are at risk of flooding. [ ] [ ] [ ]
   - 1.3. Provision must be made for lifting and moving spare supplies, parts, equipment and chemicals into and out of mechanical rooms. Consider providing electric hoist or elevator. [ ] [ ] [ ]
   - 1.4. The location of fresh air intake for buildings is extremely important. They must be located so that no car, truck or diesel generator fumes get drawn into the air system. The designer must consider the location in relationship to parking, shipping and receiving areas, loading docks etc. [ ] [ ] [ ]
   - 1.5. Avoid locating air vents on grade. If this is absolutely necessary, then the grates must be fastened down securely, and protection from outside influence must be provided. [ ] [ ] [ ]
   - 1.6. Provide adequately sized access pathways for the repair, maintenance and eventual replacement of the equipment such as heating/cooling coils and other large pieces of equipment. [ ] [ ] [ ]

2. **Mechanical room floors:**
   - 2.1. Provide sealed curbing of all floor penetrations. Curbing shall be at least 6” high. (Coordination with Architect required) [ ] [ ] [ ]
   - 2.2. Provide adequate floor drains, and slope floors down to the drains. Provide individual floor drains for equipment discharge. [ ] [ ] [ ]
   - 2.3. Provide pedestrian waterproof traffic topping system over entire mechanical room floor including over housekeeping pads under air handling units etc (see architectural finishes section). [ ] [ ] [ ]

3. **Placement of equipment on roof:**
   - 3.1. Air handling units with chilled water and hydronic coils shall utilize an appropriate glycol solution or be drainable and fitted with coil moisture evacuation fittings (see sketch # 15.1 in appendix B at end of these standards). The use of and location of steam coils in air handling units shall be approved by U. of T. representative. [ ] [ ] [ ]
   - 3.2. Cooling towers shall be equipped with platforms constructed in such a way as to allow easy and safe access to serviceable components (e.g., motors, fans, valves etc). (Coordination required between [ ] [ ] [ ]
Mechanical consultant & Architectural consultant for walkways and roof accessories).

3.3. Access to the roof for mechanical room access shall be by normal stairs and doors rather than ladders and hatches. Lifts or removable ladders shall not be relied upon for access unless approved by University representative. (Coordination required with Architect).

3.4. Adequate rooftop walkways must be provided for servicing mechanical equipment. These walkways shall be raised at least 4” above roof grade, shall be minimum 30 Inch width, be equipped with handrails and shall run from roof access to the maintenance areas of the equipment on roof. These walkways shall be constructed of galvanized steel grating or wood boards. (Refer to Architect for roof platforms, walkways & roof accessories).

3.5. The roof is to be protected from damage during equipment installation.

3.6. All guy wires shall be adequately identified with yellow protective sleeves.

3.7. If possible equipment should not be placed closer than 6’ 0” from the edge of the roof. Any mechanical equipment, (such as fans, AC units, etc.) that must be located within 6 ft. or less of roof perimeter, shall be provided with guard-rails unless there is a parapet wall of 36” high minimum at the roof perimeter. (Refer to Architectural roofing design & accessories)

3.8. **Fundamental Instructions for Installation of New Equipment on Flat Roofs**

3.8.1. Any new equipment that is to be installed on a **steel framing** (for example but not limited to; cooling towers, faculty equipment etc) above the roof level shall maintain a 30” clearance between the top of the roof system and the bottom of the equipment). This space is required to ensure access to the roof membrane under the equipment. The supporting I-beams must clear the top of the roof by minimum 12”, and there must also be access to the space under the equipment. (Refer to Architect, roofing consultant and structural engineer).

3.8.2. Any new equipment that is to be installed on top of a **curb/base/sleeper** (for example but not limited to; Exhaust fans, packaged roof top AC units, air cooled condensers, rooftop installed air-handling units) shall be mounted to ensure a clearance of 12” to 18” from the top of the roof level. (Refer to Architect & roofing consultant)

3.8.3. Ducting, piping and conduits (for example but not limited to; Cooling tower condensate water piping, side/end discharge of air-handling unit’s duct work running above the roof, refrigeration piping, electrical/control wiring, gas lines etc) shall be installed a minimum 12” above top of roof level. If the piping or duct work bundled together or the duct is wider than 24”, then the clearance from the top of the roof level must be increased from minimum of 12” to ensure access to roof membrane. (Refer to Architectural & roofing design & accessories)
3.8.4. To ensure the integrity of the new roofing, all roof penetrations must comply with IRC's detailed construction. Pitch pocket type of roof penetration are not to be used. (Refer to Architect & roofing consultant).

3.8.5. Existing equipment on old roofs, which will be replaced with the new roofing system, shall be lifted (relocated) during the re-roofing process to the heights outlined above to ensure proper access to roof membrane for maintenance purposes. (Refer to Architect & roofing consultant).

15060 Pipe Supports and Hangers

1. Provide sufficient supports and hangers for pipe services per code. Heated plastic pipes shall have continuous pipe trays on horizontal runs.

15075 Identification of Piping Systems:

1. All piping except where actually concealed in a pipe space or chase shall be identified according to latest ASME A13.1 (2007 at time of writing) “Scheme for the Identification of Piping Systems”. Directional arrows indicating the direction of flow shall be applied adjacent to each identifying legend location. The code consists of two colours for primary (background) and secondary (wording and abbreviations identifying the fluids or gases being carried within the piping) classification.

15080 Mechanical Insulation

1. Piping insulation thicknesses shall comply with ASHRAE standard 90.1
2. Metal cladding protection shall be used for high traffic areas where exposed. Canvas would be acceptable elsewhere if there is significant cost benefit.
3. Use of PVC cladding is acceptable on cold water and chilled water piping and fittings.
4. Provide removable/replaceable insulation sections at control valves, metering stations, orifices.

15100, 15200, 15300 Pipes & Fittings

(Note: For Fire Protection Piping requirements, see separate Div. 13)

1. Provide galvanized schedule 40 pipe sleeves for all piping penetrations through concrete and masonry. (Coordinate with architectural and structural for location and installation).
Pipe and pipe fittings shall be in accordance with the following schedules:

1. **Domestic Water**

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<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Cold Water: (above ground)</td>
<td>Copper Type L</td>
<td>Wrought Copper</td>
<td>Soldered, Propress, Victaulic</td>
</tr>
<tr>
<td>Domestic Cold Water: (buried)</td>
<td>Copper Type K Ductile Iron (Under 2&quot;)</td>
<td>Wrought Copper, Ductile Iron</td>
<td>Soldered Joint, Mechanical Joint</td>
</tr>
<tr>
<td>Domestic Hot Water: (above ground)</td>
<td>Copper Type L</td>
<td>Wrought Copper</td>
<td>Soldered, Propress, Victaulic</td>
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2. **Storm and Sanitary Sewage**

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<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
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<tbody>
<tr>
<td>Storm: RWL (vertical runs only inside building)</td>
<td>Cast Iron</td>
<td>Cast Iron</td>
<td>Mechanical Joint,</td>
</tr>
<tr>
<td>Storm: (buried outside building)</td>
<td>Cast Iron PVC Sch80 Concrete</td>
<td>Cast Iron PVC</td>
<td>Mechanical Joint PVC Solvent</td>
</tr>
<tr>
<td>Sanitary: (up to and including 3&quot;)</td>
<td>Copper Type DWV PVC in Fire Separations</td>
<td>Wrought Copper</td>
<td>Soldered Joint</td>
</tr>
<tr>
<td>Sanitary: (over 3&quot; inside building)</td>
<td>Cast Iron</td>
<td>Cast Iron</td>
<td>Mechanical Joint</td>
</tr>
<tr>
<td>Sanitary: (buried)</td>
<td>Cast Iron PVC Sch 80</td>
<td>Cast Iron PVC</td>
<td>Mechanical Joint PVC Solvent</td>
</tr>
</tbody>
</table>

3. **Steam /High Temp Hot Water (HTHW) and Condensate**

<table>
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<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
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<tbody>
<tr>
<td>Steam/HTHW (under 2&quot;)</td>
<td>Seamless Sch40</td>
<td>Sch40</td>
<td>Welded up to 1st isolating valve threaded after</td>
</tr>
<tr>
<td>Steam/HTHW (over 2&quot;)</td>
<td>Seamless Sch40</td>
<td>Welded Fitting Sch40</td>
<td>Welded (10% X-rayed)</td>
</tr>
<tr>
<td>Condensate (under 2&quot;)</td>
<td>Seamless Sch80</td>
<td>Sch80</td>
<td>Threaded</td>
</tr>
<tr>
<td>Condensate over (2&quot;)</td>
<td>Seamless Sch80</td>
<td>Welded Fitting Sch80</td>
<td>Welded</td>
</tr>
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</table>
1. All valves connected to the U of T district heating system (steam or HTHW) must be welded and have CRN numbers.

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2. a) Steam drip trap valves to be ¾” WO4-2054T-02TS Velan Bellows sealed valves or equivalent. All piping, valves, fittings and flex hose materials must comply with CSA B51 and ASME B31.1 power piping code and must have CRN numbers. Pressure relief valves must be reinspected and have revalidated CRN #

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b) High pressure steam drip traps shall be of Bestobel manufacture, bimetallic type, Model DM-25.

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3. All piping joints must be hydrostatic / pneumatic tested as per applicable ASME 331.1 Section code or 100% x-rayed if above test is unsafe.

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### 4. Air Conditioning Heating and Cooling Medium

<table>
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<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
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</thead>
<tbody>
<tr>
<td>Heating Water</td>
<td>Sch80</td>
<td>Under 2”: Threaded.</td>
<td>Threaded or</td>
</tr>
<tr>
<td>- inside building or tunnel</td>
<td></td>
<td>2” and over: Threaded or</td>
<td>Victaulic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Victaulic type.</td>
<td></td>
</tr>
<tr>
<td>Heating Water</td>
<td>Sch 80</td>
<td>Ricwil approved</td>
<td>Ricwil approved</td>
</tr>
<tr>
<td>- buried</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water</td>
<td>Sch40</td>
<td>Under 2”; Threaded.</td>
<td>Welded or</td>
</tr>
<tr>
<td>- inside building or tunnel</td>
<td></td>
<td>2” and over; Victaulic</td>
<td>Victaulic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water</td>
<td>Ricwil pre-</td>
<td>Ricwil approved</td>
<td>Ricwil approved</td>
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<tr>
<td>- buried</td>
<td>insulated pipe</td>
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<tr>
<td></td>
<td>or approved</td>
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<td></td>
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<tr>
<td></td>
<td>equivalent</td>
<td></td>
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</tr>
<tr>
<td>Glycol</td>
<td>Sch40</td>
<td>Welded Fitting</td>
<td>Welded</td>
</tr>
</tbody>
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1. Filament-wound fibreglass epoxy type is NOT an acceptable option
2. Ricwil buried piping shall incorporate a leak detection system. Piping shall incorporate Galva-Gard hot dipped galvanized outer casing.

### 5. Air

<table>
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<th>SERVICE</th>
<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed air – shop</td>
<td>Stainless Sch 5 or 10</td>
<td>Stainless Steel</td>
<td>Screwed or Victaulic</td>
</tr>
<tr>
<td>Compressed air - lab control air</td>
<td>Copper Type L stainless steel SS-304</td>
<td>Copper SS-304</td>
<td>Joint Welded ( 2” Pressfit joints or = 2” Welded or grooved end (Victaulic)</td>
</tr>
<tr>
<td>Vacuum Line</td>
<td>Copper Type L Sch40</td>
<td>Copper/ Mall Iron</td>
<td>Soldered Joint/ Screwed</td>
</tr>
</tbody>
</table>
6. Gases, Chemicals and Laboratory Services

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>PIPE MATERIAL</th>
<th>FITTINGS</th>
<th>JOINTS</th>
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</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>PVC</td>
<td>PVC</td>
<td>PVC Solvent</td>
</tr>
<tr>
<td>Deionized water</td>
<td>PVC</td>
<td>PVC</td>
<td>PVC Solvent</td>
</tr>
<tr>
<td>Reverse osmosis water</td>
<td>PVC Sch80</td>
<td>PVC</td>
<td>PVC Solvent</td>
</tr>
<tr>
<td>Natural gas under 2&quot;</td>
<td>Sch40</td>
<td>Mall Iron</td>
<td>Screwed</td>
</tr>
<tr>
<td>Natural gas over 2.5&quot;</td>
<td>Sch40</td>
<td>Welded Fitting</td>
<td>Welded</td>
</tr>
<tr>
<td>Laboratory waste - above ground</td>
<td>Glass or as necessary for the service</td>
<td>Glass or as necessary for the service</td>
<td>Coupling Joint</td>
</tr>
<tr>
<td>Laboratory waste - buried</td>
<td>CPVC Sch80</td>
<td>CPVC</td>
<td>CPVC Solvent</td>
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7. Other Services

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<tr>
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<th>FITTINGS</th>
<th>JOINTS</th>
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<tbody>
<tr>
<td>Lawn Sprinkler</td>
<td>PVC</td>
<td>PVC</td>
<td>PVC Solvent</td>
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15100, 15780, 15935 Heat Transfer

1. Provide reverse return hydronic piping systems. ☐ ☐ ☐
2. Individual (ie, separate loop from those serving A/H Units) hydronic circulating loop shall be provided for radiant panel heat transfer systems in order to maintain efficiency of radiant panels. Do not use radiant panel heating for reheat purposes. Constant 180 degree Fahrenheit supply water shall be used to serve radiant panels. ☐ ☐ ☐
3. Individual hydronic circulating loops shall be designed for different systems to maintain control integrity, i.e., greenhouse heating system should not be coupled to general building heating. ☐ ☐ ☐
4. Glycol heating or cooling:
   Use 50% (by volume) solution of propylene glycol and water for heating systems and 20% (by volume) solution for cooling/air conditioning systems. Use of a preheat coil for fresh air intake using hot glycol shall be discussed with U of T representative. ☐ ☐ ☐
5. Heat recovery systems which incorporate the transfer of energy between exhaust air and fresh air are preferred wherever possible. ☐ ☐ ☐

15110 Valves

General:
- Sectional valves shall be used where possible in piping systems for ease of repairs. ☐ ☐ ☐

(Part 2 Sec B Div 15 - Revised October, 2010)

C = Complies  NC = Does Not Comply  NA = Not Applicable
• Provide ¼ turn ball isolating valves for all fixtures and appliances
• Relief valves must have valid expiry date.
• Provide isolating valves (hot, cold & recirculating water) to all washrooms and labs.
• Self-actuated (Braukman) radiator valves may be used on hot water and steam systems.

1. All buried valves shall close in clockwise direction.
2. Provide curb box for all buried valves for lateral services and valve chamber for valves on water mains; size and construction of curb box and valve chamber shall comply with latest City of Toronto standard.

2. Non-Buried:
   1. Domestic hot and cold water - use ball valves up to 2”, use gate or globe of Canadian made Challenger (Manufacture) butterfly valves for larger pipe sizes.
   2. Distilled, dionized and reverse osmosis water - use PVC ball valves - material to be compatible with the fluid.
   3. Connections and valve ratings shall be compatible with pressure.
   4. Low pressure steam (less than 15 p.s.i.).pipelines shall have no ball valve larger than 1”.
   5. Butterfly valves used in cooling tower systems shall have seats and seals capable of resisting attack from the water treatment chemicals.

3. Emergency Diesel Generator Set:
   1. A fusible fire shutoff valve shall be installed in fuel supply line.

15140 Back Flow Preventers
1. Provide backflow preventers in locations and configuration per applicable codes. Acceptable manufacturer shall be Watts.

15150 Plumbing Traps
1. Plastic Poly pipe is acceptable for under-slab trap seal primer lines. Exposed shall be copper Type K soft tubing.
2. Running traps shall have cleanouts on both legs.

15150 Cleanouts and Cleanout Covers
1. Drain cleanout locations shall comply with plumbing code. These should also be installed through the floor of the room for which they serve, wherever code allows. Covers shall be of square shape.

15160 Drainage
1. For outside drainage (storm water management), brass drain catch basins sometimes prove to be too narrow to handle any sudden flow rates. Ensure drain size is adequate.
15180 Piping Expansion Joints

1. Bellows joints shall not be used unless the consultant can demonstrate that there is no other reasonable choice. Provide appropriate offsets in piping or expansion loops instead to accommodate thermal expansion.

15180 Centrifugal Pumps

1. Provide 100% back up for circulating pumps of heating, cooling and condenser water systems. In-line centrifugal pumps are preferred.

2. All exposed moving parts of pumps shall be properly guarded.

3. Mechanical seals are preferred rather than stuffing box style.

4. Provide gauge ports across pumps. A single gauge shall be piped and valved to allow isolation of pump suction and discharge pressures.

5. Provide a duplex system of fine mesh filters/strainers upstream of the pumps, complete with isolating valves, both before and after the filters/strainers.

6. Provide individual supports for centrifugal pumps and vibration isolators between pumps and pipework as appropriate.

7. Use variable frequency drive or variable speed pump for City booster pumps over 2HP. Include pressure sensor located at top floor for control of pressure.

8. Bleed line complete with solenoid shall be provided to protect the pump from overheating.

15180 Steam Components

1. Steam Traps:
   1.1. High pressure steam (above 50 PSIG) system shall have thermostatic traps selected for continuous system operation at a specific design temperature. Bimetallic traps (Bestobell DM-25) shall be used for high pressure drip traps.
   1.2. Low pressure steam systems up to 15 psig shall have float and thermostatic traps of Spirax-Sarco. Rad traps shall be either of Spirax-Sarco or Dunham-Bush manufacture.

2. Pressure Reducing Valves:
   2.1 Shall be Masoneilan series 500 or Fisher model 655 or 92B or C pilot operated and self-actuating.
   2.2 Shall be dual-station type if pressure difference exceeds 100 psig.

3. Provide strainers on the inlet side of steam traps and control valves to prevent dirt and pipe scale from entering the devices.

4. New buildings supplied with steam shall have Spirax Sarco Gilflo variable orifice steam metering connected via electronic data conversion to the University CCMS system, or shall have local totalizing read out if CCMS is not available. (See Section 15900 Controls/CCMS/Energy & Flow Metering for particulars).
5. All condensate must be collected and shall not be ‘dumped’. Metering of condensate must be provided.

6. High pressure steam valves shall be industrial grade, suitable for working pressure and temperature requirements. Bellows non-leak or zero-leak type operators are preferred.

15210 Laboratory Natural Gas

1. Provide emergency shut-off valve in a cabinet with glazed door and proper signage at the entry to each laboratory. Provide downstream of this shut-off valve a check valve with soft disk.

15220 Reverse Osmosis (R.O.) Water Service

1. Provide booster pump(s) on feed supply to R.O. unit(s) to maintain residual pressure at 35 psig.

2. Provide duplex treatment system if continuous flow is essential.

3. All systems should be supplied with city water makeup meter as well as RO output meter.

15410 Plumbing Fixtures and Trim

1. Plumbing fixtures shall be white colour except where otherwise specified.

2. Lavatory faucets shall be fitted with replaceable cartridges, not washers.

3. Lavatory basin wastes shall have grids and extra heavy quality traps.

4. Water closets shall be siphon jet type.

5. Do not use chain and plug for basins. Provide grids at drain outlet instead of pop-up drain.

6. ‘Cheater vents’ are not to be used on any system.

7. All urinals shall have cleanouts located above flood level of fixture as per plumbing code.

8. All banks of toilets (three or more, shall have four inch cleanout located in the same room as the fixtures as per plumbing code.

9. All outside hose bibs shall be frost free.

10. Floor drains shall be located in all washrooms and in any lab with a deluge shower.

11. Use of hands-free faucets, urinals and toilets is preferred and shall be discussed with UofT representative. All fixtures shall be low flow water saving type. See appendix “A” at end of these standards for schedule of acceptable manufacture/models of fixtures etc.

15410 Vanity Basins

1. The provision of lavatory basins mounted in vanity units is preferred for ALL washrooms.
2. For plumbing fixtures for physically challenged people, refer to Accessibility Standards.

15410 Mop Sinks (Also refer to “Cleaning & caretaking Standards”)

1. Minimum one (1) mop sink per floor is required.
2. Mop sinks shall be floor mounted (with a 6” lip above floor level).

15412 Emergency Eyewash & Safety Shower Units

1. Units shall comply with U of T Environmental Health & Safety specifications which can be found at the following link under item “Emergency Eyewash and Shower Standard”: Policies and Procedures Listing.

15426 Drinking Fountains

1. Drinking fountains shall be ‘EZH2O’ combination fountain/bottle filling station manufactured by ELKAY commercial products. They shall be OADA compliant for wheel chair access, have tamperproof fasteners and all-stainless steel surfaces. The water supply shall incorporate a separate one-quarter turn shutoff to enable filter replacement.

15440 Sump Pumps

1. Sump pumps shall be Gorman Rupp or Gould Pumps manufacture or equivalent and shall be self priming surface mounted direct drive type or equivalent, with the exception that fractional horsepower units may be of the submersible type.
2. ‘Column’ pumps are not acceptable.
3. Shall be fully serviceable.
4. Shall be connected to emergency power

15470 Pipeline Filters Installation

1. If pipeline filters are present for equipment serving laboratories, provide shut off valves upstream and downstream of the filters.

15480 City Water for Air Conditioning

1. Air conditioning equipment that uses once-through city water for cooling shall not be used.

15545 Water Treatment Standard

PART I – GENERAL

1.1 GENERAL REQUIREMENTS

1.1.1. Conform to the conditions stated in the contract from the detailing of the automation systems and associated software, to the outline of specific products required for pre-cleaning and inhibition programs.
1.2 WORK INCLUDED
1.2.1. Furnish all consulting, shop drawings, materials, instruments and program instruction necessary for all required aspects of the water treatment program, including testing of said program.

1.2.2. Clean and re-inhibit ALL new and existing recirculating closed systems such as Chilled Water, Glycol and Heating Water Systems, as well as any open systems such as the Condenser Water Loop. Supply ALL necessary chemicals to perform the above. NO cleaning activity shall adversely affect the existing systems by contaminating them with foreign deposits from new piping cleaning process. Cleanings must be performed independent of each other.

1.3 QUALITY ASSURANCE
1.3.1. Provide proof of ISO-9001 accreditation

1.3.2. Provide the services of an independent Water Treatment Consultant specialist who has a minimum of 10 years experience in this related field, to supervise system pre-cleanings and inhibition programs and certify that the work has been successfully completed, via reports from their laboratory analysis. All chemicals used for cleaning treatment must be compliant with outlined products in each application of this specification.

1.3.3. The flushing, cleaning and chemical treatment programs shall be administered by the Water Treatment Consultant who shall supply installation drawings, on-site supervision, detailed description procedures, and written instruction of the chemical treatment dosages control charts and test procedures. The Water Treatment Consultant must also provide automation and software program outline and training to on-site staff.

1.3.4. Test procedures shall be in accordance with applicable portions of ASME, ASHRAE, SMACNA, NFPA, CFA, ANSI and other recognized test codes as far as field conditions permit. Spectrophotometry technology must be used in on-site testing methods for all aspects of treatment program to ensure accuracy of results.

1.3.5. Maintain treatment program in such a manner as to ensure that fouling factor does not exceed 1 degree C rise above the normal operating temperature difference between condenser water leaving temperature and liquid refrigerant leaving temperatures. Program must ensure heating and cooling systems are kept deposit-free by achieving the following corrosion rate criteria:

<table>
<thead>
<tr>
<th>Mild Steel</th>
<th>Copper</th>
</tr>
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<tbody>
<tr>
<td>Open Systems</td>
<td>&lt; 0.5 mm/year</td>
</tr>
<tr>
<td>Closed Systems</td>
<td>&lt; 0.05 mm/year</td>
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</tbody>
</table>
PART II - PRODUCTS

2.1 PRE-OPERATIONAL CLEANER

2.1.1 Cleaner must ensure the REMOVAL OF ALL organic deposits such as pipe dope, oil and grease deposits. Surface corrosion must be removed by DISSOLVING rust at a NEUTRAL pH, while preventing flash rusting, utilizing same said cleaner. No TSP (Tri-Sodium Phosphate) is to be used due to its environmental impact. The Water Treatment Consultant must provide proof of cleanser's properties via product fact sheet and MSDS. Quantity of cleaner required in association with system volumes must also be submitted.

2.1.2 Cleaner must have long-term metallurgical passivating properties to ensure piping integrity through zone tie-in during the cleaning stage. Passivator must have potential in cleaner to last 2-6 months if required. Again, evidence is required via product fact sheet and MSDS.

2.2 CLOSED SYSTEM TREATMENTS & EQUIPMENT

2.2.1 Closed System inhibitor must be of the sodium molybdate type with non-sodium hydroxide pH buffers within. Proof is required via product fact sheet and MSDS. Dosage control parameters to maintain 80-100 ppm as molybdenum, in system at all times through completion of cleanings to turn over to owner and plant staff.

2.2.2 Chemical bypass feeder: Feeder shall be complete with isolating valves, drain valve, and funnel feeder with isolating valve. One unit for each system. Bypass feeder to act as back up to automation system in place, monitoring closed loops.

2.2.3 In-line filters: Filter housing sized to handle 5 percent of recirculating rate of system. The filter shall be of steel construction and shall be capable of operating at the system working pressure.

2.2.4 Each closed system shall have a minimum ¾ inch Cold Water Contact Head makeup Meter which will tie into the PLC Controller (if applicable), providing control of closed system treatment levels for water treatment automation.

2.3 COOLING TOWER TREATMENTS & EQUIPMENT

2.3.1 Chemicals: No Organo Phosphate (primary ingredient) or Chromate based scale and corrosion inhibitors shall be used in the open loop. The mode of corrosion and scale protection shall be an ALL ORGANIC natured program that is halogen resistant and environmentally friendly.

2.3.2 An oxidizing biocide shall be used in conjunction with a non-oxidizing biocide to ensure the most effective biological kill efficiency with the least environmental impact. Said biocides are also known components of killing the legionella bacterium.

2.3.3 Chemical bypass feeder: Feeder shall be complete with isolating valves, drain valve, and funnel feeder with isolating valve. This shall act as a back up to the feed automation system.

2.3.4 CHEMICAL FEED EQUIPMENT: Contact head cold water meters for makeup and bleed off shall be provided and tied in to the PLC.
based automation control panel. The Water Treatment Data Software Program shall be modem, remote viewing friendly.

2.3.5. Signals of control must come from Micrologics Control System (PLC based) with data being transferred to Water Treatment Data Software Program must be in Windows application, and able to store data transferred from PLC and/or manual data entry. Software program installment is required and training of software to on-site staff must be performed.

2.3.6. The control system shall feed organic inhibitor based on a software program that allows for a contact to come from the makeup water meter, base bleed off or conductivity regulation, and incorporate a dual biocide feed program, all coming from the PLC based controller.

2.3.7. Chemical pumps shall be provided for the organic inhibitor and the two biocides. Utilize compatible Pulsatron chemical feed pumps. Feed signal from the control device and suitable for the application. Three Pulsatron pumps required.

2.3.8. Sequence of Operations: A Jesco water meter on the makeup line to the cooling tower will send signals to the programmable controller. The controller registers the volume (litres/gallons) of water passing through the flow meter and causes the organic inhibitor feed pump to activate proportionately. Chemicals are all fed directly from on-site stations with level control sensors in the containers (use flexible hoses for pumps). The control system will regulate bleed off by measuring the conductivity of the cooling water and provide a visual display of real time conductivity, pH and ORP for oxidizing biocide feeding at all times. When the conductivity of the water exceeds a programmed set point, a bleed solenoid is activated. The biocide will be controlled by an ORP controller (or optional “Actives-based” online colourimetric analyzer) so that a free available halogen residual of 0.3 to 0.5 ppm FAC is maintained on the condenser side. The discharge of the chemical feed pumps shall be piped downstream of the bleed off solenoid, to the supply line to the Cooling Tower.

2.3.9. Bleed off solenoid must be suitable for 1-inch bleed off line with isolation BALL valves to enable isolation of solenoid in case of repair.

2.3.10. Corrosion coupon racks to be provided for each closed and open loops. Each rack must consist of 4 coupon locations installed across a recirculation pump or headers that allow for constant flow past the coupons installed. Each rack must have isolation ball valves with a drain line and flow regulators. Shall provide corrosion monitoring coupons along with laboratory results for 1 year after turnover of plant to the owner.

PART III - EXECUTION

3.1 CLEANING AND FLUSHING

3.1.1. Thoroughly inspect all piping systems and remove heavy debris and excessive oil, grease, pipe dope and surface corrosion.

3.1.2. Install temporary strainers, grids and filters just prior to cleaning and flushing piping systems.
3.1.3. Flush and clean systems before opening new piping system to existing system. Certify that systems are clean and inform consultant when system cleaning is complete. Demonstrate to consultant that systems are cleaned. Once approved, open new system to existing systems.

3.1.4. During flushing and cleaning, maintain all isolating and control valves in the open position. Also allow for Zone tie-ins.

3.1.5. Provide a letter of certificate when all cleaning and flushing has been carried out in accordance with the specifications, and authorities having jurisdiction (City of Toronto, Ministry of Environment etc.). Include copies of certificate in the Program Operating Manuals.

3.1.6. **CLOSED SYSTEMS**

3.1.6.1. Provide temporary caps, connection points, etc. as required to subdivide large systems to ensure a thorough cleaning. Install temporary connection between supply and return lines to permit circulation.

3.1.6.2. Circulate pre-operation cleaner for a minimum of 72 hours. Periodically clean all strainers and repeat flushing operating to the approval of the consultant until no foreign material collects in the strainer.

3.1.6.3. Drain and purge system and clean all strainers. Refill with fresh water and circulate to flush out remaining chemical solution, via fill and flush process.

3.1.6.4. Drain system and remove temporary caps, circulation connections, etc. for permanent operation. Refill using clean water and immediately treat with the corrosion inhibitor required for permanent operation.

3.2 **CHEMICAL TREATMENT**

3.2.1. **CLOSED SYSTEMS**

- Provide chemical treatment equipment, chemicals, and test equipment for heating, chilled, and glycol closed water systems.
- Supply and install on each pumping system a bypass feeder and in-line filter.
- Provide sufficient corrosion inhibitor chemical in each system to raise initial molybdenum level to 80 ppm. Provide additional 114 litres (25 IG) of corrosion inhibitor chemical for each system.

3.2.2. **COOLING TOWER WATER SYSTEMS**

- Provide a complete system of water treatment for the cooling tower to control scale, corrosion and algae/bacteria growth complete with chemicals and test equipment for a 1-year term after Substantial Completion.
- Provide a minimum of 1 service call per month after Substantial Completion and all necessary supervision of cleaning procedures and monitoring of treatment program prior to construction completion. Submit written reports on all activities and testing results achieved in servicing this location.
3.3 WATER TREATMENT SERVICE PROVIDER

3.3.1 Provide a minimum of 1 service call per month after Substantial Completion and all necessary supervision of cleaning procedures and monitoring of treatment program prior to construction completion. Submit written reports on all activities and testing results achieved in servicing this location.

3.3.2 Inspect any system or equipment when open for waterside inspections as requested by customer, at no additional charge.

3.3.3 Provide immediate emergency service response at no additional charge.

3.3.4 Manage and maintain on-site chemical inventories. Responsible for removing from premises all empty water treatment chemical containers, in a timely manner.

3.3.5 Maintain MSDS binder in compliance at all times.

3.3.6 Provide/maintain logbook for data collection

3.4 GENERAL

3.4.1. The chemical supply company shall instruct the Owner's operating staff (minimum 2 hours of training) before acceptance of the installation by the Consultant. Supply copies of training material, written instructions of the treatment dosages, control charts and test procedures.

3.4.2. Chemical supply company must supply written reports, submitted to the site consultant indicating progression of job status as well as PROOF of implementation of requirements within this specification.

3.4.3. Specification MUST be followed as designed and must NOT deviate from this outline.

3.4.4. Central Cooling Water is treated by the University at Central Chiller Plants. For CCW treatment, notification must be given to the Utilities Division of the startup date/time and total system volume.

15600 Refrigerants

1. In accordance with the Montreal Protocol on substances that deplete the Ozone layer, all new refrigerating, cooling and air conditioning equipment shall not contain any CFC nor HCFC based refrigerants nor mixtures of such refrigerants.

2. Major chillers MUST operate with 134/A refrigerant

15700 Access Doors

Provide access doors/panels so that the equipment and the various components that must be serviced, may easily be reached. The doors/panels should be centered on the items to be serviced and be of adequate size to allow removal of the service parts. In no case shall the size of access door be less than 24” x 24”. Provide access panels associated with each fire/smoke damper.
15720 Air Handling Equipment

1. Provide internal waterproof lighting in all accessible air handling unit compartments.

2. Provide hinged access doors to the equipment compartments, with latching hold-open devices and door handles on both sides of door. Ensure no interference of pipings and access doors with respect to coil removal space.

3. For all outside air systems, face and by-pass type dampers with anti-stratification mixing section shall be used when freeze protection freeze-stat is required.

4. Ensure that construction and equipment installation allows space sufficient for the removal of coils from the air handling units. Such allotted coil removal space should be indicated on the drawings. Provide lifting facilities such as eye bolts, I-beams and A-frames for coils heavier than 200 lbs.

5. Variable frequency drives shall be used for fans to vary air flow, rather than inlet vane control. Provide electronic filter circuits to suppress electronic noise and harmonics generated by the device.

6. Fan bearings shall be lubricated externally. Do not use remote grease pipings or tubings.

7. Fan drives: V-belt shall be industrial grade. Multi-sheave belts shall be "power bands".

8. Cooling coils shall have stainless steel frame rather than galvanized steel frame; if not available, advise U. of T. representative.

9. Moisture eliminators are mandatory and shall be made of stainless steel.

10. Provide moisture evacuation facilities for all cooling coils drained for the heating season. (See Appendix ‘C’ Diagram #15.1)

11. Provide local isolation valves for coils where possible.

12. Fogging type humidification equipment shall not be used. Humidification methods and options are to be discussed with U of T representatives.

13. Drain pans in built-up air handling units should be constructed of stainless steel of appropriate gauge. Pans shall slope down to drain. Drain trap height shall exceed maximum fan suction static pressure at dirty filter condition.

14. Air intake and exhaust outlet are to be sufficient distance apart and properly located to prevent cross contamination. Air intakes shall be located above grade so that they do not draw in vehicle exhaust fumes. The exhaust grilles are to be located so they are not placed horizontally on or just above grade so that they are not accessible to unauthorized persons. If this is not possible, slope grilles at 45° angle.

15. All external louvers shall be constructed of galvanized steel and include a galvanized steel bird screen. Prefinished anodized aluminium louvers will be considered as an alternative.

16. A Dwyer Magnehelic pressure gauge shall be provided in main supply air ducts near fan discharge, to indicate dropped fire dampers or other
obstructions in the supply duct system.

17. Do not use aluminium ductwork for corrosion resistance within supply air systems downstream of humidifiers. Stainless welded is acceptable.

18. Noise control shall comply with noise criteria (N-C) standards of noise measurement. The space noise levels shall comply with ASHRAE guidelines. Noise levels shall be measured by an independent acoustic consultant as directed by U. of T.

19. Duct configurations located upstream and downstream of air velocity measuring stations shall be sized adequately in accordance with manufacturer's installation guide and recommendations. Operating air velocity shall not be less than 700 feet per minute.

20. Air Filters for General Office Buildings

21.1. Provide air filters of the appropriate type for the application.

21.2. Test method for all particulate filters shall conform to ASHRAE Standards #52.1-1992 and #52.2-2007 and test results shall be provided.

21.3. Filters shall have Class 2 fire rating by Underwriters Laboratories of Canada.

21.4. Prefilters:

21.4.1. 24" x 24" x 2" thick, polyester media pads with average synthetic dust weight arrestance of not less than 75% and dust holding capacity of not less than 125 grams, both at a final pressure drop of 1" w.g. and a face velocity of 500 F.P.M. Equivalent to AAF VA Blue

21.4.2. 24" x 24" x 2" thick, pleated media with 25% minimum dust spot efficiency and 95% arrestance per ASHRAE 52.1-92 test method. Minimum efficiency reporting value (MERV) of 8 per ASHRAE Standard 52.2-2007. Equivalent to AAF 'Perfect Pleat Ultra' or equal.

21.5. Afterfilters;

21.5.1. 24" x 24" x 30" deep. Self supporting bag type with 80% minimum dust spot efficiency and 95% arrestance per ASHRAE 52.1-92 test method. Minimum efficiency reporting value (MERV) of 13 per ASHRAE Standard 52.2-2007. Equivalent to AAF DriPak 2000 or equal.

-OR-

21.5.2. 24" x 24" x 12" deep rigid fixed pleated media type with 80% minimum dust spot efficiency and 95% arrestance per ASHRAE 52.1-92 test method. Minimum efficiency reporting value (MERV) of 13 per ASHRAE Standard 52.2-2007. Equivalent to AAF Varicel or equal.

21.6. Filter frames;

21.6.1. Frames shall be constructed of 16 gauge galvanized steel at least 3 inches deep and permanently assembled with solid rivets.

21.6.2. Where possible, the prefilters and afterfilters shall be installed in separate frames allowing the final filters to be replaced without having to remove the prefilters.

21.6.3. Closed cell gasketing shall be included allowing a tight seal to filter header/frame.

21.7. Magnehelic type differential pressure gauge shall be provided across each air filter bank.
15760 Hydronic Radiator Installation

1. Provide a hose bib drain at all radiators that have supply and return mains above the radiators, and on any other radiator that will not drain through its piping.  

2. Provide automatic air vents and air separators at high spots in the piping systems.  

3. Provide a shut-off valve at supply and return connections of radiator. Provide separate balancing valve or shut-off valve with memory position.

15830 Fume Hood Exhaust Fans / Cof A

1. Fume Hood Ventilation Guidelines:

   The following guidelines shall be used as a checklist of items to be considered. The consultant shall refer to the standards and codes for specific requirements.

   1.1. Systems shall comply with U of T Environmental Health & Safety specifications, which can be found at the following link under item “Laboratory Fumehood Standard”: Policies and Procedures Listing

   1.2. Give consideration to use of energy conservation systems incorporating common exhaust ducting, VAV hoods and reduced face velocity standby operation.

   1.3. Radioisotope and perchloric acid fume hoods shall be separately ducted to outside; the design and construction shall incorporate precautions for safety.

   1.4. Exhaust stacks shall discharge vertically upwards at approved exit velocity and of sufficient height and so positioned as to ensure that emissions are unable to re-enter the building, and adjacent buildings.

   1.5. A drain connection system shall be provided at fan low point.

   1.6. Air filters, if installed, shall be as close as possible to the fume hood.

   1.7. Do not connect a fume hood to an existing fume hood duct, unless cleared with Environmental Health and Safety, and Utilities. Ensure air balancing is checked.

   1.8. Stack supports, stainless steel guy wires and attachment points are to be designed by a registered structural engineer. Provide identified yellow protective sleeves on guy wires.

   1.9. Label each stack with corresponding room number and exhaust hood number.

   1.10. Label each isolating disconnect as to voltage and source of supply, (e.g., PANEL ABC - CIRC 7) and ensure that source breaker is
identified as to load (e.g., AC#7 Roof).

Certificates of Approval

- Each fume hood, fume hood fan or fume hood stack that is to be added or modified shall be compliant with existing Certificates of Approval.
- Before the project can proceed, the University of Toronto Office of Environmental, Health and Safety shall be notified of any proposed additions or modifications and given all planning details and drawings in order for them to determine compliance or the need for amendment to an existing C of A.
- The University of Toronto Office of Environmental, Health and Safety shall be made aware of all chemicals that:
  o Are currently being used in the laboratory containing or will contain the fume hood;
  o Will be used in the laboratory containing or will contain the fume hood.

Labeling

- All fume hoods must be labeled numerically (ascending from 1) based on the number of fume hoods located in a lab. The label must indicate which mechanical room contains the corresponding fume hood fan.
- All fume hood fans must be labeled with the associated fume hood room number and fume hood number (or numbers if the fan is connected to multiple fume hoods).
- All fume hood exhaust stacks must be labeled with the associated fume hood room number and fume hood number (or numbers if the fan is connected to multiple fume hoods).

15840 Air Terminal Units

1. Ensure that access is provided to each air terminal unit, including VAV and CV boxes, as appropriate to enable the carrying out of periodic cleaning of the reheat coil and inlet screen.
2. VAV boxes minimum airflow settings shall comply with ASHRAE recommended values and required matching reheat coils shall comply with latest OBC/ASHRAE requirements.

15850 Air Distribution

1. When duct thermal insulation is required, it shall be of external type only. When special noise (internal) insulation is required as well as thermal, and the thermal insulating value of the internal noise insulation has insufficient thermal properties, additional external insulation may be used.
2. Internal accoustical insulation shall not be used for thermal insulation.
3. Under floor air distribution systems shall be supplied with floor mounted plenum separations. Press fitted plenum dividers are not acceptable. Air tight air plenums are essential. Caulk sealing is required around the plenum.
4. Air flow straightener turning vanes shall be installed in all cases where 90 degree square main ducts are used.
15900 Controls/CCMS/Energy & Flow Metering:

General
The University accepts two methods of building systems control/monitoring as described in the following section 15900 Parts A) & B). Whether method A) or B) is used depends on several factors which are determined on a project-by-project basis. Ultimately, the decision of which method is to be used on a particular project shall be the result of discussions between the consultant/contractor and the CCMS Manager.

15900 Part A) CCMS ‘MUX’ Implementations

Part 1:
The following sections of this document are to be used when the legacy CCMS system is being extended. This section is used when the CCMS MUX is to be the primary controller. All local controls then act as backup controls.

The sections on alarming and equipment selection are also relevant when end devices are connected to the CCMS MUX panel for the reporting of alarms.

Please contact Erik Ivanenko @ 416-978-1900 to help determine if any parts of this section apply to your project.

2. Overview

The University of Toronto is a large campus with numerous buildings of various sizes and ages. A significant number of these buildings pre-date the modern DDC based HVAC control systems. These older building control systems are continuously being upgraded. New buildings are also being constructed on an on-going basis. To assist in the operation and maintenance of campus buildings, U of T Mechanical Operations & Maintenance departments are provided with a Centralized Control & Monitoring System called CCMS to monitor these buildings from a central location; as well as, Operator Interface Workstations Personal Computer (PC) window based accessing the BAS equipment in the buildings. To facilitate the centralized CCMS standards have been applied to the selection and installation of BAS equipment in the buildings.

This document identifies the requirements for the application of BAS in these buildings. These requirements have been developed to ensure that U of T buildings are provided with high quality BAS installations.

3. Specification

3.1. Work to be done under this Section shall include furnishing of labour, materials and equipment required for installation, testing and putting into proper operation complete automatic control systems ready for continuous and satisfactory operation.

3.2. The project consultant has specified all control sequences, sizing of equipment and operation of all control elements.

3.2.1. The control systems shall be integrated to the Central Control and Monitoring System (CCMS) for the purposes of metering, monitoring, alarming and historical data collection.

3.2.2. Wiring and installation of hardware required for integration with CCMS, including network connectivity and any CCMS devices shall be provided by the contractor.

3.2.3. The contractor agrees to reimburse the University for any CCMS equipment provided by the University and damaged subsequent to
delivery to the contractor. Repairs will be on a parts and labour basis. Labour charges are based on the prevailing charge out rate as established by the Facilities and Services Department.

3.2.4. Control systems are to be adjusted, calibrated, set and tested by the contractor.

3.2.5. The consultant will receive acknowledgement from the contractor that the control systems have been properly adjusted/calibrated, set and tested.

3.2.6. The control systems supplier/installer shall demonstrate, to the satisfaction of the owner/commissioning agent that the control systems are in proper operation, calibration and perform as specified.

4. Submissions:

4.1. The University shall review materials and methods prior to installation. Pre-installation:

4.1.1. Four complete sets of shop drawings shall be submitted for review prior to installation.

4.1.2. Point wiring riser diagram indicating panel numbers and locations, conductor quantity and type (network communication, 2 pair etc.), termination designation point (eg. system and field/relay interface/control panel/MCC etc) shall be provided.

4.1.3. The quantity and location of all spare cables shall be identified.

4.1.4. Schematic control diagrams for all systems, each diagram indicating system configuration, control components, component designations, descriptions and catalogue numbers and connected control panel point addresses shall be provided.

4.1.5. The control drawings show the physical relationships of various components, such as fans/coils.

4.1.6. The control/monitoring devices can be accurately located relative to the system components.

4.1.7. Flow diagrams showing a schematic layout of the piping and equipment have been provided for all steam and liquid systems.

4.1.8. Control/Monitoring devices are shown at the appropriate locations in the piping.

4.1.9. All drawings and schematics are provided in PDF format.

4.1.10. Product description/technical specifications for all mechanical and control components, including valves, dampers, actuators, sensors, transmitters, etc (this is not an exhaustive list) shall be provided.

4.1.11. Complete sequence of operations shall be submitted for each system.

4.1.12. Control panel faces layout shall be provided, indicating all gauges, switches and tags descriptions.

4.1.13. Technical specification data sheets shall be provided for each system component.

4.2. Point lists

4.2.1. A list of all physical and software points that shall be included.

4.2.2. A point list and description of function of each point shall be provided.

4.2.3. The physical point list shall contain point name, point address, point designation, point description, point type, cable number, the connected input/output device, proposed set points and alarm limits.

4.2.4. The physical point list shall identify the type of point as one of: Analog Input (AI), Analog Output (AO), Binary Input (BI), Binary Output (BO),

4.3. Critical Alarms (Critical alarms are those alarms that require immediate attention.)

4.3.1. The critical alarm list will identify all points that can generate critical
alarms.

4.3.2. An alarm message associated with each alarm point that is to print at the Central Steam Plant will be provided.
4.3.3. A list of recipients will be included for each SMS text alarm message. (Delivered to Cell phone or PDA).
4.3.4. The operator response/action to each alarm shall be provided.
4.3.5. A list of alarms that are intended to protect the contents of the controlled space/Faculty equipment shall be provided.
4.3.6. Alarm limits/states for all critical alarms shall be provided.

4.4. Sequence of operations

4.4.1. A sequence of operations for each system shall be provided.
4.4.2. The sequence of operations includes all set-points/schedules and operating modes.
4.4.3. The sequences of operation are sufficiently detailed to enable the control system programmer to implement.
4.4.4. The sequence of operations will include an optimum start/stop schedule based on outside air temperatures for night set-back and morning start-up.
4.4.5. All sequences are provided as MS Word documents.

4.5. Post installation:

4.5.1. Four printed copies of as-built control drawings shall be submitted.
4.5.2. A process flow diagram including controlled temperatures shall be prepared for all systems and shall be posted next to the control panel of the related (air handling, chilled or heating water system).
4.5.3. One electronic copy of all drawings in AutoCAD DWG and Adobe PDF files.
4.5.4. One copy of all text files in ASCII, WordPerfect or Microsoft Word format Configuration software.
4.5.5. A report that cross-references the wire number to shop drawing label shall be submitted.
4.5.6. All configuration software and licences used in the configuration and installation of and third party BAS shall be provided to the UT.
4.5.7. All spreadsheets and other data files used in the configuration/installation of the third party BAS shall be provided to the UT.
4.5.8. As part of the Operating and Maintenance and programming manuals, submit one software manual to U of T “Controls and Technical Support Group” plus one CD version of this software information for archive use. Include:

5. Application of Alarms

5.1. CCMS is not responsible for either the life-safety of the occupant or the contents of any space serviced by CCMS. Neither alarm delivery nor timely operational response to critical alarms can be guaranteed, which precludes the use of the CCMS for such purposes.

5.2. For the above reason, all life-safety class systems are external to CCMS. This includes the fire-alarm system, smoke evacuation systems etc. Any risk to the health or safety of the occupant is managed by a separate system.

5.3. Alarm reporting is designed to assist UT staff in locating problems with building environmental control equipment. Consequently, it is not recommended that CCMS be used as the primary monitor of systems in which failure of a building engineer to provide timely response to alarms may cause damage to space contents.

5.4. We strongly urge that the occupant be reminded that he is completely liable...
for the materials/resources in any area controlled or monitored by CCMS.

<table>
<thead>
<tr>
<th>SYSTEM TYPE</th>
<th>ALARM POLICY</th>
<th>CONTROL POLICY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life-safety e.g. fire/smoke</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Animal Colonies</td>
<td>Yes¹</td>
<td>Yes</td>
</tr>
<tr>
<td>Clean Rooms</td>
<td>Yes¹</td>
<td>Yes</td>
</tr>
<tr>
<td>Environmental rooms</td>
<td>Yes¹</td>
<td>No³</td>
</tr>
<tr>
<td>Chemical Storage</td>
<td>Yes¹</td>
<td>Yes³</td>
</tr>
<tr>
<td>NMR Labs</td>
<td>Yes¹</td>
<td>Yes</td>
</tr>
<tr>
<td>Laboratories</td>
<td>Yes¹</td>
<td>Yes³</td>
</tr>
<tr>
<td>Fridges</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>Art Galleries</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>Sump Pumps</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>Parking garage</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>CO evacuation</td>
<td>Yes¹</td>
<td>No</td>
</tr>
</tbody>
</table>

¹ Remote alarm ONLY. Primary alarm is annunciaged locally.

³ Implementation of CCMS control is dependent on the tolerances/demands of the space.

⁴ CCMS does not control exhaust fans in these facilities.

⁵ Fume hoods are controlled locally, but CCMS has “stop” capability; schedules can be implemented to shut off fume hoods.

6. Control products

6.1. The Central Control and Monitoring System (CCMS) installed at the University of Toronto St. George Campus is a real-time distributed building control system.

6.2. The system can be divided into six levels of operation as a function of the data processing and associated communications:

6.3. At building level, multiplex panels are directly hardwired to building system sensors and control points communications to the panel is via DSL hardwired into the UT copper backbone.

6.4. The central facility includes the front-end computer and all operator interface devices. The front-end computer contains the application software and system database.

6.5. Operator workstations allow the user to interrogate connected field points, to create, monitor and adjust control routines, plus dynamically
expand the number of points.

6.6. Alarm monitors, located in various operational centres across the campus, report abnormal operating conditions. They are hardwired to the central facility.

6.7. Local controls for backup of the CCMS.

7. MULTIPLEX PANEL

7.1. Multiplex panels incorporate the following functionality:

7.1.1. Scanning of binary input points.
7.1.2. Scanning of analog input points including analog to digital conversion with auto-calibration.
7.1.3. Time scheduling of binary output points.
7.1.4. PD loop control
7.1.5. Network communications.
7.1.6. Non-volatile memory to retain configuration data.

8. POINTS LIST

8.1.1. The following tables describe end device points and the basic CCMS point type to which the end device point is connected. Actual system configuration may dictate additional/lesser requirements. This list is not exhaustive. For any end device points that do not appear on this list please contact CCMS.

1. Air Handling Systems

| Point Type                        | Start/stop of master fan | Proof of master fan | Proof of slave fan(s) | Supply air dry bulb temperature | Supply air velocity/velocity pressure | Supply air static pressure | Mixed air dry bulb temperature | Return air dry bulb temperature | Return air relative humidity | Return air velocity/velocity pressure | Freezestat/firestat combined alarm | Control output - heating coil | Control output - cooling coil | Control output - mixing dampers | Control output - return fan volume | Control output - supply fan volume |
|----------------------------------|--------------------------|---------------------|-----------------------|---------------------------------|--------------------------------------|-------------------------------|-------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| Point Type                        | BO                       | BI                  | BI                    | AI                              | AI                                   | AI                            | AI                            | AI                              | AI                              | AI                              | BI                              | AO                             | AO                             | AO                             | AO                             | AO                             |

2. Converters

<table>
<thead>
<tr>
<th>Point type</th>
<th>Return temperature</th>
<th>Supply temperature</th>
<th>Control output - supply temperature</th>
<th>Pump(s) start/stop</th>
<th>Pump(s) status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point type</td>
<td>AI</td>
<td>AI</td>
<td>AO</td>
<td>BO</td>
<td>BI</td>
</tr>
</tbody>
</table>

(C = Complies  NC = Does Not Comply  NA = Not Applicable)
### 3. Domestic Hot Water

<table>
<thead>
<tr>
<th>Point Type</th>
<th>C</th>
<th>NC</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank temperature</td>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control output - supply temperature</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recirculating pump start/stop</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recirculating pump status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High pressure alarm</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCMS/local switchover</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4. Radiation

<table>
<thead>
<tr>
<th>Point Type</th>
<th>C</th>
<th>NC</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump start/stop</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control output</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Fans with common usage may be grouped.

### 5. Exhaust Fans

<table>
<thead>
<tr>
<th>Point Type</th>
<th>C</th>
<th>NC</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start/stop</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6. Centrifugal Chillers

<table>
<thead>
<tr>
<th>Point Type</th>
<th>C</th>
<th>NC</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller stop/start</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiller status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water supply temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water return temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control output - supply temperature</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water pump start/stop</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled water pump status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load limit control</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser water discharge temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling tower discharge temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling tower discharge control</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiller electrical load (kW)</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building supply temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building return temperature</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building temperature control output</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7. Cooling Towers

<table>
<thead>
<tr>
<th>Point Type</th>
<th>C</th>
<th>NC</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/low motor speed status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On/off motor status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser pump start/stop</td>
<td>BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser pump status</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control output – condenser supply temp.</td>
<td>AO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Compressed Air</td>
<td>Point Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low pressure alarm</td>
<td>BI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerant dryer discharge temp.</td>
<td>AI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desiccant dryer alarm</td>
<td>BI</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>9. Elevator Room</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space temperature</td>
<td>AI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. Transformer Room</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space temperature</td>
<td>AI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Diesel</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space temperature</td>
<td>AI</td>
</tr>
<tr>
<td>Battery condition</td>
<td>BI</td>
</tr>
<tr>
<td>Diesel status</td>
<td>BI</td>
</tr>
<tr>
<td>Storage tank low level</td>
<td>BI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Building Lighting</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights off (by area)</td>
<td>BO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13. Sump and Sewage Pumps</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>High level alarm</td>
<td>BI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14. Outside Air</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry bulb temperature</td>
<td>AI</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>AI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15. Flow Metering</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow differential pressure(s)</td>
<td>AI</td>
</tr>
<tr>
<td>Supply temperature</td>
<td>AI</td>
</tr>
<tr>
<td>Return temperature</td>
<td>AI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16. Cold Water Booster System</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump start/stop</td>
<td>BO</td>
</tr>
<tr>
<td>Pump status</td>
<td>BI</td>
</tr>
<tr>
<td>High/low pressure alarm</td>
<td>BI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17. Building Electrical Demand</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilowatt load</td>
<td>AI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>18. CCMS Local Switchover</th>
<th>Point Type</th>
</tr>
</thead>
</table>

---

C = Complies   NC = Does Not Comply   NA = Not Applicable
9. Restrictions
9.1. The MUX panel is restricted to PD control. PID control is not possible at this time.
9.2. The MUX panel cannot sequence (time delay) start/stop commands directly. However, start/stop commands can be scheduled independently. Sequencing of start/stop commands is also possible with host involvement by defining Master/Slave relationships.
9.3. The MUX panel does not provide a “pulsed” binary output.
9.4. All master/slave relationships require involvement of the central host for processing.
9.5. The MUX panel itself does not provide cascaded loop control; the output of one loop cannot become the setpoint of another. However, the central host can reset a loop setpoint.
9.6. The MUX panel cannot drive two analog outputs from a single physical point. The MUX Panel cannot read 1000-Ohm RTDs.

10. Communications
10.1. Communications can be implemented from the MUX panel to the central host by either:
   10.1.1. DSL communications
   10.1.2. Inter-network communications.
10.2. DSL is the standard communications media. Inter-network communications is to be avoided whenever possible.
10.3. A DSL modem is to be located in each MUX panel. Cabling is run from the MUX panel to the UT network services “Basic Electrical Facility” within the building. UT network services, working with CCMS, ensures that the communications path between the MUX panel and the central facility is functional.
10.4. Inter-network communications are to be used only when the University’s copper backbone is not present. This may occur if the installation is off-campus.

11. CENTRAL FACILITY
11.1. The central facility contains the main control computer. The central facility provides all configuration, alarming, monitoring and high-level control functions. Control loops reside in the MUX panel, as does a scheduled start/stop facility. Programs running at the central facility perform all high-level control functions.
11.2. The central control facility enables and maintains the configuration of the MUX panels. For this reason, it is critical that communications between MUX panel and the central facility is established prior to verification of the installation.
11.3. The central facility is protected from intrusion by a firewall.
11.4. The central facility also hosts the CCMS web-site.

12. OPERATOR WORKSTATIONS
12.1. The operator workstations are currently windows running IE.

13. ALARMS MONITOR
13.1. Alarms are displayed from the CCMS web site onto any networked PC that in allowed through the firewall.
13.2. There is one dedicated alarms monitor in each of the 4 campus areas, as well as the steam plant.
14. LOCAL CONTROLS
14.1. Local controls are on-site DDC control systems. Local controls are used primarily for the backup of CCMS controlled systems.
14.2. Local controls are used as the primary controller where CCMS control is not required.
14.3. Discuss the requirement for CCMS control with Erik Ivanenko, 416-978-1900

15. Products
15.1. Equipment provided by UT:
15.1.1. Multiplex Unit Enclosure
15.1.2. The MUX panel enclosure is rated NEMA 12/13.
15.1.3. The dimensions of the MUX panel enclosure are 48” x 36” x 16” (H x W x D).
15.1.4. The MUX panel incorporates a single panel key lockable door.
15.2. Multiplex Unit Internal Card Cages:
15.2.1. 16-slot card cage (upper) for analog input (AI) boards. One slot is dedicated for RTD sensor current board. 15 AI boards can be installed – maximum 75 AI points.
15.2.2. A 16-slot card cage (lower) for binary input (BI), binary output (BO) and analog output (AO) boards.
15.2.3. Analog output cards restricted to the first 6 slots of the lower card cage and must precede any other card – maximum 36 AO points
15.2.4. Since the BO, BI, and AO points share the same card cage, the maximum number BO and BI points depend on the number of free slots available after the AO points have been defined.
15.3. Input/Output Cards:
15.3.1. Multiplex unit cards to be of University of Toronto manufacture.
15.3.2. Analog Output (UT9154): Six outputs per card, with an output of 0 - 10.23 volt supplied from multiplex unit. Minimum load resistance 500 ohm per output. D/A: 10 bit
15.3.3. Analog Input (UT9204): Five inputs per card. 12 bit A/D resolution. Each point can be switched for RTD or voltage input. RTD excitation current source is the multiplex panel internal power supply. Software assigned ranges:

- - 20° - 65 °C    0 - 1 Vdc (Also used to read 0-20 ma w/ dropping resistor)
- - 20° - 200 °C   0 - 10 Vdc

15.4. Binary Output (UT9148): Twelve relay outputs per card, 1.5 amp, 50 VA resistive, 1,500 V max. Contacts are normally open. Inductive load diode protection is provided on each output. 24 VDC excitation voltage is required from power supply.

15.5. Binary Input (UT9116): Fifteen contact-sensing inputs per card. 24 VDC excitation is required from power supply. Load is minimum of 10 ma per input (varies with end device).

16. 24VDC – Internal Power Supply
16.4.1. 24 VDC power supply loads shall be restricted to the multiplexor binary interface, CCMS/Local status indication and multiplex panel connected transmitters.
16.4.2. Three Amps (fused) of 24 VDC power is provided directly from the MUX panel power supply.
16.4.3. Power supply load shall not exceed 3 Amps all devices energised.
17 Contractor to supply: (This is not an exhaustive list.) Communications wiring
   17.1 Category 5E UTP. No substitutions.
   17.2 Point Wiring
   17.3 AI, 22 gauge twisted, 4 wire cable Belden 8723 or equivalent
   17.4 AO, 22 gauge twisted Belden 8723 / 8747 or equivalent
   17.5 BI, 22 gauge twisted Belden 8723 / 8747 or equivalent
   17.6 BO, Gauge selected so as to obtain 21.6 VDC minimum as measured at the device terminals, devices energised. Stranded conductor.

18 Power
   18.1 110 VAC
   18.2 A 110 VAC circuit is to be provided for the MUX panel.
   18.3 UT is to provide the wall mount duplex receptacle located on the MUX cabinet for termination by the contractor.
   18.4 Flexible armour is to be provided by the contractor for the 110 VAC wiring internal to the MUX cabinet.

19 24 VDC – External
   19.1 In the event that an installation requires more than 3A of 24VDC power, external power supplies are to be used.
   19.2 Power supply: 120 VAC input, 24 VDC output, 12 amp.
   19.3 This power supply is to be provided by the contractor.

20 Local Controls
   20.1 A “Local/CCMS” switch shall be provided for each system that is to be controlled in either local or CCMS mode. This switch will enable a building operator to select on-site whether local DDC or CCMS control is in effect.
   20.2 Where the system contains a Variable Speed Drive (VSD) a separate Local/CCMS switch shall be provided to switch between local/CCMS operation of the VSD.
   20.3 A binary output point shall be provided to enable CCMS to select either Local/CCMS control over each individual system. This output will be effective only when the switch is set to CCMS mode.
   20.4 A binary input point shall be provided for each local CCMS/Switch to enable CCMS to monitor the position of the switch.
   20.5 The position of the “local/CCMS” switch shall have local indication via a light on a panel.
   20.6 Local DDC control shall be activated automatically when power is lost to the CCMS controller. CCMS shall resume control when power returns, provided that the “CCMS/Local” switch is in the “CCMS” position.
   20.7 The Local DDC controller shall be mounted in a NEMA 4 rated enclosure. Accessibility shall be independent of the MUX panel.

21 POINT INTERFACE
   21.1 POINTS
   21.1.1 The C.C.M.S. can be applied to measure, monitor and/or control any of the following:
       21.1.1.1 AI: Analog In (variable measurement) e.g. temperature, pressure, R.H. etc.
       21.1.1.1.1 Where a 4-20 ma signal is transmitted to the multiplex panel, a precision resistor shall be installed on the multiplex panel card edge connector. Vishay model VSR4, 50 ohms ± 0.02%, temperature coefficient < ± 4 PPM / °C. This resistor will be provided by UT.
   21.1.2 AO: Analog Out (variable control) E.g. modulating damper, control valves, rheostat, etc.
21.1.1.2.1 A separate analog output point shall be provided for each controlled device.
21.1.1.3 BI: Binary In (status) e.g. dry contact.
21.1.1.3.1 Fractional horsepower motors shall be interfaced by interface relays:
   21.1.1.3.1.1 BI - Double pole, double throw 120 Volt AC coil, 5 amp, 24V DC contacts. Releco C3-A20 X. No substitutions.
   21.1.1.3.1.2 Individual relay base with separate terminal strips for AC and DC connections. Relay bases, Releco S3-S. No substitutions.
   21.1.1.3.1.3 Relays are mounted in Hammond series 1439 enclosures.
   21.1.1.3.1.4 Fans and pumps shall use current operated solid-state relays.
   21.1.1.3.1.5 Current relays shall be sized to match the motor being monitored, calibrated to indicate no flow or belt failure of fans.
   21.1.1.3.1.6 Current relays shall have accessible trip adjustment over 10 - 100% of range and deadband adjustment to 10% of range.
   21.1.1.3.1.7 The output relay contacts shall be SPDT.
21.1.1.3.2 Binary Out (on/off control) e.g. fan stop or start
   21.1.1.3.2.1 A binary interface relay and relay base shall be used where voltages other than 24 VDC nominal would be present at the binary output card terminals or where the current exceeds the binary output board rating.
   21.1.1.3.2.2 BO Relay – Triple pole, double throw 24 Volt DC coil, 10 amp. 120V AC contacts. Releco C3-A30 X. No substitutions permitted.
   21.1.1.3.2.3 BO Relay base - separate terminal strips for AC and DC connections. Releco S3-S. No substitutions are permitted.
   21.1.1.3.2.4 H-O-A selector switches shall be provided for system activation/deactivation. In the hand position the system is activated locally. In the auto position the multiplex panel can activate the system via the BO relay interface.

22 CONTROL DEVICES
22.1 Temperature Sensors
22.2 Temperature sensors shall be platinum RTD 100 ohm at 0 Deg C, 0.385 ohm/deg C, 4 wire, and single element complete with 4-wire connection to screw terminal connector block.
22.3 Duct Mount RTD’s shall be used for the monitoring of all uniform air temperatures.
   22.3.1 The length shall be such that the sensing element is installed to less than one third of the duct width or duct diameter from the duct wall but into the flow stream.
   22.3.2 Class B copper sheathed element with a minimum accuracy of 100 ohm +/- 0.12 ohm at 0 deg C
   22.3.3 End mounted standard electrical conduit box.
   22.3.4 Single element: Enercorp model TS-D-length-R-100, length selected to satisfy point 9.1.2.1 above. No substitutions.
   22.3.5 Dual element duct mounted sensors are not permitted.
   22.3.6 Pipe mount RTD assembly shall be of spring loaded construction, constrained to prevent rotation relative to utility box with length suitable for the application.
22.3.6.1 General purpose application: Class B (100 ohm +/- 0.12 ohm at 0 deg C) stainless steel sheathed element
22.3.6.2 Flow metering application: Class A (100 ohm +/- 0.06 ohm at 0 deg C) stainless steel sheathed element.
22.3.6.3 RTD assembly: TS-GPS-R-100-(length)-8-(degree). Length is stem length, 4" or 6" as appropriate for the application. Degree is 200, 400 or 600, depending on upper limit of temperature being measured. No substitutions.
22.3.6.5 Thermowells shall contain heat conductive compound.
22.3.7 Averaging type RTD’s shall be used wherever a stratified temperature is to be monitored.
22.3.7.1 Twenty (20) foot copper sheathed averaging sensor with end mounted standard electrical conduit box.
22.3.7.2 Nine (9) class B (100 ohm +/- 0.12 ohm at 0 deg C) platinum elements in series/parallel configuration.
22.3.7.3 Enercorp Instruments model RH-1-20-ID only, no substitutions.
22.3.7.4 Space temp: Enercorp TS-S-E-R-100. No substitutions.
22.4 Relative Humidity
22.4.1 RH transmitters shall provide 4-20 ma two wire analog inputs.
22.4.1.1 Duct mount: Enercorp Instruments HT-D-420. No substitutions.
22.4.1.2 Space mount: Enercorp Instruments HT-S-420. No substitutions.
22.5 Pressure.
22.5.1 Gauge pressure transmitters provide 4-20 ma analog inputs for the measurement of steam pressure. Rosemount model 1151GPS (Smart). No substitutions.
22.6 Fluid Flow Measurement
22.6.1 Flow metering installations shall be provided for the measurement of steam, high temperature hot water and chilled water flow rates as applicable to the installation.
22.6.1.1 High Range - Rosemount(SMART) Model 1151DPS, calibrated 0 to 100 inches. No substitutions.
22.6.1.2 Low Range - Rosemount(SMART) Model 1151DPS, calibrated 0 to 10 inches. No substitutions.
22.7 Electric Pneumatic Transducers (EPT)
22.7.1 Electric to pressure transducers shall convert a voltage signal from the analog output card in the multiplex panel to a linear pressure output for the activation of pneumatic control devices.
22.7.2 The transducer shall not require its own power source. It will be powered from the applied analog output signal: 0-10 V, 20 ma.
22.7.3 Transducers shall be factory calibrated for operation on a 2 to 10 VDC input and 20 to 103 kpa (3 to 15 psi) output; direct acting.
22.7.4 Transducers shall have minimum input impedance of 500 ohms.
22.7.5 Flow capacity of not less than 20 cc/sec at 138 kpa pressure drop.
22.7.5.1 Linearity: +/- 1% of span
22.7.5.2 Hysteresis: +/- .75% of span
22.7.6 Enercorp Instruments Model VIP 9000 required. No Substitutions.
22.8 Solenoid
22.8.1 The solenoid will be switched by application of 24 VDC @ 20 ma.
22.8.2 The required Solenoid valve is the Numatech LS03L7H00B. No substitutions.
22.9 Filter/Regulator.
22.9.1 Provide a panel mounted filter/regulator on main air supply for each pneumatic control system.
22.9.2 Conoflow model FH-60 or equivalent.
22.10 Fluid High/Low Level
   22.10.1 Fluid High/Low level will be Flygt model ENH

23 Mux Panel
   23.1 The installation must provide sufficient space around the panel to ensure unobstructed access to the MUX panel and contents for servicing.
   23.2 Three feet, six inches (3’6”) is required in front of the MUX panel.
   23.3 One foot (1’) is required on the hinged side of the cabinet. (The door is a left swing door).
   23.4 The panel should be mounted 2.5’ (30 inches) above the finished floor.
   23.5 A shield is to be mounted above the MUX panel in sprinklered installations, to protect the panel from water infiltration.
   23.6 Adequate lighting shall be provided in the area to enable work on the MUX panel without additional illumination. i.e. The Building engineer should not need additional lighting to work on the MUX.

24 Point/communications wiring
   24.1 Communications cable is to be run in conduit from the MUX panel.
   24.2 Communications cabling can be run in existing cable trays and conduit provided no AC cabling is present.
   24.3 The communications cabling shall be run from the MUX panel to the UT Central Network Services Building Electrical Facility (BEF). Contact Erik Ivanenko @ 416-978-1900 to help locate the endpoints of the communications run.
   24.4 Communications cable termination will be the responsibility of the University.
   24.5 All points associated with a building system shall be wired to a common multiplex panel.
   24.6 Installation shall provide a minimum of 10% future expansion capability for each point type (AI, AO, BI, BO) at each multiplex panel. If the expansion capability cannot be met within a single MUX panel, additional MUX panels should be installed.
   24.7 Wiring shall be installed in continuous grounded metallic conduit/EMT separate from AC wiring and no splices shall be permitted in run from sensor to multiplex panel.
   24.8 Size of EMT shall be selected so that any conduit is no more than 60% filled.
   24.9 No more than two 90-degree bends shall be installed between successive pull boxes.
   24.10 The bend radius of each bend shall be no less than 10 EMT/conduit inside diameters.
   24.11 Maximum length between pull boxes shall be 30 meters.
   24.12 A “pull string” or “Pull wire” shall be left in place between each junction box and from the MUX panel to the first pull box, to facilitate future expansion.
   24.13 Wiring shall not be exposed.
   24.14 A flexible armour jacket no longer than six feet is permissible for bringing the EMT/conduit to the end device.
   24.15 From BO relay to end device or from source to BI relay switchboard wiring is required to meet Hydro standards.
   24.16 Two (2) spare Belden 8723 cables shall be provided from each control panel.
and relay interface panel to the multiplex panel.
24.17  Maximum sensor wiring one way 1,000 feet.
24.18  Wiring shield shall be left floating.
24.19  Wiring shall be numerically labelled, with labels located at both ends of the wire pull. A unique number will identify the wire in the building. Contact Erik Ivanenko at 416-978-1900 for the starting wire number.
24.20  A report that cross-references the wire number to shop drawing label shall be submitted.
24.21  Each pull box shall be labelled CCMS. This shall not be a hand drawn label.
24.22  Each EMT/conduit shall be labelled CCMS on entrance to an area, and on exit from the area.
24.23  At exit from the MUX panel, each EMT/conduit shall be labelled to indicate the area served by the EMT/conduit.
24.24  The size of each pull box will be determined by the EMT/conduit diameters. The sides of the pull box will be a minimum of 8 pipe diameters wide. The largest EMT/conduit entering the pull box will determine this dimension.
24.25  The depth of the pull box will be appropriate for the size of the EMT/conduit entering the pull box.

25  Multiplex Panel Wiring
25.1  Field wiring conduit(s) shall enter at top of multiplex cabinet centreline within 75 mm of enclosure side(s).
25.2  All cabinet penetrations shall be made watertight.
25.3  Point wiring shall be via cable tray with cable looped backed in tray so as to provide a 0.5 meter minimum excess cable length.
25.4  Wiring to card terminal block on any cage slot shall be via either the upper or lower cable tray but not both.
25.5  Only one (1) conductor termination permitted per 24 VDC terminal.
25.6  Spare and digital communication cables shall be 2.5 meters minimum length measured from multiplex cabinet point of entry.
25.7  For point wiring, the cable sheath shall be trimmed back to the point at which the cables exit the cable trays in the MUX panel.
25.8  For point wiring, the conductor insulation shall be stripped back no more than 3 inches.
25.9  For point wiring, unused conductors shall be pulled back, wrapped around the cable sheath and taped using standard electrical tape.

26  Power
26.1  The CCMS provides a duplex receptacle for the 110 VAC power, mounted on the MUX backplane.
26.2  The contractor is to connect this directly to a dedicated 110 VAC circuit. An external receptacle shall not be installed.
26.3  The 110VAC wiring is to be run to the MUX panel in dedicated EMT.
26.4  The 110 VAC circuit shall have it’s own independent circuit breaker.
26.5  24 VDC power supply loads that use the internal MUX supply, shall be restricted to the multiplexer binary interface, CCMS/Local status indication and multiplex panel connected transmitters.
26.6  In the event that an installation requires more than 3A of 24VDC power, external power supplies are to be used.
26.6.1  The external 24 VDC power supply shall be mounted on top of multiplex panel cabinet with stand-offs to limit heat transfer from power supply to panel.
26.6.2  Max Power supply load shall not exceed 80% of rated load, all devices
27 Local Controls

27.1 Circuitry used to implement the “local DDC/CCMS” switchover shall be powered by 24 Volt DC.

27.2 Setpoints used by the local DDC controller are to be manually adjustable via panel located near the end device. It shall not be necessary to use laptop computers to change set points.

27.3 CCMS sensors shall not be re-used by the local DDC controller.

27.4 Dual type sensors are not permitted.

27.5 Sharing of sensor wells by local and CCMS sensors is not permitted.

27.6 The Local DDC and CCMS controllers shall share output points.

27.7 Monitoring of systems by CCMS is to be unaffected while local DDC control is in effect.

27.8 The Local/CCMS switch should be located near the local controller/end device.

28 Analog Inputs

28.1 4-20 ma devices shall be powered from the mux panel’s 24 VDC power supply.

28.2 All input sensors shall be direct wired to multiplex panel. No intermediate switches splices or terminal blocks are permitted.

28.3 Use of external transmitters is not permitted for temperature sensing.

29 Binary Inputs

29.1 Differential pressure switches will be constructed of materials suitable for the application.

29.2 Shock and vibration protection suitable for the application.

29.3 Overpressure protection as applicable to the installation.

29.4 When using current operated solid-state relays, over-current and over-voltage protection shall be provided.

29.5 Interface via motor starter auxiliary contacts is not acceptable.

30 Analog Outputs.

30.1 Sequencing by pilot positioner or spring range, with the exception of mixing dampers and LOCAL mode operation is not permitted.

30.2 Fresh air, exhaust and mixing dampers within a single air handler, should operate in sequence via spring range.

30.3 Spring ranges are to be calibrated within a 3-15 psi range.

30.4 Analog outputs interface to actuators via E/P transducers.

31 Binary Outputs.

31.1 To avoid excessive inrush starting currents, large motors shall be distributed among the binary output cards and “delay on operate” relays provided to delay the start of motors on subsequent cards.

31.2 All safety devices shall be effective in both the “hand” and “auto” positions of the HOA switch.

32 Pipe mount RTDs

32.1 RTD assemblies shall be installed in dual diameter threaded thermowells with end of well projecting into flow stream.

33 Averaging RTDs

33.1 Install the averaging RTD in serpentine configuration with adequate...
provision for the mechanical protection of the sensor and such that it is supported as required along its entire length.

34 High Precision Temperature Sensors RTDs used in metering (eg. BTU) applications must be in compliance with the following requirements:

34.1 Tip-Sensitive RTD sensors complete with 316 drilled stainless steel thermo-wells.

34.2 The RTD is 100 ohm Platinum Class A (100 ohm +/- 0.06 ohm @ 0 degrees C.) stainless steel sheathed element.

34.3 The sensors must be a matched pair.

34.4 Provide thermowells for temperature sensors in compliance with the following additional requirements:

34.4.1 Stainless steel probe. Probe length shall be at minimum 20% of the pipe width.

34.4.2 Moisture/waterproof housing with conduit fitting.

34.4.3 Provide complete with drilled Stainless Steel thermowells.

34.4.4 Provide complete with thermal transfer compound inside thermal well.

34.4.5 If it meets the above requirements, provide Enercorp Instruments 316SST ¾ inch or approved

35 Metering Devices used on Steam, Heating/Cooling water and Condensate.

35.1 Flow metering used for measuring energy consumption.

35.1.1 Flow metering installations shall comply with ANSI 2530/ASME Fluid Meters standards.

35.1.1.1 All metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). For detailed information please contact the Manager of the UT Controls and Tech Support Group at (416) 978-1900.

35.1.2 Flow metering installation details include:

35.1.2.1 30 pipe diameters of straight pipe length upstream and 3 pipe diameters downstream of the flow sensing device or approved by UT Controls and Tech Support Group.

35.1.2.2 A flow straighter shall be installed where sufficient upstream pipe length is not available.

35.1.2.3 The DP transmitter must be equipped with a three-way manifold.

35.1.3 Differential Pressure (DP) Transmitter installation.

35.1.3.1 Lead sensing lines shall be ½ inch OD x 0.035 316 Stainless steel with swagelok fittings. The lead sensing lines must be sloped downward toward the transmitter at a minimum slope of 1 inch per foot. Minimize the length of the lead sensing lines. The Lead sensing lines must have isolation valves at the flow sensing device.

35.1.3.2 The Lead sensing lines must have filling Tee’s installed at the isolation valves. These Tee’s should be installed in a Bull-nose fashion.

35.1.3.3 When installed on Steam service a blowdown must be added to the Lead sensing lines.
35.1.4 Steam Flow:

35.1.4.1 For Steam Flow measurement provide Spirax Sarco Gilflo Flowmeter device complete with a Smart Differential Pressure Transmitter. The Gilflo flowmeter is a spring loaded variable area orifice with high turndown capability (100:1) and a differential pressure output. Note: The transmitter must have density compensation. No substitutions. (to be sized by mechanical consultant).

35.1.5 Water (Heating or Chilled)

35.1.5.1 Provide Siemens Ultrasonic Flowmeter STRANS FUS1010 or ABB Vortex TRIO-WRL VT-40 or an approved equal.

35.1.5.2 The above flow metering devices must be capable of HART protocol.

35.1.5.3 Flow meters to be sized by mechanical consultant.

35.1.6 BTU Metering (Standalone with remote monitoring)

35.1.6.1 BTU metering shall be accomplished by an assembly consisting of the following:

35.1.6.2 All BTU Metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). See section 35.1.1.1.

35.1.6.3 Flow metering device as specified in section 35.1.

35.1.6.4 High Precision Temperature Sensors: (for heating or chilled water temperature inputs used for BTU calculations) as specified in section 34.

35.1.6.5 Local digital display/Flow Computer Unit

35.1.6.6 The Local display/Flow Computer unit shall be programmable for various flow meter types including linear, square root, or multi-point linearization data interpretation.

35.1.6.7 4-20ma flow input from flow transmitter.

35.1.6.8 Two High Precision Temperature Sensors (see section 34)

35.1.6.9 Flow transmitter may be simultaneously (looped) connected to the Digital Display/Flow Computer and the Central Control & Monitoring System (CCMS) via a Signal Isolator for ABB or approved equal.

35.1.6.10 This Display/Flow computer unit shall operate in an environment of 0 to 50 C, shall include a keypad for data input and retrieval, and an LCD display.

35.1.6.11 Shall include a EEPROM/nonvolatile RAM.

35.1.6.12 Power supply shall be 115VAC.

35.1.6.13 The flow and BTU data accumulated shall be stored in a battery backed data logger in continuous and periodic modes. Unit shall have a real time clock and shall date stamp logged data. Unit shall have an RS-232 port and shall be capable of setup from the keypad or laptop computer.

35.1.6.14 Provide all configuration software and licenses and all required interface cables to the UT “Controls and Tech Support Group”.

35.1.6.15 The BTU Display/Flow computer supplier shall set up and verify BTU measurement and shall train UT “Controls and Tech Support Group” personnel in all aspects of BTU computer setup and operation.
35.1.6.16 BTU meter installation shall be complete including sensor wiring, power wiring, coordination of flow meter installation in a pipeline, and setup for operation.

35.1.6.17 Approved Manufacturer and Model: SpiraxSarco Model M800 or an approved equal.

35.1.7 Condensate Metering

35.1.7.1 A condensate flow meter shall be installed on the line leaving the condensate tank returning back to the Central Steam Plant.

35.1.7.2 The flow meter must have a working pressure of 230 psi (16bar) and 266 degs. F (130 degs. C) operating temperature.

35.1.7.3 Equipped with a register reading smallest quantity of 1 Liter. Cubic Meter and a capacity register/pulse counter of 100 Cubic Meters (thousands). Complete with remote reading capability.

35.1.7.4 All Condensate Metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). See section 35.1.1.1

35.1.7.5 Installation

35.1.7.5.1 The meter must be installed in a clean pipeline, free from any foreign materials. 35.1.7.5.2 The flow meter must have 10 pipe diameters upstream of the unit and 5 downstream to ensure proper flow through the meter. (Refer to Diagram 15.7 for installation details)

35.1.7.6 Provide a Kent/AMCO Hot Water Meter Model M190 or an approved equal. (to be sized by Mechanical Consultant)

36 Electric/Pneumatic Transducers

36.1 Transducers shall be track mounted in an upright position.

37 Solenoids

37.1 The solenoid will be wired to a binary output on the MUX panel.

38 Safeties/Limits

38.1 All safeties and limits shall be hardwired.

38.2 No safety/limit shall be enforced through software.

39 Fire/Smoke

39.1 Fire/Smoke venting modes override both CCMS and Local DDC controllers.

39.2 Fire/Smoke venting modes are hardwired.

39.3 Fire/Smoke venting modes do not require functional CCMS/Local DDC controllers to be operative.

15900 Part B) BAS Requirements

Part 1:
GENERAL
The following sections of this document are to be used when a third party BAS is to be the primary controller.

In the event that alarms are to be directly connected to a CCMS MUX panel, the sections on alarming and equipment selection in 15900 Part A) are also applicable.
Please contact the CCMS Manager (Erik Ivanenko) @ 416-978-1900 to help determine if any parts of section 15900 Part A) apply to your project.

1. Intent

1.1. It is imperative that the processes discussed in this document be followed. Specifically: it is critical that submissions to the University of Toronto are presented prior to construction for review.

1.2. While we are aware that projects are being implemented using a “design-build” format, our reviews of the submissions can provide critical insight into the function and integration of the control systems in our environment.

1.3. We expect sufficient time to create our reviews and we expect a written response to each point raised by our reviewers.

2. Overview

The University of Toronto is a large campus with numerous buildings of various sizes and ages. A significant number of these buildings predate the modern DDC based HVAC control systems. These older building control systems are continuously being upgraded. New buildings are also being constructed on an on-going basis. To assist in the operation and maintenance of campus buildings, UT Mechanical Operations & Maintenance departments are provided with a Centralized Control & Monitoring System called CCMS to monitor these buildings from a central location; as well as, Operator Interface Workstations Personal Computer (PC) window based accessing the BAS equipment in the buildings. To facilitate the centralized CCMS, standards have been applied to the selection and installation of BAS equipment in the buildings.

This document identifies the requirements for the application of BAS in these buildings. These requirements have been developed to ensure that UT buildings are provided with high quality BAS installations.

3. Specification

3.1. Work to be done under this Section shall include furnishing of labour, materials and equipment required for installation, testing and putting into proper operation complete automatic control systems ready for continuous and satisfactory operation.

3.2. The project consultant has specified all control sequences, sizing of equipment and operation of all control elements.

3.2.1. The control systems shall be integrated to the Central Control and Monitoring System (CCMS) for the purposes of metering, monitoring, alarming and historical data collection.

3.2.2. Wiring and installation of hardware required for integration with CCMS, including network connectivity and any CCMS devices shall be provided by the contractor.

3.2.3. The contractor agrees to reimburse the University for any CCMS equipment provided by the University and damaged subsequent to delivery to the contractor. Repairs will be on a parts and labour basis. Labour charges are based on the prevailing charge out rate as established by the Facilities and Services Department.

3.2.4. Control systems are to be adjusted, calibrated, set and tested by the contractor.

3.2.5. The consultant will receive acknowledgement from the contractor that the control systems have been properly adjusted/calibrated, set and tested.

3.2.6. The control systems supplier/installer shall demonstrate, to the satisfaction of the owner/commissioning agent that the control systems are in proper operation, calibration and perform as
4. Submissions:

4.1. The University shall review materials and methods prior to installation. Pre-installation:

4.1.1. Four complete sets of shop drawings shall be submitted for review prior to installation.

4.1.2. Point wiring riser diagram indicating panel numbers and locations, conductor quantity and type (network communication, 2 pair etc.), termination designation point (eg. system and field/relay interface/control panel/MCC etc) shall be provided.

4.1.3. The quantity and location of all spare cables shall be identified.

4.1.4. Schematic control diagrams for all systems, each diagram indicating system configuration, control components, component designations, descriptions and catalogue numbers and connected control panel point addresses shall be provided.

4.1.5. The control drawings show the physical relationships of various components, such as fans/coils.

4.1.6. The control/monitoring devices can be accurately located relative to the system components.

4.1.7. Flow diagrams showing a schematic layout of the piping and equipment have been provided for all steam and liquid systems.

4.1.8. Control/Monitoring devices are shown at the appropriate locations in the piping.

4.1.9. All drawings and schematics shall be provided in PDF and Visio format.

4.1.10. Product description/technical specifications for all mechanical and control components, including valves, dampers, actuators, sensors, transmitters, etc (this is not an exhaustive list) have been provided.

4.1.11. Complete sequence of operations shall be submitted for each system.

4.1.12. Control panel faces layout shall be provided, indicating all gauges, switches and tags descriptions.

4.2. Point lists

4.2.1. A list of all physical and software points that shall be included.

4.2.2. A point list and description of function of each point shall be provided.

4.2.3. The physical point list shall contain point name, point address, point designation, point description, point type, cable number, the connected input/output device, proposed set points and alarm limits.

4.2.4. The physical point list shall identify the type of point as one of: Analog Input (AI), Analog Output (AO), Binary Input (BI), Binary Output (BO).

4.2.5. A point list and description of function for each accessible software point has been provided.

4.2.6. The software point list shall identify Analog Value (AV), Binary value (BV), Multi-state (MS).

4.2.7. A list of point objects, the vendors object names and object descriptions shall be provided to the UT in an excel spreadsheet.

4.2.8. The UT will provide point names for each point object so that the contractor can rename the points to use the UT standard.
naming convention. It is the responsibility of the contractor to provide the point lists with adequate documentation and sufficient lead time for UT to complete this process.

4.2.9. A set of control drawings containing the vendors object names and object descriptions shall be provided to the UT via PDF and Visio format.

4.3. Critical Alarms (Critical alarms are those alarms that require immediate attention.)

4.3.1. The critical alarm list will identify all points that can generate critical alarms.

4.3.2. An alarm message associated with each alarm point that is to print at the Central Steam Plant will be provided.

4.3.3. A list of recipients will be included for each SMS text alarm message. (Delivered to Cell phone or PDA).

4.3.4. The operator response/action to each alarm shall be provided.

4.3.5. A list of alarms that are intended to protect the contents of the controlled space/Faculty equipment shall be provided.

4.3.6. Alarm limits/states for all critical alarms shall be provided.

4.4. Sequence of operations

4.4.1. A sequence of operations for each system shall be provided.

4.4.2. The sequence of operations includes all set-points/schedules and operating modes.

4.4.3. The sequences of operation are sufficiently detailed to enable the control system programmer to implement.

4.4.4. The sequence of operations will include an optimum start/stop schedule based on outside air temperatures for night set-back and morning start-up.

4.4.5. All sequences are provided as MS Word documents.

4.5. Post installation:

4.5.1. Four printed copies of as-built control drawings will be submitted

4.5.2. One electronic copy of all drawings in PDF and Visio format

4.5.3. One copy of all text files in Microsoft Word or ASCII format as appropriate.

4.5.4. A report that cross-references the wire number to shop drawing label shall be submitted.

4.5.5. All configuration software and licences used in the configuration and installation of the BAS shall be provided to the UT.

4.5.6. All spreadsheets and other data files used in the configuration/installation of the BAS shall be provided to the UT.

4.5.7. As part of the Operating and Maintenance manuals, submit a Programmer’s, User guide, Operators guide and installers guide to UT “Controls and Technical Support Group” plus one hard copy and CD version of these manuals.

4.5.8. Provide one laptop PC to function as a portable terminal/service tool.

4.5.8.1. The laptop will be commercially available (i.e. Non-proprietary) with Windows operating system, the standard control vendor’s control system engineering tool set.

4.5.8.2. All configuration software and data files shall be present and functional on this laptop.

4.5.8.3. All information required to operate the laptop will be made
available on that laptop. Eg. look-up charts.

4.5.8.4. The laptop will plug in directly to all DDC and Unitary controllers using standard cabling (Ethernet preferred).

4.5.8.5. The laptop will:
   4.5.8.5.1. Backup and restore controller databases for all system panels.
   4.5.8.5.2. Display all point logs.
   4.5.8.5.3. Add, Modify and/or delete any existing or new system point.
   4.5.8.5.4. Command, change set-points, enable/disable control for any system/point.
   4.5.8.5.5. Program and load custom control sequences as well as standard energy management programs.

4.5.8.6. Connection of the laptop to any controller shall not interrupt nor interfere with normal network operation in any way.

4.5.8.7. Connection of the laptop to any controller shall not interrupt nor interfere with the usual alarm annunciation methods.

4.5.8.8. Connection of the laptop to any controller shall not interrupt nor interfere with centrally initiated commands/system modifications.

Building Automation System (BAS)

5. ACCEPTABLE CONTROL SYSTEM MANUFACTURERS
   - Johnson Controls Inc.
   - Siemens Building Technologies
   - Honeywell Inc.

5.1 The following are a list of abbreviations used throughout these design guidelines:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
</tr>
<tr>
<td>AI</td>
<td>Analog Input</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>ASC</td>
<td>Application Specific Controller</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigerating and Air-Conditioning Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing Materials</td>
</tr>
<tr>
<td>BACnet</td>
<td>Building Automation and controls Network (ANSI/ASHRAE Standard 135-2001)</td>
</tr>
<tr>
<td>BAS</td>
<td>Building Automation System</td>
</tr>
<tr>
<td>BLSC</td>
<td>Building Level Supervisory Controller</td>
</tr>
<tr>
<td>BTU</td>
<td>British Thermal Unit</td>
</tr>
<tr>
<td>CCMS</td>
<td>Central Control &amp; Monitoring System (U of T)</td>
</tr>
<tr>
<td>CFM</td>
<td>Cubic Feet Per Minute</td>
</tr>
</tbody>
</table>
6. **LAPTOP PC – SERVICE TOOL**

6.1. Provide, a commercially available laptop PC with Windows operating system, standard control system engineering tool set complete with all configuration software and licenses and provide all required interface cables the UT “Controls and Tech Support Group”

6.2. The laptop shall plug directly into all Direct Digital Controller (DDC) controllers and unitary controllers using a standard Ethernet connection.

6.3. Functionality of the portable operator’s terminal.

6.3.1. Backup and restore controller databases.

6.3.2. Display all point logs.

6.3.3. Add, modify and delete any existing or new system point.

6.3.4. Command; change set point, enable/disable any system point.
6.3.5. Program and load custom control sequences as well as standard energy management programs.

7. LOCAL CONTROL PANELS
   7.1. Local control panels shall be constructed of steel, high strength composite, or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color.
   7.2. Construction shall comply with NEMA 1 standards for interior panels, NEMA 4 for exterior panels. Local control panels shall be permanently labeled on door face.
   7.3. Panel mounted control devices, temperature indicators, relays, switches and gauges shall be factory installed and permanently labeled. Devices shall be located inside or flush mounted on face of panel.
   7.4. The panel must be equipped with 120 VAC power duplex receptacle for accommodating a Laptop.

8. NETWORKING COMMUNICATIONS
   8.1. BACnet Router: The BAS shall use the campus Wide Area Network (WAN) for communication to the campus vendor specific server.
   8.2. The communication between the UT central server (CCMS) and the BAS shall be BACnet/IP.
   8.3. The BAS shall support the BACnet auto-discovery process, by responding to “WHO-IS-ALL” requests from the central UT server with “I-AM” responses.
   8.4. The network architecture of the local BAS shall ensure that a single “WHO-IS-ALL” request broadcast is sufficient to trigger “I-AM” responses from every BACnet device in the network. The network architecture will ensure that “I-AM” responses are not dropped due to buffer overflows, etc.
   8.5. This router or a separate broadcast manager shall limit BACnet data traffic to within the building level network until a remote request for information is requested or when a message must be transmitted outside the building level network.
   8.6. The building level network (Tier 2) will use BACnet/MS-TP. Other building level communication protocols are not permitted without express written consent of the Manager of the Controls and Technical Support Group University of Toronto.
   8.7. The building level network is a network of the standard application controllers/unitary controllers that control/monitor directly connected building equipment.
   8.8. Tier 1 Local Area Network (LAN) and/or Wide Area Network (WAN) communication network shall be used for communication with the Central Control & Monitoring System and building to building communication or other high speed Ethernet communications.

9. BUILDING LEVEL SUPERVISORY CONTROLLER (BLSC)
   9.1. BLSC units shall be a general purpose multiple application Direct Digital Controller/Supervisory Controller (DDC/SC) used to manage global programs, complex system control, local data storage, building
level communications and remote server
interface.

9.2. The BLSC shall have a minimum 32-bit microprocessor. Controllers
shall be capable of operating in a stand-alone capacity or within a
networked Ethernet environment.

9.3. BLSC hardware, firmware and software shall support true, non-
volatile flash memory, input/output, 12 bit A to D conversion,
hardware clock/calendar and voltage transient and lightning protection
devices.

9.4. Units shall be equipped with full multi-tasking, multi-user real-time
operating system.

9.5. Controller size shall be sufficient to fully meet the requirements of this
specification.

9.6. The BLSC shall perform the function of monitoring all system
variables, including but not
limited to:

9.7. Hardware points, software points and controller parameters such as
setpoints.

9.8. Software/hardware required to interface at the campus intranet and
peer to peer level (Tier 1)
using the ANSI/ASHRAE Standard 135 BACnet/IP protocol.

9.9. The BLSC shall manage and direct all information traffic on the Tier 1
network, between the Tier 1 and Tier 2 networks, and to servers.

9.10. Each BLSC shall be able to extend its performance and capacity
through the use of remote Application Specific Controllers (ASC's)
and or Unitary Controllers (UC).

9.11. BLSC shall provide an RS-232C serial data communication port or
Ethernet RJ45 connection for operation of local operator I/O devices
independent of the LAN used for primary access, such as industry
standard printers, operator terminals, modems and portable laptop
operator terminals.

9.12. The BLSC shall allow temporary use of portable devices without
interrupting the normal operation of permanently connected Ethernet,
modems, printers or terminals.

9.13. Each BLSC shall have sufficient memory to support its own perating
system and databases, Including:

9.13.1. Control processes
9.13.2. Energy management applications
9.13.3. Alarm management applications including custom alarm
messages for each level of alarm for each point in the system
9.13.4. Historical / trend data for points specified
9.13.5. Maintenance support applications
9.13.6. Custom processes
9.13.7. Operator I/O
9.13.8. Ethernet/Dial-up communications

9.14. Configuration and Download: The BLSC shall have the capability of
receiving configuration and program loading by means of the
following:

9.14.2. Over the network, from the portable laptop service tool.
9.14.3. From the server or associated operator workstation PC, via the communication networks.

9.15. Configuration and Upload: The BLSC shall have capabilities of uploading configurations program to be archived on local operator terminal and/or remote server.

9.16. Each BLSC shall contain both software and firmware to perform global control strategies.

9.17. Each BLSC shall continuously perform self-diagnostics, including communication diagnosis of all panel components. The BLSC shall provide both local and remote annunciation of any detected component failures, low battery condition or repeated failure to establish communication.

9.18. Isolation shall be provided at all peer-to-peer network termination’s; as well as, all field point termination’s to suppress voltage transients consistent with IEEE Standards 587-1980.

9.18.1. In the event of the loss of normal power, there shall be an orderly shutdown of all BLSC’s to prevent the loss of database or operating system software. Nonvolatile flash type memory shall be incorporated for all critical controller configurations and battery backup shall be provided to support the real-time clock and volatile memory for a minimum of 72 hours.

9.18.2. Upon restoration of normal power, the BLSC shall automatically resume full operation without manual intervention. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, and operation of controlled equipment as a result of the auto restart processes.

9.18.3. Should BLSC memory be lost for any reason, the user shall have the capability of reloading the BLSC via the local RS-232C port or from an Internet client or server PC.

9.18.4. All BLSC units shall include an internal or external UPS power supply unit to insure of reliability network communications through any power outage event. UPS shall be sized for 50% spare capacity. The UPS shall be complete with batteries, external bypass and line conditioning.

9.18.5. The consultant shall consider UPS power backup for BLSC units when a controlled shutdown and startup of equipment is required when power is transferred from regular to emergency power. Power for BLSC controllers, ASC controllers shall be served from emergency power when controlling emergency powered equipment. 

Note: All supervisory controllers located upstream of any controller powered from the emergency system in the network should also be tied to emergency power to ensure communication is maintained throughout the BAS architecture.

9.18.6. The BLSC shall be capable of direct connection to multiple field busses.

BACnet/MS-TP is a required.
10. INTEGRATION WITH CCMS

10.1. The UT will provide the CCMS integration module (IM) for installation on the same network as the BLSC.
10.2. The contractor will provide an Ethernet drop to network the IM to the BLSC and internet.
10.3. The contractor will provide a points list to the UT, with sufficient documentation to enable the UT to provide standard names to the point objects.
10.4. The contractor will work with the UT “Controls and Technical Support Group” to ensure that all point objects are accessible via BACnet/IP and are named in accordance with the standard UT naming convention.
10.5. All point information from the internal building network will be accessible via BACnet/IP.
10.6. The BACnet implementation is a native-BACnet implementation.
10.7. A BACnet gateway into a proprietary BAS network shall not been installed.
10.8. The internal building network shall consist of one or more BACnet MS/TP segments.
10.9. Only BACnet MS/TP is present in the building level BACnet network. A written request must be provided and has been approved requesting that any other communications protocol be installed.
10.10. The BACnet system shall connect to CCMS via BACnet/IP.
10.11. The controls contractor will make any necessary configuration changes to ensure that the BACnet/IP connection can communicate to CCMS.
10.12. All necessary communications cabling is installed by the contractor for integration with CCMS in EMT/conduit accordance to division 16.
10.13. The EMT/Conduit shall be sized so that the fill ratio is less than 60%.
10.14. The BACnet system supports all of the named BIBBs in this specification:
   10.14.1. The BACnet system shall support intrinsic alarms for alarming of monitored points, (eg. Space conditions, media temperature/pressure, run-time status, binary alarms etc).
   10.14.2. All alarms (eg. Value out of range, status etc) are reflected in the status_flags property (type BACnetStatusFlags) of the objects (property_id = 111)
   10.14.3. The BACnet system supports the ReadPropertyMultiple service, as per BIBB DS-RPM-B
   10.14.4. The ReadPropertyMultiple service can be used to read a single object property.
   10.14.5. The BACnet system supports an “Autodiscovery” process via BIBB DM-DDB-B
   10.14.6. The BACnet device object will return the object list through the ReadPropertyMultiple request.
   10.14.7. Responses to BACnet requests may or may not be segmented.

10.15. Alarming via BACnet

   10.15.1. Algorithmic alarming of monitored points is not required and shall not be implemented.
   10.15.2. Intrinsic alarms are necessary for all critical alarms being
monitored.

10.15.3. Monitored BACnet points will be alarmed by CCMS by polling point value and alarm status.

10.15.4. Alarm status will reflect the limits or state the monitored value, not the health of the point.

11. APPLICATION SPECIFIC CONTROLLERS (ASC)

11.1. The ASC shall have the performance and capacity to control Fan Coil Units, Unit Ventilators, Heat Pumps, Small Single Zone Air Handlers, Clean Rooms, Roof Top Air Handlers…. etc.

11.2. Controllers shall be capable of field configuration and program uploads and downloads.

11.3. Controllers shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the BAS network.

11.4. Controllers shall be a microprocessor-based, multi-tasking, real-time digital control processor.

11.5. The ASC shall have the capability of allowing the BLSC to monitor temperatures, alarms and system status.

11.6. ASC’S shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 4- 20ma proportional signals, 0-5 Vdc or 0-10 Vdc proportional signals allowing for interface to a variety of modulating actuators.

11.7. Provide a LCD Display Terminal unit as an Operator user interface for the ASC controllers. This display unit must have a password access for protection and adjusting/overriding capabilities allowing authorized users to adjust setpoints and to override outputs between defined limits or it can be used to perform more complex workstation tasks. The display can be a portable, hand-held unit for more than one controller, or permanently mounted in a panel or on the wall as an integral part of a single controller.

12. VAV Terminal Controllers

12.1. The unit controller used for VAV applications shall support the air terminal unit used as the basis of design for this project, including the air terminal unit damper actuator and multi-point, center averaging velocity sensor. The controller shall be capable of controlling the air terminal unit in all control strategies as described in contract documents.

12.2. Setpoints, flow limits, and occupancy schedules shall be maintained indefinitely in each controller’s non-volatile memory. No batteries shall be required.

12.3. It shall be possible to monitor flow in CFM and to adjust flow limits, temperature setpoints, and schedules, by direct access to the terminal unit via the Building Level Controller (BLSC); as well as, having direct access to the terminal unit by plugging in a standard laptop computer or PDA device at the room temperature sensor.

12.4. Each controller shall control by modulating the terminal unit electrically actuated device(s) using a proportional/integral (PI) algorithm with programmable PI coefficients.

12.5. If required by the sequence of operation, ASC’s used as a VAV terminal unit controllers shall be able to accept a relay input from an occupancy sensor. This input shall toggle the air terminal unit between occupied and unoccupied modes and override occupied/unoccupied scheduling information the air terminal unit receives from the BLSC.

12.6. If required by the sequence of operation, ASC’s used as a VAV
terminal unit controllers shall be able to accept occupied/unoccupied scheduling information from the BLSC

13. Unitary Controllers (UC)

13.1. All Unitary Controllers (UC) shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in EEPROM or flash RAM.

13.2. The UC shall be a node on one of the Automation Level Network LANs and shall control its own communications so that the failure of any one node shall not inhibit communications on the network between the remaining nodes.

13.3. UC shall be BACnet Advanced Application Controller (B-AAC) and/or BACnet Application Specific Controller (B-ASC) type controllers incorporated at the Automation Level. All controllers shall be tested and certified compliant by the BACnet Testing Laboratory (BTL).

13.4. Provide each UC with a battery back-up or EEPROM for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven year life.

13.5. All associated applications programs shall reside at the UC. UC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.

13.6. Control shall be based on either three term algorithms, i.e. proportional plus integral plus derivative, or two term algorithms, i.e. proportional plus integral, unless specified otherwise.

13.7. Failure of one UC shall not affect the BMS monitoring and control or operation of other unitary equipment or BMS devices.

13.8. Provide a LCD Display Terminal unit as an Operator user interface for the UC controllers. This display unit must have a password access for protection and adjusting/overriding capabilities allowing authorized users to adjust setpoints and to override outputs between defined limits or it can be used to perform more complex workstation tasks. The display can be a portable, hand-held unit for more than one controller, or permanently mounted in a panel or on the wall as an integral part of a single controller.

14. WORKSTATION OPERATOR INTERFACE

14.1. Basic Interface Description

14.1.1. The software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. The software shall provide, as a minimum, the following functionality:

14.1.1.1. Real-time graphical viewing and control of environment
14.1.1.2. Scheduling and override of building operations
14.1.1.3. Collection and analysis of historical data
14.1.1.4. Point database editing, storage and downloading of controller databases
14.1.1.5. Alarm reporting, routing, messaging, and acknowledgment
14.1.1.6. Display and graphing of dynamic data trend.
14.1.1.7. Must be able to run multiple plots simultaneously
14.1.1.8. Each plot must be capable of supporting 10 pts/plot minimum
14.1.1.9. Must be able to command points directly off dynamic trend plot application.
14.1.1.10. Definition and construction of dynamic color graphic displays.
14.1.1.11. Program editing
14.1.1.12. Transfer trend data to 3rd party software
14.1.1.13. Scheduling reports
14.1.1.15. Open communications via operator workstation Server
14.1.1.16. Open communications via BACnet Client & Server

14.1.2. Use existing graphical user interface, which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

14.1.3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows XP based 32 bit operating system. These Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

14.1.4. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows:

14.1.4.1. Dynamic color graphics and graphic control
14.1.4.2. Alarm management, routing to designated locations, and customized messages.
14.1.4.3. Year in advance event and report scheduling
14.1.4.4. Dynamic trend data definition and presentation
14.1.4.5. Graphic definition and construction
14.1.4.6. Program and point database editing on-line.

14.1.5. Operator shall be able to drag and drop information between applications, reducing the number of steps. Example: (Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).

14.1.6. Report and alarm printing shall be a manual function done locally at the Operator Workstation.

**14.2. Username Password Access protection**

14.2.1. U of T Operator specific Username and Password access protection shall be provided to allow the Administrator to limit workstation control, display and data base manipulation as deemed appropriate for each user.

14.2.2. Access control should allow for the following groups of capabilities:
14.2.3. Monitoring only
14.2.4. Monitoring plus set-point changes, forcing outputs, Trending & Scheduling activities.
14.2.5. Administrator access limited to the UT “Controls and Tech Support Group” personnel.  
**NOTE:** Username and Password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
14.2.6. Reports shall be generated on demand or via pre-defined schedule and directed to LCD displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

14.2.7. A general listing of all or selected points in the network
14.2.8. List of all points currently in alarm
14.2.9. List of all points currently in override status
14.2.10. List of all disabled points
14.2.11. List of all points currently locked out
14.2.12. List of user accounts and access levels
14.2.13. List all weekly schedules
14.2.14. List of holiday programming
14.2.15. List of limits and dead bands
14.2.16. Custom reports from 3rd party software
14.2.17. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
14.2.18. List of programs

14.3. **Scheduling and override**

14.3.1. Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line; PC is not required to execute time scheduling.
14.3.2. Provide override access through menu selection or function key.
14.3.3. Provide the following spreadsheet graphic types as a minimum:
   14.3.3.1. Weekly schedules
   14.3.3.2. Zone schedules, minimum of 200 unique zones
   14.3.3.3. Scheduling for up to 365 days in advance
   14.3.3.4. Schedule reports to print at PC.
   14.3.3.5. Collection and Analysis of Historical Data
14.3.4. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to
network drives or removable disk media for future retrieval.

14.3.5. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred online to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions.

14.3.6. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

14.4. **Workstations Locations**

Provide two (2) complete Workstation for monitoring and control at the following Location:

14.4.1. Provide an Workstation Locally within the building for interfacing the BAS monitoring and control facility. Location to be determined by U T.

14.4.2. Provide an additional Workstation in the Area responsible for the operation and control of the buildings. Such as, the North, Central, South West & South East Areas.

14.5. **Dynamic Color Graphic Displays**

14.5.1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water boiler systems, and room level terminal units shall be provided by the DDC contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition.

14.5.2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.

14.5.3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

14.5.4. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" a “pointer/slider” to change the set-point.

14.5.5. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
14.5.6. Equipment state can be changed by clicking on the point block or graphic symbol and then selecting the new state (on/off) or setpoint.

14.5.7. State text for digital points can be defined up to eight characters.

14.5.8. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

14.5.9. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

14.6. **System Configuration & Definition**

14.6.1. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

14.6.2. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

14.6.3. System configuration, programming, editing, graphics generation shall be performed on-line.

14.6.4. If programming and system back up must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

14.7. **Alarm Management**

14.7.1. Alarm Routing shall allow the user to send alarm notification to PC location based on time of day, alarm severity, or point type.

14.7.2. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BAS alarm display screen shall be displayed when the user clicks on the alarm icon.

14.7.3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a
14.7.4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

15. BAS FIELD DEVICES AND INSTRUMENTATION

15.1. All BAS components, including equipment, instrumentation, field devices, etc., shall be ULc, UL, listed, and CSA certified where applicable and shall bear the appropriate labeling.

15.2. BAS Field Devices and Instrumentation shall be provided in compliance with the following minimum requirements:

15.2.1. Temperature Sensors

15.2.1.1. Platinum or Nickel RTD type sensors.

15.2.1.2. Platinum RTD type temperature sensors shall be either 100 ohm Platinum at 0 Deg.C. (Coefficient of resistivity of 0.00385 ohms/ohm/Deg.C.) Class B. OR 1000 ohm Platinum at 0 Deg.C. (Coefficient of resistivity of 0.00385 ohms/ohm/Deg.C.).

15.2.1.3. Nickel RTD sensors shall be 1000 ohm.

15.2.1.4. If the RTD is 100 ohm Pt, provide a 3 wire connection.

15.2.1.5. If the RTD is 1,000 ohm Pt or Nickel, provide a transmitter at the RTD: when the I/O subsystem at the UC or DCP cannot interface directly to an RTD. If the distance between the RTD and the associated UC or DCP exceeds 50m (160 feet).

15.2.1.6. The end-to-end accuracy for all BAS monitored temperature sensors shall be ± 0.5 Deg.C. (1.0 Deg.F.). (Does not apply to temperature sensors used in metering)

15.2.1.7. An exception to the above is that positive temperature coefficient thermistor type temperature sensors are acceptable for space temperature sensing associated with terminal units (e.g. VAV terminal units, reheat coils, etc.)

15.2.2. Provide outside air temperature sensors in compliance with the following additional requirements:

15.2.2.1. Ventilated white PVC sun shield.

15.2.2.2. Wall mounted weather proof enclosure with conduit fitting.

15.2.2.3. Preferably installed at a northern exposure.

15.2.2.4. Operating temperature range of -50 °C. to +50 °C.
15.2.3. Provide **duct temperature sensors** in compliance with the following additional requirements:

15.2.3.1. Single point type sensor probe. Sensor probe length shall be no less than 1/3 of duct width or diameter.

15.2.3.2. Complete with duct mounting facilities and conduit fittings.

15.2.3.3. Operating temperature range of 0 Deg.C. to 65 Deg.C.

15.2.4. Provide **duct averaging type temperature sensors** in compliance with the following additional requirements:

15.2.4.1. Duct averaging probe materials may be stainless steel, copper or aluminum.

15.2.4.2. Probe length of 3.66m (12 feet) minimum or 3.25m per sq.m. (one linear foot per square foot) of duct cross-sectional area, whichever is greater.

15.2.4.3. Duct mounted moisture/waterproof housing with conduit fitting.

15.2.4.4. Suitable supports at all bends and at intermediate points to prevent movement in the air stream.

15.2.4.5. Operating temperature range of -5 Deg.C. to 50 Deg.C.

15.2.5. Provide **Space Thermostats on BAS system** in compliance with the following additional requirements:

15.2.5.1. All thermostats must be capable of local temperature setpoint adjustment limiting, occupied/unoccupied mode, motion detection and reporting to the BAS system were applicable. (To be determined by Mechanical consultant)

15.2.5.2. All space thermostats shall not have local temperature indication.

15.2.5.3. The accuracy of the temperature sensor must be +/- 0.2° C.

15.2.5.4. All space thermostats in labs, and offices shall have exposed temperature setpoint adjustment. The temperature setpoint is limited to 18° C minimum and 23° C maximum and shall be capable of remote reset by the BAS system.

15.2.5.5. Any thermostat used in energy savings shall be capable of reporting the space temperature, setpoint, occupied/unoccupied and motion detection to the BAS system.

15.2.5.6. Thermostats requiring occupied/unoccupied must have a timed override request push button with LED status for activation after hours operation. Shall be capable of remote reset by the BAS system.

15.2.5.7. All space thermostats in public areas, such as, corridors, lobbies, cafeterias, gyms, auditoriums, classrooms...etc will have concealed setpoint adjustment with blank covers or lockable protective enclosures. Blank covers or enclosures shall be ventilated type to ensure sensor accuracy.
15.2.5.8. Insulated mounting bases must be installed when thermostat are located on exterior walls.

15.2.5.9. Each thermostat shall be capable of reporting the space temperature and setpoint. Also, shall be capable of remote reset by the BAS system.

15.2.5.10. Mounted at locations approved by U of T and the BAS Design Consultant.

15.2.5.11. For all construction projects, the space thermostats locations shall be identified in the mechanical plans.

15.2.6. **Standalone Space Thermostats** shall comply to the following:

15.2.6.1 Line-voltage thermostats shall be UL-listed, SPDT, SPST, or DPST with contact rating suitable for application, maximum 2 degree F differential. Johnson Controls T-26, Siemens 134.

15.2.6.2 Low-voltage thermostats shall be single or multi-stage heating and/or type as required by application.

15.2.6.2.1 Combination heating/cooling thermostats shall have independent adjustments for heating and cooling set points and shall not allow set point crossover.

15.2.6.2.2 Provide individual heat or cooling anticipator for each control stage. Anticipator shall be matched to connected load, or shall be adjustable.

15.2.6.2.3 Suitable switch sub-bases shall be provided when required by application, with switch functions clearly identified by permanent labels. Field-applied "stick-on" labels are not acceptable.

15.2.6.2.4 Microprocessor-based programmable type thermostats, when used, shall not lose time or program upon power failures of 12 hours or less and must have password protection capability.

15.2.6.3 All space thermostats in labs, and offices shall have exposed temperature setpoint adjustment. The temperature setpoint is limited to 18º C minimum and 23º C maximum.

15.2.6.4 All space thermostats in public areas, such as, corridors, lobbies, cafeterias, gyms, auditoriums, classrooms etc will have concealed setpoint adjustment with blank covers or lockable protective enclosures. Blank covers or enclosures shall be ventilated type to ensure sensor accuracy.

15.2.6.5 Insulated mounting bases must be installed when thermostat are located on exterior walls.

15.2.6.6 Mounted at locations approved by U of T and the Mechanical Consultant.

15.2.6.7 All new construction projects shall show the space thermostats locations identified in the mechanical plans.
15.2.7. **Space Temperature Sensors** associated with Unitary Control of Terminal Units shall comply with the following:

15.2.7.1. All space temperature sensors in labs, and offices shall have exposed temperature setpoint adjustment. The temperature setpoint is limited to 18°C minimum and 23°C maximum and shall be capable of remote reset by the BAS system.

15.2.7.2. The accuracy of the temperature sensor must be +/- 0.2°C.

15.2.7.3. All space temperature sensors in public areas, such as, corridors, concealed lobbies, cafeterias, gyms, auditoriums, classrooms …etc will have setpoint adjustment with blank covers or lockable protective enclosures. Blank covers or enclosures shall be ventilated type to ensure sensor accuracy.

15.2.7.4. Mounted at locations approved by U of T and the Mechanical Consultant.

15.2.7.5. All construction projects the space temperature sensor locations shall be identified in the mechanical plans.

15.2.8. **High Precision Temperature Sensors** used in metering (eg. BTU) applications must be in compliance with the following requirements:

15.2.8.1. Tip-Sensitive RTD sensors complete with 316 drilled stainless steel thermo-wells.

15.2.8.2. The RTD is 100 ohm Platinum Class A (100 ohm +/- 0.06 ohm @ 0 degrees C.) stainless steel sheathed element.

15.2.8.3. The sensors must be a matched pair.

15.2.8.4. Provide thermowells for temperature sensors in compliance with the following additional requirements:

15.2.8.4.1. Stainless steel probe. Probe length shall be at minimum 20% of the pipe width.

15.2.8.4.2. Moisture/waterproof housing with conduit fitting.

15.2.8.4.3. Provide complete with drilled Stainless Steel thermowells.

15.2.8.4.4. Provide complete with thermal transfer compound inside thermal well.

15.2.8.4.5. If it meets the above requirements, provide Enercorp Instruments 316SST ¾ inch or approved equal.

15.2.9. **Low Temperature Detection Device (AHU Air Service)**

15.2.9.1. Minimum 6.1 m (20 feet) vapor tension element, which shall serpentine the inlet face on all coils. Provide additional sensors, wired in series, to provide 3.25 m per sq.m. (One linear foot per square foot) of coil surface area.

15.2.9.2. Hardwire interlock device to shut down fans and position mixing dampers to the full recirculation.
position. Refer to sequences of operation.

15.2.9.3. Provide device hardwire interlocked such that AHU fan will shut down when HOA switch is in Hand or Auto position.

15.2.9.4. Manual reset.

15.2.9.5. Set-point shall be adjustable in the range of, at minimum, 0 Deg. C. to 7 Deg. C. (32 Deg. F. to 45 Deg. F.). Provide a scale with temperature setting clearly displayed.

15.2.9.6. SPDT switch contacts. Switch contacts shall be rated for duty.

15.2.9.7. Provide suitable supports.

15.2.9.8. Provide complete with auxiliary contacts for monitoring by the BAS.

15.2.10. Relative Humidity Sensors

15.2.10.1. Overall accuracy of +/- 3 % reading from 0 to 95 % RH unless the individual application requires higher accuracy.

15.2.10.2. Operating temperature range of -20 Deg.C. to 80 Deg.C.

15.2.10.3. Long term stability with less than 1 % drift per year.

15.2.10.4. Sensitivity of 0.5 % RH.

15.2.10.5. Complete with built in transmitter for 2-10 Vdc or 4-20 mA output proportional to RH to the BAS. Sensor is to be fully compatible with BAS.

15.2.10.6. Humidity sensor shall be replaceable.

15.2.11. Provide outdoor air relative humidity sensors in compliance with the following additional requirements:

15.2.11.1. Non-corroding outdoor shield to minimize wind effects and solar heating.

15.2.11.2. Wall mount weather proof enclosure with conduit fitting.

15.2.12. Provide duct mount relative humidity sensors in compliance with the following additional requirements:

15.2.12.1. Duct mount moisture resistant enclosure with conduit fitting.

15.2.12.2. 8 inch probe length.

15.2.12.3. Operating temperature range of 0 Deg. C. to 50 Deg. C. (32 Deg. F to 122 Deg. F.).

15.2.12.4. Sensor shall be suitable for operation in moving air streams as required to suit application.

15.2.13. Provide space relative humidity sensors in compliance with the following additional requirements:

15.2.13.1. Suitably finished wall mounted enclosure with discrete manufacturer logos markings only. Enclosure shall not have temperature or RH indication devices.

15.2.13.2. Mounted at locations approved by U of T and the Mechanical consultant. For new construction projects the RH sensor locations shall be identified in the
mechanical plans.

15.2.13.3. Provide protective enclosures for all sensors mounted in mechanical and electrical rooms, janitor closets, etc. Enclosure to be ventilated type to ensure sensor accuracy.

15.2.14. **Combination Relative Humidity and Temperature Sensors**

15.2.14.1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BAS contractor may provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications detailed above.

**Combination Dewpoint and Dry Bulb Temperature Transmitter**

15.2.14.2. Complete with mounting accessories and enclosures for interior or exterior wall or duct mounting.

15.2.14.3. Stainless steel probe with NEMA 4 transmitter housing. Outside air sensor shall have a solar shield.

15.2.14.4. Two wire, 4-20 mA output proportional to minimum dewpoint temperature range of -40 Deg. C. to +63 Deg.C. (-40 Deg.F. to +145 Deg.F.).

15.2.14.5. Two wire, 4-20 mA output proportional to minimum dry bulb temperature range of -23 Deg.C. to +79 Deg.C. (-10 Deg.F. to +175 Deg.F.).

15.2.14.6. Probe shall be a minimum of 200mm for duct application.

15.2.14.7. BAS shall report the monitored dry bulb temperature with an accuracy of ± 0.5 Deg. C. (1.0 Deg. F.).

15.2.14.8. BAS shall report the monitored dewpoint temperature with an accuracy of ± 1.0 Deg. C. (1.8 Deg. F.) at 50% RH and dry bulb temperature of -25 Deg.C. to +65 Deg.C. (-13 Deg.F. to 140 Deg.F.).

15.2.14.9. If it meets the above requirements, provide Honeywell HyCal model HYD840, Honeywell HyCal HYDMP2 Moisture Pro or approved equal.

15.2.15. **Latching Type Control Relays**

15.2.15.1. Pickup rating, time and hold rating as required for individual applications.

15.2.15.2. Rated for a minimum of ten (10) million mechanical operations and a minimum of 500,000 electrical operations.

15.2.15.3. Provide complete isolation between the control circuit and the BAS digital output.

15.2.15.4. Located in the BLSC, ASC, UC or other local enclosures.

15.2.15.5. Malfunction of an BAS component shall cause the controlled output to fail to the positions identified in the failure procedure.

15.2.15.6. 10 amp contact rating.
15.2.15.7. Pin type terminals complete with mounting bases.
15.2.15.8. If it meets the above requirements, provide IDEC, RR Series, Potter Bromfield, Cutler Hammer or approved equal.

15.2.16. Momentary Type Control Relays
15.2.16.1. Coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application.
15.2.16.2. Provide complete isolation between the control circuit and the BAS digital output.
15.2.16.3. Located in the BLSC, ASC, UC or other local enclosures.
15.2.16.4. 10 amp contact rating.
15.2.16.5. LED status indication.
15.2.16.6. If it meets the above requirements, provide Core Components, Model CVR or approved equal.

15.2.17. Duct Static Pressure Transmitter
15.2.17.1. Input pressure range to suit each individual application.
15.2.17.2. 4-20 mA output signal proportional to pressure input range.
15.2.17.3. ± 5% accuracy.
15.2.17.4. Operating temperature range of -7 Deg. C. to 49 Deg. C. (20 Deg. F. to 120 Deg. F.)
15.2.17.5. Easily accessible, integral non-interacting zero and span adjustment.
15.2.17.6. Minimum over pressure input protection of five times rated input.
15.2.17.7. If it meets the above requirements, provide MODUS, Model T40, Setra or approved equal.

15.2.18. Space Static Pressure Transmitter
15.2.18.1. Input range to suit application. Typically input range of -0.25 to +0.25 inches w.g.
15.2.18.2. 4-20 mA output proportional to pressure input range.
15.2.18.3. ± 5% accuracy of range.
15.2.18.4. Temperature range of 0 Deg. C. to 38 Deg. C. (32 Deg. F to 100 Deg. F.).
15.2.18.5. Easily accessible, integral non-interacting zero and span adjustment.
15.2.18.6. Over pressure input protection of five times rated input.
15.2.18.7. Exterior static pressure references shall be monitored via a static pressure sensor dampening pot. Coordinate exact mounting locations of exterior static pressure reference points. Dampening pot shall be manufactured by Dwyer, Model A-306 or approved equal.
15.2.18.8. If it meets the above requirements, provide MODUS, Model T40, Johnson Controls DPT2641, Setra or approved equal.
15.2.19. **Air Flowrate Sensor - Duct Mounted**

15.2.19.1. Multipoint flow cross or grid measuring device.

15.2.19.2. Complete with transducer. Input pressure range of pressure transducer shall be appropriate for application. Coordinate with Division 15 subcontractor.

15.2.19.3. Bulkhead fittings to allow sensor tubing to be connected or removed without removing ductwork.

15.2.19.4. Internal materials of the transducer suitable for continuous contact with air.

15.2.19.5. Sensing grid shall be constructed of stainless steel.

15.2.19.6. Integral signal integrator to minimize primary signal noise from the output signal.

15.2.19.7. Output signal of 4-20 mA proportional to input pressure.

15.2.19.8. Temperature range of -18 Deg. C. to 60 Deg. C. (0 Deg. F. to 140 Deg. F.)

15.2.19.9. ± 5% accuracy of measured value.

15.2.19.10. Transducer to be provided complete with easily accessible, integral non-interacting zero and span adjustment.

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15.2.20. **Air Flowrate Sensor - Fan Inlet**

15.2.20.1. Multipoint flow cross or grid measuring device mounted at the inlet of the fan.

15.2.20.2. Complete with transducer. Input range appropriate to application. Coordinate with Division 15 subcontractor.

15.2.20.3. Bulkhead fittings to allow sensor tubing to be connected or removed without removing the device from the fan.

15.2.20.4. Internal materials of the transducer suitable for continuous contact with air.

15.2.20.5. Sensing grid shall be constructed of stainless steel.

15.2.20.6. Integral signal integrator to minimize primary signal noise from the output signal.

15.2.20.7. Output signal of 4-20 mA proportional to input pressure.

15.2.20.8. Temperature range of -18 Deg. C. to 60 Deg. C. (0 Deg. F. to 140 Deg. F.)

15.2.20.9. Combined sensor and transducer accuracy of ± 3% of measured value.

15.2.20.10. Transducer to be provided complete with easily accessible, integral non-interacting zero and span adjustment.

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15.2.21. **Current Sensing Transformer and Relay Combination** - Electric Motor Status Monitoring Service

15.2.21.1. Rated for the applicable load.

15.2.21.2. SPDT Status Indication relay contacts. Status indication relay shall have an accessible trip
adjustment over its complete operating range. Provide LED indication of relay status.

15.2.21.3. Long term drift shall not exceed 5% of full range per 6 months.

15.2.21.4. Current transformer and relay shall have over current and over voltage protection.

15.2.21.5. Transformer and relay may be combined into a single unit or can be separate units.

15.2.21.6. Transformer core shall be sized for the application.

15.2.21.7. Accuracy—± 2% of reading from 10% to 100% of full scale range, ± 2% full scale from 0 to 10% of full scale range.

15.2.21.8. Temperature range of -15 Deg. C. to 60 Deg. C. (5 Deg. F. to 140 Deg. F.).

15.2.21.9. Must be split core complete with LED indication and have a zero and span adjustments.

15.2.21.10. If it meets the above requirements, provide Hawkeye or approved equal.

15.2.21.11. Relay portion shall not be installed within the MCC tubs. Relay portion shall be installed in local field panel enclosure, in the BLSC, ASC, UC enclosure, or in the wiring channel between MCC tubs. Provide device securely mounted with screw type wire terminations.

15.2.21.12. Device shall be mounted for easy access.

15.2.22. Water Differential Pressure Sensor (not used in flow metering)

15.2.22.1. Cast aluminum NEMA 1 enclosure.

15.2.22.2. Complete with transducer with output of 4-20 mA proportional to the pressure sensed.

15.2.22.3. Over pressure protection of five times the rated input.

15.2.22.4. Easily accessible, integral non-interacting zero and span adjustment.

15.2.22.5. Operating range to suit application.

15.2.22.6. Accuracy of ± 2% of full scale reading.

15.2.22.7. Valved tappings shall be installed by the Division 15 subcontractor. Furnish the valves to the Division 15 subcontractor. Provide differential pressure transducer installation complete with a 3-valve manifold mounted within a suitable enclosure. Installation shall allow the transducer to be isolated for service.

15.2.22.8. If it meets the above requirements, provide Setra, Model 230, modus or approved equal.

15.2.23. Differential Pressure Switch - Air Service - Duct Static Pressure Limit Devices

15.2.23.1. UL, ULc, CSA listed and approved.

15.2.23.2. SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.

15.2.23.3. Adjustable set-point with a setpoint range to suit the application.
15.2.23.4. 1/4 inch compression fittings suitable for copper sensing tubing.
15.2.23.5. Temperature range of -18 Deg. C. to 71 Deg. C. (0 Deg. F. to 160 Deg. F.).
15.2.23.7. Provide sensing inputs complete with signal dampening facilities to prevent nuisance tripping where required.
15.2.23.8. If it meets the above requirements, provide Dwyer, or approved equal.

15.2.24. **Differential Pressure Switch - Air Service - Filter Status Indication**

15.2.24.1. UL, ULc, CSA listed and approved.
15.2.24.2. SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.
15.2.24.3. Adjustable set-point with a setpoint range to suit the application.
15.2.24.4. 1/4 inch compression fittings suitable for copper sensing tubing.
15.2.24.5. Operating range to suit application.
15.2.24.6. Automatic reset
15.2.24.7. If it meets the above requirements, provide devices as manufactured by Cleveland Controls, Inc. (Model AFS-222) Dwyer, or approved equal.

15.2.25. **Differential Pressure Switch - Water Service**

15.2.25.1. UL, ULc, CSA listed and approved.
15.2.25.2. SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.
15.2.25.3. Adjustable set-point with a setpoint range to suit the application.
15.2.25.4. 1/4 inch compression fittings suitable for copper sensing tubing.
15.2.25.5. Operating temperature and pressure range to suit application.
15.2.25.6. Durable Nema-4 rated enclosure.
15.2.25.7. Provide sensing inputs complete with signal dampening facilities to prevent nuisance tripping where required.
15.2.25.8. Suitable for continuous contact with the sensed fluid and rated for operating temperature.
15.2.25.9. Repeatability of +/- 1 % of span.
15.2.25.10. Over pressure input protection to a minimum of five (5) times rated input.
15.2.25.11. If it meets the above requirements, provide devices as manufactured by Dwyer, Penn or approved equal.

15.2.26. **Water Pressure Sensor**

15.2.26.1. Input range of 0 to 200 psi or range as per mechanical consultant.
15.2.26.2. Complete with transducer with 4-20 mA output signal
proportional to water pressure.
15.2.26.3. 0.5% accuracy over entire sensing range.
15.2.26.4. Temperature range of 0 Deg. C. to 38 Deg. C. (32 Deg. F to 100 Deg. F.).
15.2.26.5. Transducer with easily accessible, integral non-interacting zero and span adjustment.
15.2.26.6. Over pressure input protection of two times rated input.
15.2.26.7. NEMA-4 rated fittings.
15.2.26.8. Stainless steel wetted parts.
15.2.26.9. Burst pressure of 5 times rated input
15.2.26.10. Long-term stability of .25 percent of full scale.
15.2.26.11. Shall be ANSI 300 rated or as per mechanical consultant.
15.2.26.12. Stainless Steel wetted parts suitable for continuous contact with the sensed medium.
15.2.26.13. If it meets the above requirements, provide devices as manufactured by Dwyer or approved equal.

15.2.27. Air Quality Sensor
15.2.27.1. Measurement of volatile organic compounds (VOC) containing, at minimum, the following gases:
  15.2.27.1.1. Methane
  15.2.27.1.2. Ethylene
  15.2.27.1.3. Hydrogen
  15.2.27.1.4. Carbon Monoxide
  15.2.27.1.5. Carbon Dioxide
  15.2.27.1.6. Ammonia
15.2.27.2. Ventilated cover, Circuit board covered by a polycarbonate housing.
15.2.27.3. 135 mA max current, 4 K OHMS min. load resistance, 24 VAC + 10%- 50% or 24DC. (Min. 12V, Max 24V) power supply.
15.2.27.4. Rate or rise circuit to filter out short term disturbances and provide a stable output.
15.2.27.5. Temperature range of 0 Deg. C. to 60 Deg. C. (32 Deg. F. to 140 Deg. F.).
15.2.27.6. Mounting and enclosure suitable for duct air or space air monitoring as specified.
15.2.27.7. If it meets the above requirements, provide G-Controls, Model AQS/D or approved equal.

15.2.28. Carbon Dioxide Sensor
15.2.28.1. Negligible temperature and humidity effect on accuracy.
15.2.28.2. Complete with transducer with selectable 4-20 mA or 0-10VDC output signal proportional to carbon dioxide concentration.
15.2.28.3. 0 - 2000 ppm CO2 sensing range.
15.2.28.4. Manufacturer 5 year or longer calibration interval guarantee.
15.2.28.5. Accuracy - ± 3% of reading or ± 50 ppm, whichever is the more stringent requirement over 15 Deg.C. to 32 Deg.C temperature range. (60 Deg.F. to 90 Deg.F.) Accuracy of +/- 5 % or 100ppm of reading whichever is the more stringent requirement over 0 Deg.C. to 50 Deg.C temperature range. (32 Deg.F. to 122 Deg.F.).

15.2.28.6. Annual Drift not to exceed +/- 10 ppm.

15.2.28.7. Operating temperature of 0 Deg. C. to 50 Deg. C. (32 Deg. F. to 122 Deg. F.).

15.2.28.8. Complete with auxiliary relay contacts for alarm indication.

15.2.28.9. For space monitoring applications provide with a white enclosure with no manufacturer Logo or LED indication. Provide complete with blank display cover.

15.2.28.10. For duct sensing applications provide sensor complete with aspiration box and air stream sensor.

15.2.28.11. If it meets the above requirements, provide Vaisala or approved equal.

15.2.28.12. Non-dispersive Infrared technology based sensor.

15.2.29. **Damper Position Switch**

15.2.29.1. Mechanically actuated electrical switch.

15.2.29.2. Provide damper end switch which indicates actual damper blade position.

15.2.29.3. Damper position switches which are actuated by damper crankshaft or actuator position will not be accepted.

15.2.29.4. Contacts shall be rated for the electrical load to be switched.

15.2.29.5. Provide auxiliary contacts as required.

15.2.30. **Electronic to Pneumatic Transducers**

15.2.30.1. Provide current-to-pneumatic (I/P) transducers for BAS DDC control of pneumatically actuated devices.

15.2.30.2. Output range shall be as required for the control device.

15.2.30.3. Provide device mounted within the associated BLSC/ASC/UC controller panel or remote field panel enclosure mounted adjacent to the associated BLSC/ASC/UC.

15.2.30.4. Operable temperature range of, at minimum, -10 Deg. C. to 50 Deg. C. with 5% to 90% RH (non-condensing).

15.2.30.5. Internal materials suitable for continuous contact with commercial standard controls air supply

15.2.30.6. Combined non-linearity, hysteresis and repeatability effects not to exceed +/- 2% of span over the entire range.

15.2.30.7. Integral and accessible zero and span adjustments.

15.2.30.8. Complete with pressure gauge on the pneumatic control output.
15.2.30.9. Capable of accepting a 4-20 mA, 0-10 vdc, or other industry standard control signal and outputting a corresponding proportional output pressure.
15.2.30.10. Capable of manual override of output signal.
15.2.30.11. If it meets the above requirements, provide devices as manufactured by KMC, EXC 3004 or approved equivalent.

15.3. Installation
15.3.1. Install sensors in accordance with the manufacturers recommendations to sense the variables specified.
15.3.2. Mount sensors securely. Mountings shall be suitable for the environment within which the sensor operates.
15.3.3. Install sensors as required to properly sense the controlled medium.
15.3.4. Sensor locations shall be such that access to the instruments can be obtained for service and removal.
15.3.5. Sensors mounted on water lines shall have isolation valves that shall enable the sensor to be easily removed without the need to drain any lines or portions of lines.

16.1. Flow metering used for measuring energy consumption.
16.1.1. Flow metering installations shall comply with ANSI 2530/ASME Fluid Meters standards.
16.1.1.1 All metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). For detailed information please contact the Manager of the UT Controls and Tech Support Group at (416) 978-1900.
16.1.2. Flow metering installation details include:
16.1.2.1. 30 pipe diameters of straight pipe length upstream and 3 pipe diameters downstream of the flow sensing device or approved by UT Controls and Tech Support Group.
16.1.2.2. A flow straignter shall be installed where sufficient upstream pipe length is not available.
16.1.2.3. The DP transmitter must be equipped with a three-way manifold.

16.1.3. Differential Pressure (DP) Transmitter installation. □ □ □
16.1.3.1. Lead sensing lines shall be ½ inch OD x 0.035 316 Stainless steel with swagelok fittings. The lead sensing lines must be sloped downward toward the transmitter at a minimum slope of 1 inch per foot. Minimize the length of the lead sensing lines. The Lead sensing lines must have isolation valves at the flow sensing device.
16.1.3.2. The Lead sensing lines must have filling Tee’s installed at the isolation valves. These Tee’s should be
installed in a Bull-nose fashion.

16.1.3.3. When installed on Steam service a blowdown must be added to the Lead sensing lines.

16.1.4. **Steam Flow:**

16.1.4.1. For Steam Flow measurement provide Spirax Sarco Gilflo Flowmeter device complete with a Smart Differential Pressure Transmitter. The Gilflo flowmeter is a spring loaded variable area orifice with high turndown capability (100:1) and a differential pressure output.

Note: The transmitter must have density compensation. **No substitutions.** (to be sized by mechanical consultant).

16.1.5. **Water (Heating or Chilled)**

16.1.5.1. provide Siemens Ultrasonic Flowmeter STRANS FUS1010 or ABB Vortex TRIO-WRL VT-40 or an approved equal.

16.1.5.2. The above flow metering devices must be capable of HART protocol.

16.1.5.3. Flow meters to be sized by mechanical consultant.

16.1.6. **BTU Metering (Standalone with remote monitoring)**

16.1.6.1. BTU metering shall be accomplished by an assembly consisting of the following:

16.1.6.2. All BTU Metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). See section 16.1.1.1.

16.1.6.3. Flow metering device as specified in section 16.1.

16.1.6.4. High Precision Temperature Sensors: (for heating or chilled water temperature inputs used for BTU calculations) as specified in section 15.2.8.

16.1.6.5. Local digital display /Flow Computer Unit

16.1.6.6. The Local display/Flow Computer unit shall be programmable for various flow meter types including linear, square root, or multi-point linearization data interpretation.

16.1.6.7. 4-20ma flow input from flow transmitter.

16.1.6.8. Two High Precision Temperature Sensors (see section 15.2.8.)

16.1.6.9. Flow transmitter may be simultaneously (looped) connected to the Digital Display/Flow Computer and the Central Control & Monitoring System (CCMS) via a Signal Isolator for ABB or approved equal.

16.1.6.10. This Display/Flow computer unit shall operate in an environment of 0 to 50 C, shall include a keypad for data input and retrieval, and an LCD display.

16.1.6.11. Shall include a EEPROM/nonvolatile RAM.

16.1.6.12. Power supply shall be 115VAC.

16.1.6.13. The flow and BTU data accumulated shall be stored in a battery backed data logger in continuous and
periodic modes. Unit shall have a real time clock and shall date stamp logged data. Unit shall have an RS-232 port and shall be capable of setup from the keypad or laptop computer.

16.1.6.14. Provide all configuration software and licenses and all required interface cables to the UT “Controls and Tech Support Group”.

16.1.6.15. The BTU Display/Flow computer supplier shall set up and verify BTU measurement and shall train UT “Controls and Tech Support Group” personnel in all aspects of BTU computer setup and operation.

16.1.6.16. BTU meter installation shall be complete including sensor wiring, power wiring, coordination of flow meter installation in a pipeline, and setup for operation.

16.1.6.17. Approved Manufacturer and Model: SpiraxSarco Model M800 or an approved equal.

16.1.7. Condensate Metering

16.1.7.1. A condensate flow meter shall be installed on the line leaving the condensate tank returning back to the Central Steam Plant.

16.1.7.2. The flow meter must have a working pressure of 230 psi (16bar) and 266 degs. F (130 degs. C) operating temperature.

16.1.7.3. Equipped with a register reading smallest quantity of 1 Liter. Cubic Meter and a capacity register/pulse counter of 100 Cubic Meters (thousands). Complete with remote reading capability.

16.1.7.4. All Condensate Metering shall be remotely monitored by the UT Central Control and Monitoring System (CCMS). See section 16.1.1.1.

16.1.7.5. Installation

16.1.7.5.1 The meter must be installed in a clean pipeline, free from any foreign materials.

16.1.7.5.2 The flow meter must have 10 pipe diameters upstream of the unit and 5 downstream to ensure proper flow through the meter. (Refer to Diagram 15.7 for installation details)

16.1.7.5.3 Provide a Kent/AMCO Hot Water Meter Model M190 or an approved equal. (to be sized by mechanical consultant)

16.2. Automatic Control Valves.

16.2.1. Provide automatic control valves that comply with the requirement with these requirements:

16.2.1.1. Valve schedules shall be submitted for review and shall clearly show the following for each valve:

16.2.1.1.1. Associated system

16.2.1.1.2. Manufacturer and model number.

16.2.1.1.3. Valve size and line size.
16.2.1.1.4. Flow-rate, flow coefficient (CV) - and pressure drop at design conditions or Valve authority, flow-rate and pressure drop across the valve at design conditions and pressure drop across the associated mechanical equipment, e.g., coil, heat exchanger, etc., at design conditions.

16.2.1.1.5. Valves configuration (e.g. two-way, three-way, butterfly).

16.2.1.1.6. Leakage rate.

16.2.1.1.7. Maximum pressure shut-off capability.

16.2.1.1.8. Actuator manufacturer and model number.

16.2.1.1.9. Valve body pressure and temperature rating.

16.2.1.1.10. Normally open/closed and failure positions.

16.2.1.2. Valves shall “fail safe” in a normally open or closed position as dictated by freeze, Humidity, fire or temperature protection and shall be easily accessible for servicing.

16.2.1.3. All screwed control valves from 1/2” up shall have replaceable stem plug and seat ring.

16.2.1.4. Control valve shall be provided with pneumatic or electric actuator.

16.2.1.5. Actuators shall be sized to allow the control valve to shut off against normal inlet operating pressures.

16.2.1.6. Pneumatic valve actuators used to sequence multiple valves shall be provided with pilot positioners to ensure proper sequence of each valve and to allow for an adjustable dead band between heating and cooling valves.

16.2.1.7. Valves shall have the manufacturer's name and the pressure rating clearly marked on the outside of the body. Where this is not possible manufacturer's name and valve pressure rating shall be engraved on a minimum 50mm (2 inch) diameter stainless steel tag that shall be attached to the valve by a chain in such a manner that it cannot be unintentionally removed.

16.2.1.8. Valves 13mm to 50mm (0.5 inch to 2 inches) shall have screwed ends with union fittings to allow easy removal for servicing. Valves 63mm (2.5 inches) and larger shall have flanged ends. All valves shall meet the appropriate ANSI requirements.

16.2.1.9. The BAS subcontractor shall certify that the materials of construction are appropriate for the application. In particular, valves used for the control of glycol solutions shall have a trim that is suitable for a glycol solution.

16.2.1.10. Two-way valves:

16.2.1.10.1. Shall have equal percentage characteristics.

16.2.1.10.2. Valve shall be capable of tight shut-off when operating at system pressure with the system pump operating at shut-off head. Leakage rate shall not exceed 0.01% of the rated valve.
16.2.11. Three-way valves:

16.2.11.1. Shall have linear characteristics, sized for maximum 3 psi drop.

16.2.11.2. Three-way control valves shall be of the mixing or diverting pattern type as indicated in the mechanical documents. The inner valve shall have a linear plug and stainless steel trim. Valves shall have metal-to-metal stainless steel seats to assure tight seating.

16.2.11.3. Mixing valves shall be capable of tight shut-off between each inlet port and the outlet port and diverting valves shall be capable of tight shut-off between each outlet port and the inlet port when operating at system pressure.

16.2.12. Water Service Valves:

16.2.12.1. Valves for water service shall be provided with stainless steel stems.

16.2.12.2. Valves supplied for water service at 150 psig or less shall be provided with brass plugs and elastomer U-cup or teflon packing; valves shall be provided with removable brass seat rings.

16.2.12.3. Valves supplied for water service over 150 psig shall be provided with stainless steel plugs and teflon packing; all valve sizes shall be provided with removable stainless steel seat rings.

16.2.13. Steam Service Valves:

16.2.13.1. Valves for steam service shall be provided with stainless steel stems.

16.2.13.2. Valves supplied for steam service at 35 psig or less shall be provided with brass plugs and removable brass seat ring and teflon packing.

16.2.13.3. Valves supplied for steam service over 35 psig shall be provided with stainless steel plugs and teflon packing.

16.2.13.4. For capacities of modulating steam valves greater than 2000 lbs/hr, two valves shall be supplied and sequenced, one sized for 2/3 and the other for 1/3 capacity.

16.2.14. High Temperature Hot Water Service:

16.2.14.1. Valves for High Temperature Hot Water service shall be provided with the following:

16.2.14.2. Flanged - bolts to ANSI Class 300 rated flanges (DN 25-300)

16.2.14.3. Carbon steel body materials


16.2.14.5. (DN 80-300) 316L stainless steel with...
hardfaced seating surface

16.2.1.14.7. Upper & Lower Bearings seals must be for slurry/viscous service.
16.2.1.14.10. Actuator, spring-opposed rolling diaphragm.
16.2.1.14.11. Actuator bench test spring range, 7 – 24 psi on supply.
16.2.1.14.13. Provide Masoneilan valve 35002 Series Camflex® II Complete with SVI-II smart positioner (No substitutions) sized by Mechanical Consultant

16.3. Valve Actuators – Electric/Electronic

16.3.1. The BMS subcontractor shall provide electric/electronic actuators for all valves. Pneumatic type actuators may be acceptable for steam control valves where required to meet the shut-off and torque requirements. BMS Subcontractor shall request permission from the Mechanical Consultant and U of T “Controls and Tech Support Group” for the proposed application of pneumatically actuated valves. Note: Pneumatic type actuators are required for High Temperature Hot Water service.

16.3.2. Actuator shall be motor driven type. Valve stem position shall be adjustable in increments of one (1) percent or less of full stem travel.

16.3.3. Actuator shall have an integral self-locking gear train, mechanical travel stops and adjustable travel limit switches with electrically isolated contacts.

16.3.4. Actuator gear assembly shall be made of hard-anodized aluminum or steel or material of equivalent durability. No plastic components shall be acceptable.

16.3.5. Actuator shall be rated for continuous duty and have an operating voltage of 24 VAC, an input of 0 -10 VDC or 4-20 ma control signal and provide a 0-10 VDC feedback.

16.3.6. Actuators on valves located in the outdoors shall have covers of aluminum or a material of equivalent strength.

16.3.7. Actuator motor shall be fully accessible for ease of maintenance.

16.3.8. Actuator shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head.

16.3.9. Actuator shall control against system maximum working pressures.

16.3.10. Actuator shall fail as indicated on the control drawings that form part of these contract documents. Provide spring return to de-energized position on loss of power or loss of control.
signal if so required by the sequences of operation.

16.3.11. Actuator shall accept control signals compatible with the BMS analog or digital output subsystem as appropriate. The valve stem position shall be linearly related to the control signal.

16.3.12. Actuator shall have visual mechanical position indication, showing valve position.

16.3.13. Actuator shall operate the valve from the fully closed to the fully open position and vice versa in less than two minutes.

16.3.14. Actuator shall be constructed to withstand high shock and vibration without operations failure. Materials of construction shall be non-corroding.

16.3.15. All valve actuators shall be equipped with an integral position potentiometer or 0 – 10vdc feedback to indicate the stem position of the valve All valve actuators shall have integral end position indicators.

16.3.16. Actuators shall have manual over-ride capability. The operator will be able to manually modulate valves located in mechanical rooms in the event of loss of power.

16.3.17. Actuator motor shall be fully accessible for ease of maintenance.

16.3.18. Approved Manufacturers:

16.3.18.1. Belimo
16.3.18.2. Siemens Building Technologies
16.3.18.3. Johnson Controls Inc.
16.3.18.4. Honeywell

16.4. **Damper Actuators: Electric/Electronic**

16.4.1. Unless otherwise specified the BMS Subcontractor shall provide electric/electronic actuators for all dampers. Electric/Electronic shall meet, at minimum, the following requirements:

16.4.1.1. Damper actuators shall be selected as per manufacturer’s recommendations to provide sufficient close-off force to effectively seal the damper.

16.4.1.2. Modulating actuators shall provide smooth modulating control under design flow and pressure conditions.

16.4.1.3. Provide one actuator for each damper section. Damper actuators shall not be stacked.

16.4.1.4. Multiple actuators “stacked” on a single damper drive shaft will not be acceptable.

16.4.1.5. Actuator for modulating automatic dampers shall be rated for continuous duty and have an operating voltage of 24 VAC, an input of 0-10 VDC or 4-20 ma control signal and provide a 0-10 VDC feedback.

16.4.1.6. Actuators for two position dampers shall be controlled by 24Vac, 24Vdc power.

16.4.1.7. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
16.4.1.8. All actuators shall accept 1 inches diameter shaft directly, without the need for auxiliary adapters.

16.4.1.9. All actuators shall have self-centering damper shaft clamp that guarantees concentric alignment of the actuator’s output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed “V” shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.

16.4.1.10. All actuators shall have an all metal housing made from die-cast aluminum.

16.4.1.11. All actuators must provide overload protection throughout the full range of rotation, enabling the actuator to detect a blockage in the damper and withstand a continuous stall condition without premature failure in performance.

16.4.1.12. All spring return actuators shall be capable of both clockwise or counterclockwise spring return fail-safe operation.

16.4.1.13. Stroke dampers from fully closed to fully open in accordance with the following:

<table>
<thead>
<tr>
<th>Service</th>
<th>Timing Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two position normal service</td>
<td>75 seconds</td>
</tr>
<tr>
<td>Modulating normal service</td>
<td>120 seconds</td>
</tr>
<tr>
<td>Emergency service (stair pressurization, smoke containment, Fail-safe etc.)</td>
<td>15 seconds</td>
</tr>
</tbody>
</table>

16.4.1.14. All actuators shall be equipped with a manual drive release mechanism and manual positioning mechanism in the absence of power.

16.4.1.15. Rated for operation at ambient temperatures of minus 40 Deg.C. to 50 Deg.C. (-40 Deg. F. to 122 Deg. F.).

16.4.1.16. All actuators shall provide an easily readable damper/actuator stroke position indicator.

16.4.1.17. Actuators shall be quiet in operation such that noise from actuator operation is not detectable in any occupied spaces.

16.4.1.18. Approved Manufacturers:

16.4.1.19.1. Belimo
16.4.1.19.2. Siemens Building Technologies
16.4.1.19.3. Johnson Controls Inc.
16.4.1.19.4. Honeywell
CCMS Acronym Structure

**Part 1: MUX panel connected points**

Characters 1-4 denote BUILDING numbers.  
Characters 5-8 denote Systems.  
Characters 9-12 denote points.

### SYSTEM DESIGNATIONS

Character Number 1 or the system:

- A - Air systems  
- B - Boiler  
- C - Chilled / Chiller systems  
- D - Dual systems  
- E - Electrical systems  
- F - Fire systems  
- G - Gas systems  
- H - Heating systems  
- I - Intrusion  
- K - Cooling towers  
- M - Muxes  
- W - Water systems  
- Z - Miscellaneous systems

Character Number 1-3 of the system

**Air Systems:**

- ABRx - blower  
- ACPx - compressed or control  
- ADAx - dental air  
- ADVx - dental vacuum  
- AHxx - handling systems  
- AOVx - oral vacuum  
- APKx - packaged  
- AXxx - exhaust systems

**Boiler Systems:**

- BICx - incinerator  
- BLRx - boiler

**Chilled/Chiller Systems:**

- CAGx - ammonia gas  
- CBRx - brine  
- CDCx - dechlorinated  
- CDXx - direct expansion  
- CFGx - freon gas  
- CGLx - glycol medium
CLRx - water
CRxx - room freezer

Dual Systems:

DFCx - fan coil units

Electrical Systems:

EDGx - diesel generator
EIMx - ice melting
ELLx - lighting
EMGx - motor generator
ESMx - snow melting
ESSx - substation

Fire Systems:

FIRx - main building alarm

Gas Systems:

GAMx - ammonia
GCOx - carbon monoxide
GNOx - nitrous oxide
GOXx - oxygen

GNGx - natural gas

Heating Systems:

HDCx - dechlorinated hot water
HGLx - glycol converter
HGSx - glycol snowmelting
HHDx - hot domestic
HJRx - radiation or induction
HQOx - steam condensate
HSPx - swimming pool
HSSx - steam supply
HTHx - high temp hot water
HTRx - terminal reheat
HWHx - hot water converter

Note: HWH & HGL are general purpose heating systems.
others are dedicated purpose heating systems.

Intrusion:

IBHx - bio-hazard labs
ICRx - cold room
IER. - environmental rooms
IRlx - radio-isotope labs
IRTx - intrusion
Cooling Tower Systems:

KTRx - Condenser, tower

NOTE: KTR is used for general purpose condenser tower systems only.

Multiplexer:

MUXxx- Multiplexers, CCMS

Water Systems:

WCDx - domestic, cold
WDCx - dechlorinated
WDIx - de-ionized
WDSx - distilled
WFlx - filtered
WHDx - domestic, hot
WROx - reverse osmosis

Miscellaneous systems:

ZOSx - Outside Air
ZMPx - Sump Pumps

POINT DESIGNATIONS

Character 1 of the point field:

M - Analog output point.
  - Virtual point

Character 2 of the point field:

C - chilled
D - decks hot/cold, diesel
E - electric
G - GAS
H - heated
K - condensor
M - mixed
N - snow melting
O - outside
P - pumps
Q - condensate
R - return
S - supply
V - fans
Z - binary switching/alarming
Character 2 and 3 of the point field:

Chilled:

CLx - chilled

Decks Hot & Cold, Diesel:

DCx - deck cold
DGN - diesel generator no.
DHx - deck hot

Electric:

ELx - electric

Gas:

GSx - gas

Heated:

HEx - heated
HMx - heated mass

Condenser:

KRx Condenser water, return
KSx Condenser water, supply

Load Limit:

Ln% Load Limit Percentage

Mixed:

MXx mixed

Snow Melting:

NMx Snow melting

Outside:

OSx Outside
OA% Air, percentage

Pumps:

PAx = air (air compressor)
PCx = chilled water
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDx</td>
<td>Domestic</td>
</tr>
<tr>
<td>PEx</td>
<td>Electric(al)</td>
</tr>
<tr>
<td>PFx</td>
<td>Fire fighting</td>
</tr>
<tr>
<td>PGx</td>
<td>Glycol</td>
</tr>
<tr>
<td>PHx</td>
<td>Heating hot water</td>
</tr>
<tr>
<td>PJx</td>
<td>Radiator</td>
</tr>
<tr>
<td>PKx</td>
<td>Condenser water</td>
</tr>
<tr>
<td>PQx</td>
<td>Condensate (steam)</td>
</tr>
<tr>
<td>PRx</td>
<td>Return/recirculating</td>
</tr>
<tr>
<td>PSx</td>
<td>Supply</td>
</tr>
<tr>
<td>PTx</td>
<td>Terminal reheat</td>
</tr>
<tr>
<td>PUX</td>
<td>Unit (system controller)</td>
</tr>
<tr>
<td>PVx</td>
<td>Vacuum</td>
</tr>
<tr>
<td>PWx</td>
<td>Pump sewage or bilge</td>
</tr>
<tr>
<td>Qox</td>
<td>Condensate</td>
</tr>
<tr>
<td>REx</td>
<td>Return or recirculate</td>
</tr>
<tr>
<td>Rnx</td>
<td>Return, multiple</td>
</tr>
<tr>
<td>SPx</td>
<td>Supply</td>
</tr>
<tr>
<td>Snx</td>
<td>Supply, multiple</td>
</tr>
<tr>
<td>VKx</td>
<td>Condenser</td>
</tr>
<tr>
<td>VRx</td>
<td>Return</td>
</tr>
<tr>
<td>VSx</td>
<td>Supply</td>
</tr>
<tr>
<td>VXx</td>
<td>Exhaust</td>
</tr>
<tr>
<td>VYx</td>
<td>Fume hood group</td>
</tr>
<tr>
<td>ZAx</td>
<td>System alarm</td>
</tr>
<tr>
<td>ZBx</td>
<td>Face-bypass switchover</td>
</tr>
<tr>
<td>ZCx</td>
<td>LOCAL/CCMS switchover</td>
</tr>
<tr>
<td>ZDx</td>
<td>Dampers</td>
</tr>
<tr>
<td>ZEx</td>
<td>Enthalpy</td>
</tr>
<tr>
<td>ZHx</td>
<td>Humidity</td>
</tr>
<tr>
<td>ZIx</td>
<td>Intercom</td>
</tr>
<tr>
<td>ZXx</td>
<td>Master switchover</td>
</tr>
<tr>
<td>ZOx</td>
<td>Unoccupied/occupied switchover</td>
</tr>
<tr>
<td>ZPx</td>
<td>Preheat</td>
</tr>
<tr>
<td>ZSx</td>
<td>High low speed switchover</td>
</tr>
<tr>
<td>ZUX</td>
<td>System unit switchover</td>
</tr>
<tr>
<td>Znx</td>
<td>Binary switching</td>
</tr>
</tbody>
</table>

12th FIELD of ACRONYM (4th character of point)
### Part 2: BACnet naming convention

Characters 1-4 denote BUILDING numbers.
Characters 5-12 denote Systems.
Characters 13-16 denote points.

The BACnet point naming convention differs only in the size of the system portion from the above naming convention.

The BACnet naming convention requires that the size of the system field be increased to 8 characters, the building and point portions are left unchanged.

The system acronyms are the same however, they are left justified and padded on the right by underscores.

In addition to this change, a numbering convention for room level controls has been adopted.

#### Room level equipment (eg. VAV box)

Room level controllers are identified by the room being serviced.
Character 1 of system: ‘R’ or <digit>. The <digit> replaces the ‘R’ in the event that
the room number has 5 digits.

Character 2 of system: <blank> or <digit>. The <digit> replaces the <blank> in the
event that the room number has 4 digits.

Character 3,4,5 of system: Each is a <digit>. This is the room number itself.

Character 6 of system: <blank> or <alpha>. An <alpha> character replaces the
<blank> in the event that the room is one of a suite or a hallway/stairwell.

Character 7 and 8 of system: ‘C’ followed by <digit>. This pair of characters
identifies the controller “number” within the room. All points wired back to the
same controller will have the same “number”.

Valid systems: ‘R 123 C1’, ’R1234KC2’,’12345AC1’

Examples of Complete BACnet acronyms:

‘160 R 123 C1 RMT’ denotes that in building 160, room 123 controller ‘1’ has a
room temp sensor.

‘160 R 123 C2 RMT’ denotes that in building 160, room 123 controller ‘2’ also has
a room temp sensor.

‘160 R1000KC1 SPT’ denotes that in building 160, room 1000K controller ‘1’ has a
supply temp sensor.

‘160 12002AC1 RMH’ denotes in building 160, room 12002A controller ‘1’ has a
room humidity sensor.

**BACnet point description attribute:**

This attribute contains a sensible description of the point being monitored or
controlled.

**Effects on other systems:**

The simplest approach is for all other systems to be stretched to 8 characters by
the addition of 4 underscores.

Eg. Mixed air temperature control output:

“160 AH01MMXT” => “160 AH01____MMXT”

Mixed air temperature:

“160 AH01 MXT” => “160 AH01____ MXT”

**15915 Electrical Work**

Electrical power and control wiring for mechanical equipment and systems
shall comply with the following requirements;
Motor Starters and Motor Control Centres

1. **Combination Across the Line Magnetic Motor Starters**
   1.1. Combination starters shall be CSA certified

1.2. Combination magnetic starters shall be complete with.

1.3. Main circuit breaker (fuses not acceptable) sized to provide motor short circuit protection and meet system interrupting capacity. Circuit breaker operating handle shall be lockable in the open position

1.4. Magnetic contactor

1.5. Overload relays, one per phase

1.6. Sprinklerproof enclosure for stand alone starters

1.7. Primary and secondary fused control transformer having 120vac secondary rating and 100 watt spare capacity. Fuses shall be type CC time delay

1.8. Hand-Off-Auto selector switch

1.9. Running LED type pilot light (red)

1.10. Reset Button

1.11. Minimum two sets of Form C auxiliary dry contacts in mylar enclosure and wired to a terminal strip within the starter for remote status wiring connections

1.12. Prewired control relays compatible with thermistors where motors are provided with thermistors wired to initiate immediate motor shutdown in the event of thermistor operation. Provide a separately identifiable LED type pilot light to indicate when a control relay has been operated by a motor thermistor together with a separately identifiable reset button for resetting the control relays. Wire the relay activation circuit to a terminal strip within the starter for connection to the motor thermistor wiring

1.13. Terminal strip within the starter for termination of all external protection and control wiring (e.g.: remote firestat, freezestat)

1.14. Provide accurate schematic permanently affixed to the inside of door showing all internal and external wiring connections

1.15. Provide defeat mechanism to access starter without having to deenergize starter

1.16. Starter components shall be readily accessible for replacement and shall not require major component replacement to repair or access a minor component

1.17. A lamacoid plate shall be affixed to the starter cover with stainless steel screws, identifying load supplied, voltage rating, and source of supply. For starters on normal supply, letter shall be black on white background. For starters on emergency supply letters shall be white on green background.

1.18. Starters shall be of North America manufacture and of the same manufacturer
2. **Variable Frequency Drive Starters**

*General*

2.1. Variable frequency drives shall be CSA certified

2.2. Drives shall be of the adjustable frequency totally digital pulse width modulated type

2.3. Drives shall be suitable for use with high efficiency motors

2.4. Drive enclosures shall be rated UL Type 1 and shall be UL listed as a plenum rated VFD, designed to prevent unfiltered air from entering enclosure utilizing filters and associated integral fan cooling

2.5. Drives shall be provided with an Auto-Off-Bypass selection feature (keypad, selector switch) mounted on front face/door together with a red LED running light

2.6. The bypass system shall NOT depend on the VFD for bypass operation. The bypass shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the enclosure for repair/replacement

2.7. Drives shall interface via terminal block(s) for connection of all external wiring. Hardwire connections between drive and external wiring are not acceptable

2.8. Drives shall have an accurate schematic wiring diagram permanently affixed to the inside of door showing all internal and external wiring connections

2.9. A door defeat mechanism shall be provided to open door to access drive components when the main disconnect switch is in the closed position

2.10. Drive components shall be readily accessible for replacement and shall not require major component removal nor replacement to repair or access a minor component

2.11. Drives shall have a lamacoid plate affixed to the cover with stainless steel screws, identifying the load supplied, and in the case of stand alone drives (not installed in an MCC), shall also indicate voltage rating and source of supply. For drives on normal supply, letters shall be black on white background. For drives supplied from an emergency power source during normal power supply outage, letters shall be white on green background

2.12. Drives shall be manufactured by ABB or acceptable equivalent.

*Performance*

2.13. Drives shall be designed to operate at rated voltage +/- 15%, 3 phase, 60 Hz input power supply and rated motor voltage output at 0.5 to 60 Hz output. Transformers shall not be used to achieve rated voltage inputs and outputs.

2.14. The total harmonic distortion for any particular installation must be less than 5%.

2.15. Drives shall have a continuous duty service factor of 110% of rated motor current

2.16. Drives shall have a minimum efficiency of 98% at maximum load and speed
2.17 Drives shall have a minimum line side displacement power factor of 0.98 at all speeds

2.18 Drives shall meet all performance requirements to a maximum of 40 degrees C, 95% maximum non condensing humidity, and maximum 1000 metres ASL

2.19 Drives shall have adjustable minimum speed of 0-80% and adjustable maximum speed of 50-110%

2.20 Drives shall have separately adjustable acceleration and deceleration ramps from 1 to 999 seconds (0 to 110% speed)

2.21 Drives shall automatically initiate motor restart when a momentarily or prolonged power interruption has occurred and been restored and provided a run enable signal is present. The motor shall restart at the speed at which it is rotating and accelerate to the speed called for by the last speed reference signal

2.22 Drives shall be provided with a 30 Hz ride through

2.23 Drives shall be capable of operating for setup and testing without a motor connected

Protection

2.24 Drives shall be provided with main horsepower rated disconnect switch to isolate the drive. Switch handle shall be accessible on the front of the drive and padlockable in the closed and open positions.

2.25 A combination circuit breaker and contactor shall be provided on the load side of the main disconnect switch for supply of the motor in Auto mode. A combination circuit breaker and contactor shall be provided also on the load side of the main disconnect switch for supply of the motor in bypass mode. Circuit breakers shall provide motor and drive short circuit protection and meet system supply available short circuit rating

2.26 Drive contactors shall be horsepower rated and match the motor maximum horsepower rating

2.27 Drives shall be provided with line over and under voltage protection, phase loss protection and phase unbalance protection to trip the drive off whether in Auto or Bypass mode

2.28 Drives shall have thermal overload protection to trip the drive off should a motor overload or stall condition occur in either the Auto or Bypass mode

2.29 Drives shall have internal over temperature protection to protect the internal drive components and trip the drive off in the event of over temperature

2.30 Drives shall have 3 phase thermistor relay protection for connection to external motor thermistors in motors 100HP and larger. Should a relay operate, the drive controller shall shut down whether in Auto or Bypass mode, and a separate LED on the front of the door shall indicate “Motor Overtemp”

2.31 Drives shall be provided with input transient protection in the form of line reactors to prevent drive damage from line transients on the power distribution system

2.32 Drives shall be able to accept a remote isolation of the motor (e.g.: remote motor disconnect switch operation) while motor running
without causing damage to the drive whether running in the Auto or Bypass mode

2.33 Drive control and logic supply transformers shall have primary and secondary fusing. Fuses shall be Type CC time delay

Control and Monitoring

2.34. Drives shall be provided with an Auto-Off-Bypass selector switch on the front of the door together with a red LED running light

2.35. Drives shall have a regulated 24 VDC power supply for output connection to remote sensors requiring power to supply drive input control

2.36. Drives shall have a signal follower for interface connection to both 4-20ma and 0-10VDC remote inputs from remote sensors controlling drive in the Auto mode

2.37. Drives shall have interface connection to the following remote University Central Control and Monitoring System (CCMS) connections:

   2.37.1. 4-20MA output when in Auto and Bypass for remote monitoring

   2.37.2. Remote dry contact from CCMS for run command in the Auto mode

   2.37.3. Dry contact for connection to CCMS to indicate VSD shutdown (fault condition)

2.38. Drives shall have interface connection to remote safety interlocks (e.g.: firestat, freezeastat, etc) in Auto and Bypass modes

2.39. Drives shall be provided with external interlock contact connection for run control in either the Auto or Bypass mode

2.40. Drives shall be provided with a door mounted microprocessor driven digital control module to allow operating personnel to setup and monitor the drive parameters, output speed, load, voltage, and monitor fault information, all as detailed below

   2.40.1. All readout information shall be displayed on a high resolution dot matrix alpha-numeric high resolution LCD display. Information shall be presented in descriptive user friendly format. Coded and abbreviated displays are not acceptable

   2.40.2. Speed, load, and output voltage shall be continuously displayed and shall be in absolute values and not in percentage

   2.40.3. Direct keyboard entry shall enable display of and password enable changing of the following parameters:

      .1 Maximum speed setting
      .2 Minimum speed setting
      .3 Acceleration rate
      .4 Deceleration rate
      .5 Current limit-motoring
      .6 Current limit-regenerating
      .7 Up to 3 preset speeds
      .8 Up to 3 frequency points to avoid resonant speeds
2.41 Direct keyboard entry shall enable display of the following to permit diagnostic troubleshooting:

- Lockout and cause
- Line under/over voltage, phase loss/unbalance
- Drive overtemperature
- Motor thermal overload trip
- Motor thermistor trip operation
- Inverter DC bus over/under voltage
- Loss of 24VDC for remote sensing devices
- Output fault on any one phase including phase identification
- Missing or zero speed reference
- Trip caused by external interlock

2.41.1 Direct keyboard entry shall enable display of the following:

- Power on
- Ready
- Running
- Jogging
- Motor accelerating
- Motor decelerating
- Direction of rotation
- Selection status (Auto, Off, Bypass)
- Current limit

2.41.2 Direct keyboard entry shall enable a manual (non permanent override control of preset memory settings) control of the following control functions:

- Run
- Stop
- Jog (enabled in Stop mode)
- Acceleration and deceleration speed
- Speed set

2.41.3 Direct keyboard entry shall enable non erasable non volatile memory display of the last 30 drive shutdowns and include the following data:

- Date, time, and elapsed time of shutdown
- Cause of shutdown
- Output frequency, voltage and load at time of shutdown
- Accelerating or decelerating at time of shutdown
3. **Motor Control Centers**
   3.1. Motor control centres shall comply to the latest CSA requirements.
   3.2. MCC's shall be sprinklerproof construction, free-standing, front access, Class II type B, with rms current interrupting rating to suit and comply with and include the following:
   - Closed, dead front construction
   - Main breaker
   - Tinned copper main bus
   - Tinned copper vertical bus in each section
   - Continuous ground bus
   - Full height barrier to isolate the vertical bus from the starters
   - Full height wiring trough with cable supports for wiring for power and control wiring
   - Line and control terminal blocks, each with 20 percent spare capacity
   - Starters and disconnects shall have free floating, self-aligning construction with silver-to-silver contact. Each starter and disconnect shall be capable of being removed with the remainder of the MCC still energized.
   - Where spaces are noted for future, provide each space with blank cover, rails and necessary hardware to allow a starter or breaker to be installed and connected at a later date without changes to the internal distribution.

15950 **Testing, Adjusting and Balancing**

Testing and Balancing of Piping and Air Systems:

1. This work may be tendered and contracted separately to appropriately divorce it from the Mechanical construction contract. This separate contract should include the stratification testing and adjustments.

2. Design flow rates on VFD systems shall be accomplished with the VFD operating at 55-58 Hz

3. Systems shall be balanced to AABC or NEBB standards

4. Check airflow capacity to ensure that at filter simulated maximum (dirty filter) differential pressure, maximum design flow values are maintained.
### LIST OF MANDATORY and PREFERRED MANUFACTURERS

<table>
<thead>
<tr>
<th>Canadian Master Format</th>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>sealed valves</td>
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<td></td>
<td></td>
<td>#4 High Pressure Steam Drip Traps</td>
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<td>Manufacturer: Bestobel</td>
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<td>Model: DM-25, bimetallic type</td>
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<td></td>
<td>#4 H&amp;A/C- Chilled Water</td>
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<tr>
<td>15100; 15200; 15300</td>
<td>8</td>
<td>General: Rad. Valves</td>
<td>Braukman, or equivalent</td>
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<tr>
<td>221000; 226000;</td>
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<td>231500; 23113;</td>
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<td>232100;232200</td>
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<td>and Cold Water</td>
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<td></td>
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<td>Model: Gate, or Globe butterfly valves</td>
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<td>224201</td>
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<td>1.9 Litre, model DEL81T231BTA-19</td>
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<td>0.5 Litre, model DEL81T231BTA-05 (not</td>
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<td>allow a clear flow discharge)</td>
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<td>8” CENTER SET: Model DEL590T1850</td>
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<td>4” CENTER SET: Model DEL590T1250</td>
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<td>SINGLE HOLE: Model DEL590T1150</td>
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<td>(also available in hard wired)</td>
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<td>19 #16 Air Handler Unit: Pressure Gauges</td>
<td>Mandatory Manufacturer: Dwyer Model: Magnehelic</td>
</tr>
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</table>
Appendix ‘D’
Sample installation condensate meter