UNIVERSITY OF TORONTO | Facilities & Services

Mechanical design standard

Revision 02

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General requirement

1. This standard shall be read in conjunction with the Client's (University of Toronto's) deliverable standard and design standards.

2. The standard does not specify materials for installation at any particular location, such as plenum-rated area and vertical shafts. Acceptable materials shall comply with Ontario Building Code (OBC) for their intended installation areas. It is the responsibility of the Architect (Consultant of Record) to review specific application areas and select appropriate materials from the standard, ensuring they align with OBC requirements.

22 05 00 – Common work results for plumbing

1. Galvanized schedule 40 pipe sleeves shall be provided for all piping penetrations through concrete and masonry. Sleeves shall extend a minimum of 50mm (2 in) beyond each side of the penetration.
2. Safety relief devices shall be vented individually.
3. Connected vent piping shall be designed to convey the fluid without pockets.
4. All vents shall terminate external to the building and be directed away from air intakes and operable windows.

Plumbing traps

1. Running drainage traps shall have cleanouts on both legs.
2. Trap-seal primer lines:
    a. Buried application: Plastic Poly or Type K copper soft tubing conforming to ASTM B88.
    b. Exposed application: Type K copper soft tubing conforming to ASTM B88.

Cleanouts

1. Where code allows, washroom cleanouts shall be installed in the room to allow for cleaning within the washroom and not the ceiling below.

22 10 00 – Plumbing piping

1. Pipe and pipe fittings shall be in accordance with the following schedules:

    a. Potable water:

Table 1: Pipe and pipe fittings for potable water

Service	Size mm (in)	Pipe material	Fittings	Joints
Domestic hot and cold (above ground)	All sizes	Copper tube type L conforming to ASTM B88	Wrought copper	Soldered or brazed joint, Pressed (Viega, Apollo or approved equivalent), grooved joint (Victaulic or approved equivalent)
Domestic cold water: (buried)	50 (2) and smaller	Copper tube type K conforming to ASTM B88.	Wrought copper	Soldered or brazed
Domestic cold water: (buried)	65 (2 ½) and larger	Ductile iron conforming to ANSI/AWWA C151/A21.51, PVC conforming to CSA B137.3, Polyethylene (PE) conforming to standard CSA B137.1	Ductile iron PVC PE	Rubber gasket Restrained joints Butt heat fusion
Domestic hot and cold (shafts and other locations with limited access)	All sizes	Copper tube type L conforming to ASTM B88	Wrought copper	Soldered, pressed, or brazed

    b. Storm and sanitary sewage

Table 2: Pipe and pipe fittings for storm and sanitary sewage

Service	Size mm (in)	Pipe material	Fittings	Joints
Storm (vertical risers)	All sizes	Cast iron conforming to standard CSA-B70	Cast iron	Mechanical Joint
Storm (buried)	80 (3) and smaller	PVC conforming to standard CSA B181.2	PVC	Solvent welded
Storm (buried)	100 (4) and larger	PVC conforming to standard CSA B182.2, white color	PVC	Gasketed joint
Sanitary (above ground)	65 (2 ½) and smaller	Copper type L conforming to ASTM B88 PVC	Wrought copper PVC	Soldered joint PVC solvent

Sanitary (above ground)	80 (3) and larger	Cast iron conforming to standard CSA-B70	Cast iron	Mechanical joint
Sanitary (buried)	80 (3) and smaller	Cast iron conforming to standard CSA-B70 PVC conforming to standard CSA B181.2	Cast iron PVC	Mechanical joint Solvent welded
Sanitary (buried)	100 (4) and larger	Cast iron conforming to standard CSA-B70 PVC Cast conforming to standard CSA B182.2, green color	Cast iron PVC	Mechanical joint Gasketed joint
Bottoms of storm and sanitary risers where they connect to horizontal mains, as well as all horizontal and vertical sanitary and storm joints at elevations below grade, including those in parking garages	All sizes	Cast iron conforming to standard CSA-B70	Cast iron	Mechanically braced and combined with a heavy-duty mechanical joint.
Vent	All sizes	DWV Copper conforming to ASTM B306 Cast Iron conforming to standard CSA-B70	Wrought copper Cast iron	Soldered joint, mechanical joint, pressed (Viega, Apollo or approved equivalent)
Notes	Sanitary drainage piping and fittings shall be rated to withstand the temperature of the discharge fluid. Ensure that appropriate piping is used for high-temperature sewage from autoclaves, cage washes, and similar appliances. Refer to section 22 66 53 for laboratory drainage requirements.			

22 11 19 – Domestic water piping specialties

Main incoming service

1. Buildings with laboratories and mission critical spaces that require year-round water shall have two incoming services. The services shall be configured to allow for continuous water supply when one service is offline.

2. For buildings with a single water feed incoming cold water service shall have two backflow preventers installed in parallel configuration for redundancy. Refer to Appendix A for a list of acceptable backflow preventer manufacturers.

3. For buildings with two independent water feeds, where each feed can supply the entire building, a single backflow preventer on each feed is sufficient.

4. Laboratory facilities shall have backflow prevention provided to conform to CSA Standard B64.10.

22 13 29 – Sanitary sewage pump

1. Shall be self-priming, base mounted, direct drive type for motor sizes 1 horsepower (HP) and above.

2. Submersible type is acceptable for fractional horsepower motors.

3. Shall be serviceable at grade level and not within the sump.

4. Shall be connected to emergency power.

5. Standard of acceptance: Gorman Rupp, Goulds Pumps, or equivalent as approved by CoR and the owner.

22 32 00 – Domestic water filtration equipment

1. When a heat exchanger is utilized to generate steam for humidification in air handling units, the incoming city water supply to the heat exchanger shall be treated with at least a water softener. Reverse osmosis systems are also permitted if the process necessitates high purity steam.

22 40 00 – Plumbing fixtures

1. Lavatory faucets shall be fitted with replaceable cartridges, not washers.
2. Water closets shall be of the syphon jet type.
3. Water closets must be able to operate adequately within the entire specified range when flushing flow rates require adjustment at flush valves.
4. Lavatory basin wastes shall have grids and extra heavy quality traps. Chain and plug or pop-up plug shall not be used for basins.
5. Urinals shall have cleanouts located above flood level of fixture.
6. Grouped toilets (three or more) shall have 100 mm cleanout located in the same room as the fixtures.
7. All outdoor hose bibs shall be frost-proof self-draining type to provide freeze protection.
8. Washrooms shall be equipped with a floor drain set at a suitable elevation to facilitate installation of the floor with sufficient slope for complete drainage of the area.
9. Labs with a deluge shower shall have a floor drain.
10. Washroom faucets:
    a. Hands-free type,
    b. Deck mount,
    c. Battery operated with adjustable sensor range. Battery type shall be AA or C only.
    d. Thermostatic mixing valve with adjustable temperature range and anti-scald feature shall be provided with each faucet.
    e. Low flow water conservation type.

f. Refer to appendix “A” for acceptable manufacturers and models.

11. Flush valves serving water closets and urinals

    a. Hands-free and exposed,

    b. Battery operated with manual override and adjustable sensor range. Battery type shall be AA or C only.

    c. Low flow water conservation type.

    d. Refer to Appendix ‘A’ for acceptable manufacturers and models. Lower flow products may be considered to meet water reduction targets, but they shall first be approved by Facilities and Services.

12. Laboratory faucets

    a. Manual with lever style handle(s),

    b. Deck mount,

    c. Complete with vacuum breaker and serrated nozzle.

    d. Refer to Appendix ‘A’ for acceptable manufacturers and models.

Mop sinks

1. Refer to the space requirements section in the Client’s caretaking design standard.

Drinking fountains and bottle filling station combo

1. Shall comply with Client’s facility accessibility design standard.
2. Tamperproof fasteners and all stainless-steel surfaces.
3. Water supply shall incorporate a separate isolation valve to enable filter replacement.
4. Refrigeration system shall be incorporated into the unit to provide refrigerated water.
5. Refer to Appendix A for acceptable manufacturers.

Emergency plumbing fixtures

1. Units and locations shall comply with the Client’s laboratory safety design standard and safety eyewash and shower standard.

22 61 13 – COMPRESSED-AIR PIPING FOR LABORATORY

1. Pipe and pipe fittings shall be in accordance with the following schedules:

Table 3: Pipe and pipe fittings for laboratory

Service	Size mm (in)	Pipe material	Fittings	Joints
Compressed air - shop	All sizes	Stainless Schedule 10	Stainless steel	Screwed, Pressed (Viega or approved equivalent), grooved joint (Victaulic or approved equivalent)
Compressed air lab control air	40 (1 1/2) and smaller	Copper Type L SS-304	Wrought copper SS-304	Soldered, Welded, Pressed (Viega, Apollo or approved equivalent)
Compressed air lab control air	50 (2) and larger	Copper Type L SS-304	Wrought copper SS-304	Brazed, Pressed (Viega, Apollo or approved equivalent), Grooved (Victaulic, Shuroint or approved equivalent)
Vacuum Line	All sizes	Copper Type L Schedule 40	Wrought copper Malleable iron	Soldered or brazed, Screwed, Pressed (Viega, Apollo or approved equivalent)

22 63 13 – Gas piping for laboratory

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

2. Pipe and pipe fittings shall be in accordance with the following schedules:

Table 4: Gas piping for laboratory

Service	Size mm (in)	Pipe material	Fittings	Joints
Natural gas	50mm (2) and smaller	Schedule 40 steel conforming to ASTM A53/A53M or ASTM A106	Malleable iron	Threaded, Pressed (Viega or approved equivalent)
Natural gas	65 mm (2 1/2) and larger	Schedule 40 steel conforming to ASTM A53/A53M or ASTM A106	Welded fitting	Welded

22 66 53 – Laboratory chemical-waste and vent piping

1. Pipe and pipe fittings shall be in accordance with the following schedules:

Table 5: Pipe and pipe fittings for laboratory waste

Service	Pipe material	Fittings	Joints
Laboratory waste - above ground	Glass, polypropylene, plenum rated PVDF or as necessary for the service	Glass, polypropylene, plenum rated PVDF or as necessary for the service	Compression coupling Mechanical joint Electrofusion
Laboratory waste - buried	Polypropylene	Polypropylene	Electrofusion

22 67 13 – Processed water piping

1. Pipe and pipe fittings shall be in accordance with the following schedules:

Table 6: Pipe and pipe fittings for process water

Service	Pipe material	Fittings	Joints
Distilled water	Polypropylene PVDF Schedule 80 Stainless steel	Polypropylene PVDF Schedule 80 Stainless steel	Socket fusion Welded
Deionized water	Polypropylene PVDF Schedule 80 Stainless steel	Polypropylene PVDF Schedule 80 Stainless steel	Socket fusion Welded
Reverse osmosis water	Polypropylene Schedule 80 PVDF Schedule 80 Stainless steel	Polypropylene PVDF Schedule 80 Stainless steel	Socket fusion Welded

22 67 19 – Process water equipment

1. Provide booster pump(s) on inlet to Reverse Osmosis packaged filtration unit(s) to ensure sufficient pressure to pass through a dirty unit.

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

3. All systems shall be supplied with city water makeup meter as well as RO output meter, this section shall be read in conjunction with building automation systems design standard.

23 05 00 – Common work results for HVAC

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

2. Due to the capacity and hydraulic limitations of the mechanical utilities from the Central Heating Plant (17 Ursula Franklin Street) and the Central Cooling Plants (North-West Chiller, Bahen Centre, and Medical Sciences), the design team shall provide the pressure drop, temperature range, and flow rate requirements. They will then determine whether the existing systems can support additional loads based on available documents, site tours, and BAS trend data. The analysis and conclusion will be submitted to the Facilities and Services building operations group for review and approval.

3. Exposed moving parts, such as belt drives, fan blades, and similar components that could cause injury through accidental contact, shall be properly guarded.

4. Equipment access shall be in accordance with O. Reg. 851 Industrial Establishments under Occupational Health and Safety Act (OHSA). Lifts and removable ladders and staircases shall not be used. Refer to equipment access section of the deliverable standard for design requirements.

5. Serviceable equipment and components shall not exceed 3 m (10 ft) above the finished floor.

6. Provide pedestrian waterproof traffic topping system over entire mechanical room floor including over housekeeping pads under air handling units, for the new construction.

7. Mechanical system components must be kept clean and dry as manufactured prior to operating the mechanical systems.

8. Equipment rendered obsolete due to the project shall be removed. Services rendered obsolete shall be cut back to the source unless otherwise approved by owner.

Air and water audit

1. An air and water audit shall be conducted in the renovation area and on the central building HVAC equipment that serves this area to verify available airflow rates. This audit shall be completed early in the design phase to provide the design team with feasible design options that comply with applicable codes and standards. The Architect shall develop the scope of work for the air and water balancing company and shall review the balancer's report after the site measurements are completed. An air and water audit can be forgone for a renovation project only if the Client has recent balancing or audit reports that the Architect can use; otherwise, an air audit early in the design phase is mandatory. A recent balancing or audit report must pertain to the renovation area, be no more than three years old, and have no renovation work done within that period.

Access doors

1. Access doors/panels shall be provided in ACT ceiling or hard ceiling so that the various equipment components are easily reached and serviceable. The doors/panels should be centered on the items to be serviced and be of adequate size to allow removal of the service parts. Access doors shall be no less than 600 x 600 mm (24” x 24”) where bodily access into a ceiling space is required.

2. Access panels associated with each fire/smoke damper shall be provided.

3. For duct mounted reheat coils, access openings shall be installed in the duct in front of and behind the device to facilitate cleaning and maintenance.

4. Access for repair and replacement shall be provided for, and not limited to, dampers, valves, coils, VAV boxes, motors, fans, controls, etc.

Rooftops

1. To maintain the integrity of the new roofing when creating penetrations, refer to the Client’s roofing design standard.

2. Rooftop equipment shall have access by a stair and wide enough to accommodate the largest rooftop component.

3. Equipment shall be located and installed in a manner to minimize their susceptibility to flooding.

4. Provide service walkways from the roof access point to each piece of mechanical equipment shall, at a minimum, use pavers with dimensions of at least 600 mm x 600 mm (24 x 24 in). Provide fixed elevated metal platforms and stairs for the safe service and maintenance of rooftop mechanical equipment. Fixed metal crossovers shall be provided over any obstructions along the path to the equipment. The specific

requirements shall be determined during the design phase, based on the equipment manufacturer's specifications, provincial legislation, and the Client's Environmental Health and Safety requirements.

5. The roof shall be protected from damage during equipment installation.

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

7. Any new mechanical rooftop equipment installed on steel framing above the roof with the exception of cooling towers (e.g., air handling units, air-cooled chillers, facility equipment etc.) shall maintain a minimum clearance of 600 mm (24 in) between the top of the roof system and the bottom of the support framing. This clearance is essential to ensure access to the roof membrane beneath the equipment for future maintenance and replacement without needing to remove the mechanical equipment. Coordinate with the architect, roofing consultant, and structural engineer.

8. Equipment intended for installation on a curb, base, or sleeper—such as exhaust fans, packaged rooftop air conditioning units, and air-cooled condensers—shall be mounted to ensure a clearance of 305 mm (12 in) to 460 mm (18 in) from the top of the roof level. If safe service and maintenance of the rooftop mechanical equipment necessitate perimeter elevated platforms and handrails, these shall be provided. Coordinate with the architect, roofing consultant, and structural engineer.

9. The cooling towers shall have a galvanized steel service platform that completely encircles all four sides. The platform walkway shall be at least 1,200 (48 in) mm wide and equipped with guardrails and stair access. A minimum clearance of 1,900 mm (75 in) beneath the service platform is required to access valves and drains.

10. Ducts, pipes, electrical conduit, and controls conduit shall be installed at a minimum height of 305 mm (12 in) above top of finished roof level. If the piping, ducts, or conduits are bundled together or the duct is wider than 600 mm (24 in), then the clearance from the top of the roof level shall be a minimum height of 600 mm (24 in) above top of finished roof level.

11. 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.

12. Paint gas lines yellow in their entirety where exposed to the outdoors.

Mechanical spaces

1. For new construction, preferred access to the mechanical room is through the service elevator that leads directly to the room. Alternatively, a clear and sufficient travel path between the service elevator and the new mechanical room must be provided, ensuring that door openings along the route are wide enough to allow for the removal of the largest equipment component via the elevator.

2. Provide the greater of 1,200 mm (48 in) or the manufacturer's recommendation for equipment clearance to allow for operation and maintenance.

3. For mechanical spaces, stairs and/or access platforms equipped with handrails shall be provided for mechanical equipment raised 450 mm (18 in) or higher above the finished floor. This requirement applies when servicing components or performing maintenance cannot be easily or safely conducted from the floor level or requires entry into the equipment itself. Specific design requirements for each project shall be determined during the design phase in collaboration with the UofT Facilities and Services.

4. Provide hoist beams, jib cranes, or chain hoists to facilitate the movement of supplies, parts, equipment, and chemicals.

5. Provide sealed curbing of all floor penetrations. Curbing shall be at least 150 mm high. Provide adequate floor drains, and slope floors down to the drains.

6. Provide an individual floor drain for each equipment discharge.

7. 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 Appendix C).

Air intakes and exhaust

1. Fresh air intakes shall be located to avoid contamination from vehicle exhaust, nearby building exhaust, diesel generator fumes, and other harmful sources.

2. Air intakes and exhausts positioned at ground level shall be raised on a curb to a minimum 1000 mm (40 in) above the ground. Grates/louvers shall be securely fastened and tamper-proof.

3. Provide acoustic measures on equipment connected to air intakes and exhausts to meet the Client's site noise requirements.

23 05 13 – Common motor requirements for HVAC equipment

Electrical power and control wiring for mechanical equipment and systems shall comply with the following requirements.

Motor starters and motor control centres

1. Combination starters shall be CSA certified.

2. Combination magnetic starters shall be completed with the following:

    a. 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.

    b. Magnetic contactor

    c. Overload relays, one per phase.

    d. Sprinkler proof enclosure for stand-alone starters.

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

    f. Hand-Off-Auto selector switch

    g. Running LED type pilot light (red)

    h. Reset Button

    i. 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.

    j. 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.

    k. Terminal strip within the starter for termination of all external protection and control wiring (e.g.: remote fire stat, freeze stat)

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

    m. Provide defeat mechanism to access starter without having to de-energize starter.

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

o. A limacoid 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.

p. Starters shall be of North America manufacture and of the same manufacturer.

Variable frequency drive starters general

1. Variable frequency drives (VFD) shall be CSA certified.

2. Adjustable frequency totally digital pulse width modulated type.

3. Shall be suitable for use with high efficiency motors.

4. Enclosures shall be rated NEMA 12 UL Type 12 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.

5. Where redundant equipment exists, as is typically the case with pumps in an N+1 configuration, a VFD bypass is not required. However, where redundant equipment is unavailable, as is often the case with fans in air handling units, the VFDs must be provided with a bypass.

6. Where a VFD bypass is required, it shall be provided with an isolation ‘service switch’ and an Auto-Off-Bypass selection feature (keypad, selector switch) mounted on front face/door together with a red LED running light. The bypass 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.

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

8. Shall have a schematic wiring diagram permanently affixed to the inside of door showing all internal and external wiring connections.

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.

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.

11. Drives shall have a lamacoid plate affixed to the cover with stainless steel screws, identifying the load supplied, and in the case of standalone drives (not installed in an MCC), shall also indicate voltage rating and

source of supply. The source of supply is defined as the panel or MCC supplying the VFD, and it shall contain both the name of the panel/MCC and the room in which it is located. For example:

VFD-P-CW-001

Fed from 078-NPP-B2-06-AA in room 0045

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. This section shall be read in conjunction with electrical design standard (26 05 53.03 Identification for electrical systems and accessories).

12. Drives shall be manufactured by ABB, Danfoss, or acceptable equivalent.

Performance:

1. 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. The total harmonic distortion for any installation must be less than 5%.
3. Shall have a continuous duty service factor of 110% of rated motor current.
4. Shall have a minimum efficiency of 98% at maximum load and speed.
5. Shall have a minimum line side displacement power factor of 0.98 at all speeds.
6. Shall meet all performance requirements to a maximum of 40 degrees C, 95% maximum noncondensing humidity, and maximum 1000 metres ASL.
7. Shall have adjustable minimum speed of 0-80% and adjustable maximum speed of 50-110%.
8. Shall have separately adjustable acceleration and deceleration ramps from 1 to 999 seconds (0 to 110% speed).
9. 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.
10. Shall be provided with a 30 Hz ride through.
11. Shall be capable of operating for setup and testing without a motor connected.

Protection:

1. 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 lockable by padlock in the closed and open positions.

2. 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.

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

    a. 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.

    b. 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.

    c. Drives shall have internal over temperature protection to protect the internal drive components and trip the drive off in the event of over temperature.

    d. 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 Over temp”.

    e. 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.

    f. 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.

    g. Drive control and logic supply transformers shall have primary and secondary fusing. Fuses shall be Type CC time delay.

4. Control and Monitoring

    a. This section shall be read in conjunction with the Client’s building automation systems design standard.

    b. Drives shall be provided with an Auto-Off-Bypass selector switch on the front of the door together with a red LED running light.

c. Drives shall have a regulated 24 VDC power supply for output connection to remote sensors requiring power to supply drive input control.

d. Drives shall have a signal follower for interface connection to both 4-20 ma and 0-10 VDC remote inputs from remote sensors controlling drive in the Auto mode.

e. Drives shall have interface connection to the Client's Energy Management and Reporting System (EMRS) using BACnet – 135 communication and interoperability protocols through the BAS:

   A. BACnet IP
   B. BACnet MS/TP
   C. MODBUS RTU
   D. Proprietary

f. Provide current Protocol Implementation Conformance Statement (PICS)

g. 4-20MA output when in Auto and Bypass for remote monitoring

h. Remote dry contact from BAS for run command in the Auto mode

i. Dry contact for connection to BAS to indicate VSD shutdown (fault condition)

j. Drives shall have interface connection to remote safety interlocks (e.g.: firestat, freezestat, etc.) in Auto and Bypass modes

k. Drives shall be provided with external interlock contact connection for run control in either the Auto or Bypass mode.

l. 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.

m. All readout information shall be readable at the EMRS and includes at a minimum:

   A. Amps per phase
   B. Volts per phase
   C. Kilowatt-Hours
   D. Reactive power
   E. Real Power
   F. Time stamps

n. Direct keyboard entry shall enable display of and password-enable changing of the following parameters:

A. Maximum speed setting
B. Minimum speed setting
C. Acceleration rate
D. Deceleration rate
E. Current limit-monitoring
F. Current limit-regenerating
G. Up to 3 preset speeds
H. Up to 3 frequency points to avoid resonant speeds
I. Direct keyboard entry shall enable display of the following to permit diagnostic troubleshooting:
J. Lockout and cause
K. Line under/over voltage, phase loss/unbalance
L. Drive overtemperature

o. Motor thermal overload trip

A. Motor thermistor trip operation
B. Invertor DC bus over/under voltage
C. Loss of 24VDC for remote sensing devices
D. Output fault on any one phase including phase identification
E. Missing or zero speed reference
F. Trip caused by external interlock
G. Direct keyboard entry shall enable display of the following:
H. Power on
I. Ready
J. Running

p. Jogging

A. Motor accelerating
B. Motor decelerating
C. Direction of rotation
D. Selection status (auto, off, bypass)
E. Current limit
F. Direct keyboard entry shall enable a manual (non-permanent override control of preset memory settings) control of the following control functions:
G. Run
H. Stop
I. Jog

q. Acceleration and deceleration speed

A. Speed set
B. Direct keyboard entry shall enable nonerasable non-volatile memory display of the last 30 drive shutdowns and include the following data:
C. Date, time, and elapsed time of shutdown
D. Cause of shutdown
E. Output frequency, voltage and load at time of shutdown

r. Accelerating or decelerating at time of shutdown

A. Motor Control Centers
B. Motor control centres shall comply to the latest CSA requirements.
C. MCC's shall be sprinkler-proof construction, free-standing, front access, Class II type B, with rms current interrupting rating to suit and comply with and include the following:
D. Closed, dead front construction

s. Main breaker

A. Tinned copper main bus
B. Tinned copper vertical bus in each section
C. Continuous ground bus
D. Full height barrier to isolate the vertical bus from the starters
E. Full height wiring trough with cable supports for wiring for power and control wiring
F. Line and control terminal blocks, each with 20% spare capacity
G. 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.
H. 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.

23 05 16 – Expansion fittings and loops for HVAC piping

1. Provide appropriate offsets in piping or expansion loops to accommodate for thermal expansion. Expansion joints shall not be used.

23 05 23 – General-duty valves

Isolation valves

1. Standard of Acceptance: Apollo, Bray, Challenger, Crane, Jenkins, Kitz, Viega, Victaulic and DeZurik.

2. Provide isolating valves for the following:

    a. Plumbing fixtures and appliances.

    b. On the inlet and outlet sides of all mechanical equipment. Equipment shall include, but not be limited to, coils, fan coils, heat exchangers, radiators, pumps, chillers, cooling towers, boilers, and pressure reducing valves.

    c. On hot, cold, and recirculating water services to all washrooms and labs.

    d. Floor level branch piping off of heating and cooling risers.

    e. Inlet and outlet of meters.

3. Balancing valves shall not be used as isolating valves.

4. Isolating valves for various services shall conform to the following table:

Table 7: Isolating valves for various services

Service	Ball	Gate	Butterfly
Domestic hot water	≤ 50mm (2”)	> 50mm (2”)	> 80mm (3”)
Domestic cold water	≤ 50mm (2”)	> 50mm (2”)	> 80mm (3”)
Heating water	≤ 50mm (2”)	> 50mm (2”)	> 80mm (3”)
Condenser water			All sizes
Chilled water	≤ 50mm (2”)	> 50mm (2”)	> 80mm (3”)
Distilled, de-ionized, reverse osmosis water	All sizes		

5. Isolating valves for distilled, de-ionized and reverse osmosis water shall be compatible with the fluid.

6. Butterfly valves used in condenser water systems shall have seats and seals suitable for the water treatment chemicals.

7. Connections and valve ratings shall be compatible with pressure and temperature conditions.

8. Valves shall not be installed higher than1.5 m (5 ft) from the finished floor in mechanical service spaces.

9. Thermostatic Radiator Valves

    a. Thermostatic valves may be used for hydronic and steam radiators.

    b. Valves control shall be tied to any perimeter cooling device to avoid simultaneous heating and cooling.

    c. Standard of acceptance for hydronic valve

        i. Braukmann

        ii. Danfoss

    d. Standard of acceptance for steam valve

        i. Armstrong or approved equivalent

10. Steam, condensate, and high temperature hot water valves

    a. High pressure steam valves shall be industrial grade, suitable for working pressure and temperature requirements. Complete with bellows non-leak or zero-leak type operators.

    b. All valves connected to the Client's district heating system (steam or HTHW) must be welded and have CRN numbers.

    c. Steam drip trap valves to be 20 mm (¾ in) WO4-2054T-02TS Velan Bellows sealed valves or equivalent.

    d. 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.

Table 8: Isolating valves for various services

Service	Ball	Gate
Steam < 100 kPa (15 psig)	≤ 40 mm (1 1/2")	> 40 mm (1 1/2")
Steam > 100 kPa (15 psig)	≤ 25 mm (1")	> 25 mm (1")
Steam condensate	≤ 25 mm (1")	> 25 mm (1")
High temperature hot water	≤ 25 mm (1")	> 25 mm (1")

Buried valves

1. All buried valves shall close in a 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.

Emergency diesel generator set

1. A fusible fire shutoff valve shall be installed in the fuel supply line.

Balancing valves

1. Balancing valves 50 mm (2”) or less shall be globe type.

23 05 29 – Hangers and supports for HVAC piping and equipment

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

23 05 53 – Identification for HVAC piping and equipment

1. All piping except where concealed in a pipe space or chase shall be identified according to latest ASME A13.1 “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.

2. All mechanical equipment and field devices must have a unique identification number. Contact a Facilities and Services representative for information on existing identification numbers to prevent duplication when assigning numbers to new equipment. Equipment and field devices connected to the BAS must be labeled with identification numbers matching those on the BAS graphics. For naming conventions, refer to the BAS design standard.

3. For equipment and field devices not connected to the BAS, apply the same naming conventions from the BAS design standard.

4. Each tag shall include the unique identification number, a description of the equipment type (e.g., chiller, pump), the type of service (e.g., chilled water, compressed air), the panel number and circuit number of the power source, the controller number, and the controller’s power source panel number with circuit number (refer to Appendix D).

5. Tags shall be resistant to weather and UV light without fading over time. The default material for identification tags is plastic with a white background and black engraved lettering. Attach the tags to the equipment using adhesive, a chain, or an S-clip. If plastic tags are unsuitable due to the equipment’s working conditions, such as high surface temperatures, use metal tags with engraved lettering, riveted or chained to the equipment.

6. Letter height shall be at least 8 mm for text at eye level. For tags positioned at higher elevations, the text must be large enough to be easily readable from floor level.

23 05 93 – Testing, adjusting, and balancing for HVAC

1. This section shall be read in conjunction with the Client's building commissioning standard.

2. The air and water balancing contractor shall be AABC or NEBB certified.

3. Design flow rates on VFD systems shall be accomplished with the VFD operating at 55-58 Hz.

4. Check airflow capacity to ensure that, at the filter simulated maximum differential pressure (dirty filter differential pressure), maximum design flow values will be maintained.

5. Reported measurements shall be subject to verification by the Commissioning Authority (CxA). Provide instrumentation and manpower required to verify up to 30% of all reported measurements. The number and location of the verified measurements shall be at the discretion of the CxA. A measured deviation of more than 10% between the verification reading and the design value is considered unacceptable.

23 07 19 – HVAC piping insulation

8. Provide pipe and fitting insulation on the services as prescribed in the latest edition of ASHRAE Standard 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings). Provide insulation on the cold condensate drain lines when condensation is likely to occur on the pipe and fitting surfaces. The insulation thickness shall comply with the same ASHRAE 90.1 standard.

1. Where a vapor barrier is required, the barrier shall be an integral part of the insulation. Pipe insulation and cladding materials shall comply with the Ontario Building Code and Fire Code. Pipe insulation cladding (jackets) is required for all services (pipes and fittings) as outlined in Table 9. Provide removable/replaceable insulation sections at control valves, metering stations, and orifice plates.

Table 8: Pipe insulation cladding

Pipe insulation cladding (jacket)	All services exposed to ultraviolet light and weather (e.g. roofs, etc.)	All services excluding steam – interior, exposed installation	All services excluding steam – interior, concealed installation	Steam – interior installation
PVC		X		
Aluminum (minimum 0.024 in. / 0.6 mm thickness)	X			X
Canvas				X
ASJ – all service jacket			X	

23 09 23.13 – Energy meters

1. Metering
    a. This section shall be read in conjunction with building automation system design standard.
    b. Energy metering shall be provided at both the building and system levels in addition to the requirements outlined in points A through C.
        A. Provide flow, temperature, and energy meters on all central cooling water, steam, condensate, and high and low temperature heating water systems, domestic hot water heating and recirculation systems, and process heating. Where applicable all thermal energy meters shall comply with the requirements of the current version of CSA 900, parts 1 through 6.
        B. Provide energy metering for any energy sources used in tenant spaces and for individual energy end uses that represent 10% or more of the total annual consumption of the tenant space.
        C. Provide volume metering on all irrigation system supplies, city water makeups and bleeds for cooling and steam systems, and swimming pool makeup.

c. Meters shall be permanently installed, record data at intervals of one hour or less, and transmit this data to a remote location.

d. The data collection system shall utilize a local area network or building automation system.

e. The data collection system shall be capable of storing all meter data for at least 18 months.

f. The data shall be remotely accessible.

g. Provide isolation valves on the inlet and outlet of the meter assembly. Provide a full bypass connection with isolation valve to allow continuous service when maintenance is performed on the meters (Appendix B).

23 21 13 – Hydronic piping

1. Provide reverse return hydronic piping systems.

2. Radiant panel heating should not be used for reheating purposes.

3. Constant 57.2°C (135°F) degree supply water shall be used to serve building heating systems.

4. Dedicated hydronic circulating loops shall be designed for different systems to maintain control integrity. Building heating systems that shall have independent circulation loops:

    a. Perimeter heating

    b. Terminal reheat

    c. Air handling unit heating and preheating coils

5. Glycol heating and cooling systems, use a 50% volume solution of propylene glycol in water.

6. Provide galvanized Schedule 40 pipe sleeves for all piping penetrations through concrete and masonry. (Coordinate with architectural and structural disciplines for location and installation).

7. Safety relief devices shall be vented individually, with connected vent piping designed to convey the fluid without pockets to the outside atmosphere, and then directing it away from ventilation equipment and vents from other systems.

8. Pipe and pipe fittings shall be in accordance with the following schedule:

Table 9: Pipe and pipe fittings for heating and chilled water

Service	Size mm (in)	Pipe material	Fittings	Joints

Heating water, chilled water and glycol – non-buried	50 (2) and smaller	Schedule 40 steel conforming to ASTM A53/A53M or ASTM A106	Schedule 40	Threaded, pressed (Viega, Apollo or approved equivalent)
	65 (2 ½") and larger	Schedule 40 steel conforming to ASTM A53/A53M or ASTM A106	Welded, Pressed Grooved.	Welded, Pressed, (Viega, Apollo or approved equivalent), Grooved (Victaulic, Shurjoint or approved equivalent)
Heating Water up to 93.3 °C (200°F) - buried	All Sizes	Steel as per EN253 Standard	Fittings as per EN448 Standard and to match manufacturer's system	Inner carrier pipe - welded. Outer Casing – HDPE Electro-weldable
Chilled water up to 18.3 °C (65°F) - buried	All Sizes	Steel as per EN253 Standard	Fittings as per EN448 Standard and to match manufacturer's system	Inner carrier pipe – welded. Outer Casing – HDPE Electro-weldable
Heating, chilled, glycol systems (shafts and other non-accessible locations)	All Sizes	Schedule 40 steel conforming to ASTM A53/A53M or ASTM A106	Schedule 40	Welded
	• Buried system piping to be designed to EN 13941 Standard. Logstor, Isoplus, or approved equivalent. • 100% x-ray inspection for inner carrier pipe welded joints performed on site. Welded inner carrier pipe joints performed off-site shall be pressure tested according ASME B31.3. • 100% buried system outer casing joints to be pressure tested (bubble test) for leaks • Buried piping shall incorporate a leak detection system.			

Table 10: Pipe and pipe fittings for radiant floor and snowmelt systems

Service	Pipe material	Fittings	Manufacturers
In-floor radiant	PEX with oxygen barrier	In-floor loops shall have no fittings. Manifold fittings shall be the same manufacturer as the piping system and suitable for the service.	Rehau, Uponor, Watts, or equivalent
Snow melt branch circuits	PEX with oxygen barrier	Buried loops shall have no fittings. Manifold fittings shall be the same manufacturer as the piping system and suitable for the service.	Rehau, Uponor, Watts or equivalent
• Snow melting main shall follow heating water-buried requirements. • Snow melting manifold branch circuits and in-floor radiant systems do not need leak detection systems.			

23 21 23 – Hydronic and city water boosting pumps

1. Heating, cooling, condenser water, and city water boosting systems shall be designed with N+1 pumping redundancy.
2. Pumps to have mechanical seals.
3. Provide gauge ports on the suction and discharge side of the pump.
4. A single gauge shall be piped and valved to allow isolation of pump suction and discharge pressures gauges.
5. Provide a fine mesh filter/strainer upstream of the pumps, complete with isolating valves, both before and after the filter/strainer.
6. Strainers that serve chilled water and condenser water pumps shall have upstream and downstream pressure gauges installed.
7. Provide individual supports and vibration isolation for each pump and associated pipework.
8. Pump motors shall be variable speed type.
9. Pumps shall operate using a variable frequency drive.
10. For City booster pumps, include pressure sensor located at top floor for control of pressure.
11. Bleed line complete with solenoid valve shall be provided to protect the pump from overheating.

23 22 13 – Steam and condensate heating piping

1. Campus steam system piping and fittings shall be designed for 2068 kPaG (300 psig) pressure.

2. Campus pumped steam condensate piping and fittings shall be designed for 1034 kPaG (150 psig) pressure

3. Provide galvanized schedule 40 pipe sleeves for all piping penetrations through concrete and masonry. Safety relief devices:

    a. Shall not be combined with non-safety vents,

    b. Shall terminate at a minimum of 3 m (10 ft) above finished roof,

    c. Shall terminate a minimum 3 m (10 ft) distance away from air intakes and building openings

    d. Shall be vented individually, with connected vent piping designed to convey the fluid without pockets to the outside atmosphere, and then directing it away from ventilation equipment and vents from other systems.

Pipe and pipe fittings shall be in accordance with the following schedules:

Table 11: Pipe and pipe fittings for steam, condensate, and high temperature hot water (HTHW)

Service	Size mm (in)	Pipe material	Fittings	Joints
Steam - above 103 kPaG (15 psig)	32 (1 1/4) and smaller	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80 3000 lb. WOG	Note #3
Steam - above 103 kPaG (15 psig)	40 (1 1/2) and larger	Schedule 40 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 40 2000 lb. WOG Welded Fitting	Welded Note #4
Steam condensate above 103 kPaG (15 psig)	50 (2) and smaller	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Socket welded
Steam condensate above 103 kPaG (15 psig)	65 (2 ½) and larger	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Butt welded
Steam condensate below 103 kPaG (15 psig)	50 (2) and smaller	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Threaded
Steam condensate below 103 kPaG (15 psig)	65 (2 ½) and larger	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Butt welded
Pumped Condensate	50 (2) and smaller	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Socket welded
Pumped Condensate	65 (2 ½) and larger	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Butt welded
HTHW	32 (1 1/4) and smaller	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80 3000 lb. WOG	Note #3
HTHW	40 (1 1/2) and larger	Schedule 40 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 40 2000 lb. WOG Welded Fitting	Welded Note #4
Buried Steam - above 103 kPaG (15 psig)	All sizes	Schedule 40 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless. 100 mm (4 in) insulation thickness.	Schedule 40 2000 lb. WOG Welded Fitting	Welded

Buried Steam Condensate	All sizes	Schedule 40 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless. 100 mm (4 in) insulation thickness.	Schedule 80 2000 lb. WOG Welded Fitting	Welded
Steam below 103 kPaG (15psig) - shafts and other non-accessible locations	All sizes	Schedule 40 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 40 2000 lb. WOG Welded Fitting	Welded
Steam condensate - shafts and other non-accessible locations	All sizes	Schedule 80 steel in compliance with ASTM A53/A53M, Grade B, seamless or ERW; or A106/A106M Grade B, seamless	Schedule 80	Welded
Notes:	1. All piping joints must undergo hydrostatic testing in accordance with the applicable ASME B31.1 code section. If hydrostatic testing is deemed unsafe, the joints must be 100% x-rayed instead. 2. Welded piping shall have no flanges in the line unless when connecting to equipment. 3. Socket welded connection shall be used up to the first isolating valve, with threading implemented thereafter. 4. 10% of welded joints shall be x-rayed. Refer to note #1 if hydrostatic test is deemed unsafe. 5. Buried piping shall incorporate a leak detection system. Piping shall incorporate Galva-Gard hot dipped galvanized outer casing.			

23 22 16 – Steam, condensate, and high temperature hot water (HTHW) heating piping specialties

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

2. New buildings supplied with steam shall have a steam meter as per the Client's building automation system design standard.

3. The steam meter shall be connected to the building BAS as per the Client's building automation system design standard.

4. All steam coils shall include a steam vacuum breaker.

Steam Traps

1. High pressure steam (above 50 psig) system shall have thermostatic traps selected for continuous system operation at a specific design temperature.

2. Bimetallic traps (Bestobell DM-25) shall be used for campus steam high pressure drip traps.

3. Low pressure steam systems up to 15 psig shall have float and thermostatic traps by Spirax-Sarco.

4. Radiator steam traps shall be either by Spirax-Sarco, Armstrong or Mepco.

Pressure Reducing Valves:

1. Building main pressure reducing valves shall be Masoneilan series 500 or Fisher model 655, 92B or 92C pilot operated and self-actuating.

    A. Two pressure reducing valves shall be provided in series if the pressure reduction exceeds 100 psig.

23 23 23 – Refrigerants

1. All new refrigerating, cooling, and air conditioning equipment shall not contain any CFC or HCFC-based refrigerants or mixtures of such refrigerants. Chiller refrigerants shall not exceed the global warming potential limits prescribed by Environment and Climate Change Canada. Refrigerants scheduled for phaseout are prohibited.

2. Major chillers shall operate with refrigerants 513A, 515B or 1233zd.

3. Refer to refrigerant alarm/monitoring system section of the “Building automation systems design standard” for acceptable manufacturers.

23 25 00 – HVAC water treatment

General Requirements

1. The water treatment vendor for new buildings and additions shall be the current water treatment vendor used across the Client's St. George campus.

2. Compliance with the Client's water treatment contract is mandatory, encompassing all aspects from automation systems and associated software to the specified products for pre-cleaning and inhibition programs.

3. Submit the MSDS or product data sheet for all chemicals used.

Products

1. Pre-Operational Cleaner
    a. The cleaner shall ensure elimination of all organic deposits like pipe dope, oil, and grease, as well as address surface corrosion by neutralizing rust without inducing flash rusting.
    b. Shall possess long-term metallurgical passivating properties to safeguard piping integrity during the cleaning process.
    c. The passivator within the cleaner shall ideally maintain effectiveness for 2-6 months.
    d. Tri-Sodium Phosphate (TSP) is prohibited.
    e. Provide documentation verifying the cleaner's efficacy and environmental safety.
    f. Provide the quantity of cleaner needed relative to system volumes.

2. Closed System Treatment and Equipment
    a. The closed system inhibitor shall be of the sodium molybdate type and include pH buffers that do not contain sodium hydroxide.
    b. The inhibitor concentration shall be maintained between 80-120 ppm as molybdenum within the system until all cleanings are complete.
    c. pH shall be controlled within the range of 9-10.
    d. For the chemical bypass feeder, each feeder unit shall include isolating valves, a drain valve, and a funnel feeder with an isolating valve. There shall be one feeder unit dedicated to each system. The bypass feeder shall serve as a backup to any existing automation system that monitors closed loops.
    e. In-line filters shall be appropriately sized to handle 5 percent of the system's recirculating rate. Constructed from steel, the filter housing shall be capable of withstanding the system's working pressure.

f. Additionally, each closed system shall include a cold makeup water contacting head meter with a minimum size of 20 mm. This meter shall be connected to the programmable logic controller (PLC) to manage the closed system's water treatment levels automatically. If the meter is not connected to the PLC, it shall be linked to the BAS for data logging purposes.

3. Open Evaporative Cooling, Condenser Cooling Water (CCW) Treatments and Equipment

a. For a galvanized cooling tower, a passivation program shall be implemented according to the manufacturer's recommendations before operating the tower under a standard water treatment program.

b. Suppliers shall use halogen-stable phosphonates in their formulations and submit the product MSDS for evaluation.

c. HPA shall be included in all treatment formulations.

d. All formulas shall incorporate terpolymers. Products containing homo-polymers or co-polymers are not permitted.

e. Yellow metal inhibitors are essential for protecting non-ferrous metals and preventing metallic contamination. Formulations shall contain a blend of inhibitors to maximize product synergies, and these materials shall be listed on the MSDS or product data sheet.

f. Heavy metals are not permitted in cooling water formulations.

g. For oxidizing biocides, liquid bromine shall be used for smaller systems and solid bromine for larger plants. Product data for both forms shall be provided. The application of solid versus liquid form shall be determined based on the calculation sheet.

h. The non-oxidizing biocide to be used in all CCW applications is isothiazolin, chosen for its high biological kill efficiency and minimal environmental impact. This biocide is also effective against the legionella bacterium.

i. No organophosphate or chromate-based scale and corrosion inhibitors shall be used in the open loop system. Corrosion and scale protection must utilize an all-organic program that is halogen-resistant and environmentally friendly.

j. For the chemical bypass feeder, each feeder unit shall include isolating valves, a drain valve, and a funnel feeder with an isolating valve. The bypass feeder shall serve as a backup to any existing automation system that monitors open loops.

k. Chemical feed equipment: Makeup water and bleed off contacting head meters shall be provided and connected to the PLC-based automation control panel.

l. The water treatment data software program shall be user-friendly and compatible with remote monitoring. Control signals shall originate from the Micrologic Control System, with data transferred to the Windows-

based Water Treatment Data Software Program for storage. Software shall be provided, and on-site staff shall receive software training.

m. The control system shall administer organic inhibitor based on a software program that allows for PTSA sensor input, base bleed off on conductivity control, and incorporate a dual biocide feed program, all coming from the PLC-based controller.

n. Chemical pumps, three Pulsatron pumps in total, shall be supplied for the organic inhibitor and two biocides. The pumps shall be suitable for the application and compatible with the control system.

o. Sequence of operation: A Jesco water meter installed on the makeup line to the cooling tower shall transmit signals to the programmable controller. This controller shall record the volume of water (in liters or gallons) passing through the flow meter. To maintain a specific PTSA level in the recirculating water, the organic inhibitor shall be dosed using a PTSA sensor. All chemicals shall be supplied directly from on-site stations equipped with level control sensors in the containers. The control system shall regulate bleed-off by measuring the conductivity of the cooling water, providing a real-time visual display of both conductivity and ORP for oxidizing biocide feeding. When the water conductivity exceeds a pre-set threshold, a bleed solenoid shall be activated. The oxidizing biocide shall be managed by an ORP controller (or an optional "Actives-based" online colorimetric analyzer) to maintain a free available halogen residual of 0.3 to 0.5 ppm FAC on the condenser side. The non-oxidizing biocide shall be dosed based on a quarter-life calculation. The chemical feed pumps shall discharge downstream of the bleed-off solenoid, into the supply line leading to the cooling tower. Both biocide pumps shall use polytube for suction and discharge lines. For the inhibitor pump, the suction line shall use polytube, while the discharge line shall utilize 5 to 10 mm (3/16” to 3/8") stainless steel tubing. The inhibitor shall be introduced into the cooling tower recirculation pump header. Refer to Appendix E.

p. The bleed line shall be separate and independent from the chemical feed recirculation line. It shall be sized to provide adequate flow based on the designed tonnage of the cooling tower. Additionally, the bleed-off solenoid shall be equipped with isolation ball valves to allow for solenoid isolation during repairs.

4. Steam Boilers

a. The steam boiler system shall undergo testing both during operational periods and lay-up. A single blended application of a molybdenum-based corrosion inhibitor, synthetic polymeric sludge conditioner with antifoam additive, and 20 ppm morpholine condensate treatment shall be used.

b. The chemical water treatment program must effectively control scale and oxygen corrosion.

c. During operation, the boiler water shall maintain a maximum conductivity of 4200 mmhos (or as specified during the site survey) with soft water makeup.

5. Corrosion Coupons

a. Corrosion coupon racks shall be installed for each loop to monitor corrosion rates. Each rack shall include four coupon holders, isolation ball valves, drain lines, and flow regulators to ensure a constant flow around the coupons. Each coupon rack shall comprise one mild carbon steel coupon, one copper coupon, and any other metal present in the system.

Execution

1. Cleaning and Flushing

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

   c. Install temporary strainers, grids, and filters just before cleaning and flushing the piping systems.

   d. Ensure the systems are flushed and cleaned before connecting new piping to existing systems. Certify that the systems are clean and notify the Architect when the cleaning process is complete.

   e. Demonstrate to the Architect that the systems have been cleaned.

   f. During flushing and cleaning, keep all isolating and control valves in the open position, and allow for zone tie-ins. Provide a certificate confirming that all cleaning and flushing have been performed according to the specifications and the requirements of the authorities having jurisdiction (such as the City of Toronto and the Ministry of Environment). Include copies of this certificate in the Program Operating Manuals.

   g. Provide temporary caps, connection points, and other necessary components to subdivide large systems for thorough cleaning. Install a temporary connection between supply and return lines to enable circulation. Circulate a pre-operation cleaner for at least 72 hours. Periodically clean all strainers and repeat the flushing process until no foreign material collects in the strainers, as approved by the Architect.

   h. Drain and purge the system, then clean all strainers. Refill the system with fresh water and circulate to flush out any remaining chemical solution using the fill and flush process.

   i. Drain the system again and remove temporary caps, circulation connections, and other temporary components. Perform a permanent fill using clean water and immediately treat the system with the required corrosion inhibitor for permanent operation.

2. Chemical Treatment

   a. Closed Systems

      A. Provide chemical treatment equipment, chemicals, and testing equipment for heating hot water and chilled water closed loop systems. Install a bypass feeder and in-line filter on each pumping system.
      B. Supply sufficient corrosion inhibitor chemicals to achieve an initial molybdenum concentration of minimum 80 ppm in each system, along with an additional 114 liters (25 imperial gallons) of corrosion inhibitor for each system.
      C. Control parameters for heating hot water and cooling chilled water shall be as follows:

Table 12: Control parameters for heating hot water and cooling chilled water

Treatment	Control range	Measurement
Molybdenum	80 - 120	Ppm as Mo
pH	9 - 10	

D. The following tests shall be performed:
   i. pH
   ii. Conductivity
   iii. Total hardness
   iv. Treatment level
   v. Record makeup water volume at the meter

E. Produce a system service report for a closed loop heating hot water and chilled water system and include the following information:

Table 13: System service report requirements

Category/Test	Measurement
pH	Reading vs control range
Conductivity	Reading vs control range
Total hardness	Reading vs control range
Treatment level	Reading vs control range
Record makeup water at the meter	Record value

b. Open Evaporative Cooling, Condenser Cooling Water (CCW) Systems

A. Provide a comprehensive water treatment system for the open loop to control scale, corrosion, and algae/bacteria growth. This system shall include all necessary chemicals and testing equipment for a one-year term following substantial performance.

B. Maintain a minimum of one service call per month following substantial performance, accompanied by continuous supervision of cleaning procedures and monitoring of the treatment program until construction is completed.

C. Control parameters for open loop applications shall be as follows:

Table 14: Control parameters for open loop applications

Category/Test	Control range	Measurements
Target Cycles of Concentration	3.8 – 4.2	CCW water CL divided by Raw water CL

Target Conductivity	1100 – 1250	mmhos
PTSA	100 – 120	ppb
ATP	150 - 300	Living RLU's
pH	8 - 10	

D. The following tests shall be performed:

i. pH
ii. Conductivity
iii. Total hardness
iv. Treatment level
v. Microbiological counts
vi. LSI/RSI saturation index reading
vii. Calibration of all probes incorporated in the automation as required
viii. Record makeup / bleed water volume at the meter

F. Produce a system service report for an open loop system and include the following information:

Table 15: System service report requirements

Category/Test	Measurement
pH	Reading vs control range
Conductivity	Reading vs control range
Total hardness	Record value
Treatment level	Reading vs control range
Microbiological counts	Reading vs control range
FRC/ORP	Record for COC calculation
System chlorides	Record for COC calculation
LSI/RSI saturation index reading	Reading vs control range
Calibration of probes incorporated in the automation	Description of action taken
Record makeup / bleed at the meters	Record value
Treatment consumption report	Explanation of overage or underage

c. Steam Boilers

A. By design be a multi blended product in a single formulation that incorporates molybdenum as a corrosion inhibitor and 20 ppm morpholine as an amine and include a synthetic polymeric sludge conditioner with antifoam additive.

B. Control parameters for boiler water applications shall be as follows:

Table 16: Control parameters for boiler water applications

Category/Test	Control Range	Measurements
Target cycles of concentration	30	CCW water Cl divided by Raw water CL
Target conductivity	3400 - 4200	mmhos
P alkalinity	300 - 500	ppm as $CaCO_3$
M alkalinity	< 700	ppm as $CaCO_3$
OH alkalinity	200 - 300	ppm as $CaCO_3$
Mo (in boiler water)	100 - 150	ppm

C. Control parameters for boiler feedwater shall be as follows:

Table 17: Control parameters for boiler feedwater

Category/Test	Control Range	Measurements
Total hardness	< 1.0	ppm as $CaCO_3$
pH	> 7.5	mmhos

D. The following tests shall be performed:

i. Feed water pH
ii. Boiler water pH
iii. Total hardness
iv. Treatment level
v. P alkalinity
vi. M alkalinity
vii. OH alkalinity
viii. Boiler conductivity
ix. Feed water conductivity
x. Calibration of all probes incorporated in the automation

E. Produce a service report for a boiler system and include the following information:

Table 18: Service report for a boiler system

Category/Test	Measurement
pH	Reading vs control range
Conductivity	Reading vs control range

Total hardness	Record value
Treatment level	Reading vs control range
Microbiological counts	Reading vs control range
FRC/ORP	Record for COC calculation
System chlorides	Record for COC calculation
LSI/RSI saturation index reading	Reading vs control range
Calibration of probes incorporated in the automation	Description of action taken
Record makeup / bleed at the meters	Record value
Treatment consumption report	Explanation of overage or underage

Category/Test	Measurement
Feed water pH	Record value
Boiler water pH	Record value
Total hardness	Record value
Treatment level	Reading vs control range
P alkalinity	Reading vs control range
M alkalinity	Reading vs control range
OH alkalinity	Reading vs control range
Boiler conductivity	Reading vs control range
Feed water conductivity	Record value
Calibration of all probes in the automation system	Describe actions taken
COC (cycles)	Calculate vs target
Record percentage of makeup	Record value
Non-operational period testing	
Lay-up inhibitor level	Reading vs control range

d. Water Treatment Service Provider

A. Provide at least one service visit per month after substantial performance, including all necessary supervision of cleaning procedures and monitoring of the treatment program prior to construction completion. Submit written reports on all activities and testing results performed at this location.
B. Inspect any system or equipment when open for waterside inspections as requested by the customer, at no additional cost.
C. Check operation of chemical feed and bleed off equipment.
D. Provide immediate emergency service response at no additional cost.
E. Manage and maintain on-site chemical inventories, ensuring the timely delivery of water treatment chemicals and removal of all empty containers from the premises.
F. Do annual analysis of all glycol systems and provide written report/recommendations.
G. Maintain the MSDS binder in compliance at all times.
H. Provide and maintain a logbook for data collection.
I. Conduct a coupon test and deliver the results one year after the plant turnover. Each coupon test shall include, at a minimum, one mild carbon steel coupon, one copper coupon, and any other metal present in the system being tested.
J. Coupon study shall be for a term of 60 days.
K. Copy of the test results shall be provided ten business days of their removal from the system.
L. Corrosion rate test results shall be reported in MPY (mills per year).
M. Coupons shall be returned after evaluation for the purpose of historical records thirty business days after removal.

e. General

A. The chemical supply company shall provide a minimum 2-hour training for the owner's operating staff before installation can be accepted by the Architect. Copies of the training materials, written instructions for treatment dosages, control charts, and test procedures shall be supplied. Additionally, the company shall conduct annual training and refresher sessions for building operators, covering various test procedures related to chemical programs. This annual training shall include lay-up training and software training.
B. The chemical supply company shall also provide written reports to the site consultant detailing the progress of the job and proof of compliance with the specified requirements.
C. The Client manages the treatment of chilled water at the central chiller plants. For chilled water treatment, the building operations division shall be notified of the startup date and time, as well as the total system requirements.

23 30 00 – HVAC air distribution

1. When duct thermal insulation is required, it shall be of external type only.

2. Use appropriate noise silencers.

3. Internal acoustic insulation may be used for transfer ducting only.

4. Air flow straightener turning vanes shall be installed in all cases where 90-degree square main ducts are used.

23 36 00 – Air terminal units

1. Access shall be provided to each air terminal unit, including VAV and CV boxes, as appropriate to enable maintenance and removal of the reheat coil and inlet screen. The equipment shall be positioned in a way that does not require the use of scissor lifts, articulated boom lifts, or similar equipment for access.

2. VAV boxes minimum airflow settings shall comply with ASHRAE recommended values and required matching reheat coils shall comply with latest OBC/ASHRAE requirements.

23 38 16 – Fume hoods

Fume hood ventilation guidelines:

1. Systems shall comply with the Client's Environmental Health & Safety specifications, refer to laboratory fume hood standard.
2. Main exhaust system shall incorporate a heat recovery system.
3. Radioisotope shall be separately ducted to the highest point on the roof.
4. Perchloric acid fume hoods shall be separately ducted to the highest point on the roof.
5. Exhaust stacks shall discharge vertically upwards at approved exit velocity and height to ensure that emissions are unable to re-enter the building, and adjacent buildings. An air dispersion model is required to determine points of impingement.
6. A drain connection system shall be provided at fan low point.
7. Air filters, if installed, shall be as close as possible to the fume hood.
8. Do not connect a fume hood to an existing fume hood duct unless approved by the Client in writing.
9. Verify air balance for existing hoods prior to reuse.
10. Stack supports, stainless steel guy wires and attachment points are to be located and designed by a registered structural engineer.
11. Label each stack with the corresponding room number and exhaust hood number using weather-resistant tags.
12. Label each isolating disconnect according to voltage and source of supply (e.g., PANEL ABC - CIRC 7) and ensure that the source breaker is identified with the corresponding load (e.g., AC#7 Roof).

Environmental Compliance Approval

1. Before the project can proceed, the Client's Office of Environmental Health and Safety (EHS) 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 ECA.
2. The Client's Office of EHS group shall be notified of the following:
    a. Chemicals being used in laboratory and the fume hood.

b. Chemicals that will be used in the laboratory and the fume hood.

Labeling

1. Numerical identification for all fume hoods and associated controls and exhaust air valves shall match the labels used on BAS graphics. For the identification format, refer to the Client's building automation systems design standard.

2. All fume hoods shall be labeled numerically (ascending from 1) based on the number of fume hoods located in a lab. The label shall indicate which mechanical room contains the corresponding fume hood fan.

3. All fume hood fans shall be labeled with the associated fume hood room number and fume hood number (or numbers if the fan is connected to multiple fume hoods).

4. All fume hood exhaust stacks shall be labeled with the associated fume hood room number and fume hood number (or numbers if the fan is connected to multiple fume hoods).

23 40 00 – HVAC air cleaning devices

1. For all new building or building expansion with new HVAC equipment, the equivalent clean air flow shall be determined in accordance with ASHRAE Standard 241, Control of Infectious Aerosols.

2. The equivalent clean air flow options shall be calculated per room and space type using the Equivalent Clean Airflow Calculator (ECAC) available on the ASHRAE website.

3. Analyze a minimum of two scenarios:

    a. Calculate the equivalent clean air flow rate for each room assuming full occupancy and develop required engineering controls to meet ASHRAE Standard 241.

    b. Calculate the maximum number of occupants for each room that does not require additional engineering controls to meet ASHRAE Standard 241.

4. Develop a Building Readiness Plan after the assessment, planning, and implementation phases to describe the engineering and non engineering controls that the building's systems will use to achieve its target clean air flow for infection control.

23 64 00 – Packaged water chillers

1. Centrifugal chillers shall have marine water boxes for both the evaporator and condenser.

2. All new centrifugal chillers with a cooling capacity of 200 tons or more shall undergo eddy current testing on both the evaporator and condenser.

3. A third-party testing company shall conduct the eddy current test at the factory. A detailed report of the testing results shall be submitted to the Client for review and acceptance. The chiller manufacturer can only ship the new equipment to the Client after receiving a written acceptance letter from the Client.

    The Client shall accept the eddy current test results based on the following:

    a. Up to 1% of the total tubes on the evaporator or condenser experience tube wall thickness loss in the range of 0% to 25%.

    b. No tubes experience wall thickness loss in the range of 26% to 100%.

    If these requirements are not met, the manufacturer shall rectify the defects, repeat the eddy current test, and submit a new report for review and acceptance at no extra cost to the Client.

23 70 01 – Air handling units

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 the door. Piping shall not interfere with the access doors with respect to coil removal space.
3. Ensure there is sufficient clearance for the removal of coils from the air handling units. Coil removal space shall be identified on the drawings.
4. Provide lifting facilities such as eye bolts, I-beams and A-frames for coils heavier than 90.7 kg (200 lbs).
5. Variable frequency drives shall be used for fans.
6. Fan bearings shall be lubricated externally. Do not use remote grease piping or tubing.
7. Fan drives: V-belt shall be industrial grade. Multi-sheave belts shall be "power bands".
8. Cooling coils shall have stainless steel frame.
9. Provide moisture eliminators made of stainless steel.
10. Provide moisture evacuation for all cooling coils as per Appendix C. Connections to the pipe shall be by ‘Threadolet’.
11. Provide local isolation valves to enable moisture evacuation of coils and air venting.
12. Drain pans shall 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.
13. 14 Gauge checker plate floor shall be installed on the base. Floor shall be flat, reinforced from below, with all seams continuously welded. The base shall be insulated with 50 mm (2”) 24 kg/m^3 (1-1/2 Lb/ft^3) fibreglass under the floor.
14. All external louvers and bird screens shall be constructed of corrosion resistant materials.
15. A Dwyer Magnehelic pressure gauge shall be provided in main supply air ducts near fan discharge.
16. Utilize welded stainless ductwork downstream of humidifiers.

17. Noise control shall comply with noise criteria (N-C) standards of noise measurement. The space noise levels shall comply with ASHRAE guidelines or recommended by an acoustic consultant. Noise levels shall be measured by an independent acoustic consultant as directed by the Client.

18. 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 3.55 m/s (700 ft/min).

19. Air filters for general office buildings

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

    b. Filters shall be purchased from the Client's incumbent supplier.

    c. Test method for all particulate filters shall conform to ASHRAE Standard 52.2-2017 or later revision, including ‘Appendix J’ of this standard. Test results shall be provided.

    d. Filters shall have Class 2 fire rating by Underwriters Laboratories of Canada or be classified as UL900.

    e. Manufacturer shall provide evidence of facility certification to ISO 9001:2000

    f. Prefilters: 600 x 600 x 50 mm thick (24 x 24 x 2 in 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 250 Pa (1” w.g.) and a face velocity of 2.54 m/s (500 ft/min). Equivalent to AAF VA Blue

    g. Medium Efficiency Filters:

        A. Air filters shall be medium efficiency ASHRAE pleated panels consisting of lofted media blend, welded wire media support grid, and beverage board enclosing frame. Sizes shall be noted on drawings or other supporting material.

        B. Construction:

            i. A welded wire grid treated for corrosion resistance shall be bonded to the downstream side of the media to maintain radial pleats and prevent media oscillation.

            ii. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media on all sides to prevent air bypass. Integral diagonal support members on the air entering and air exiting side shall be bonded to the apex of each pleat to maintain uniform pleat spacing in varying airflows.

        C. Performance:

            i. The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2017 (or the latest). It shall also have a MERV 8A rating

when tested per Appendix J of the same standard. The media shall maintain or increase in efficiency over the life of the filter.

ii. Initial resistance to airflow shall not exceed 58, 77, 67 Pa (0.23", 0.31" or 0.27" w.g.) at an airflow of 1.78, 2.54, 2.54 m/s (350, 500 or 500 fpm) on 25, 50, 100 mm (1", 2" or 4") deep models respectively.

iii. Filter shall be warranted by manufacturer to last at least 4380 hours @ 0.93 m/s (1970 cfm), and 250 Pa (1.0" w.g.) under normal operating conditions in the case of 50 mm (2") depth filter.

iv. Manufacturer shall guarantee the integrity of the filter pack to 500 Pa (2.0" w.g.)

h. High Efficiency Final Filters:

A. 610 x 610 x 305 mm (24 x 24 x 12 in) 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.

B. Air filters shall be high efficiency ASHRAE extended surface pocket style filters consisting of high loft air laid microfine glass media, a reinforced ABS plastic header, ABS plastic pocket retainers, and bonding agents to prevent air bypass and ensure leak free performance.

C. Sizes shall be as noted on drawings or other supporting materials. Performance values for reference purposes shall be based upon 610 mm (24 in) by 610 mm (24 in) by 530 mm (21 in) or 560 mm (22 in) 10-pocket model.

D. Construction:

i. Filter media shall consist of high-density air laid lofted microfine glass media that is chemically bonded to a micro mesh media support backing forming a lofted filter blanket.

ii. All stitching centers shall be sealed using a foam-based sealant that shall remain pliable throughout the life of the filter.

iii. Pockets shall be formed into tapered pleats, supported by controlled media space stitching, to promote uniform airflow across the surface of the media. The pockets shall also have a conical configuration to minimize contact with HVAC system components.

iv. Support members shall include an ABS plastic header and ABS plastic pocket retainers that may be either recyclable or incinerable to promote sustainability. The header shall be joined to the media to prevent air bypass. The frame shall form a rigid and durable support assembly. The air exiting side of the air tunnels include a pocket flange to ensure pocket integrity throughout the life of the filter. A downstream pocket-to-pocket partition shall provide additional pocket separation to ensure full flow through the entire media area. A filter-to-filter sealing gasket shall be installed on one of the vertical members of the filter header.

E. Performance:

i. The filter shall have a Minimum Efficiency Reporting Value of MERV 13 per ASHRAE Standard 52.2 2007B (or later revision), Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. It shall further have a MERV 13A rating when tested under Appendix J of said standard.

ii. Initial resistance to airflow as listed by the manufacturer on a 530 or 560 mm (21” or 22”) depth 10-pocket bag shall be a maximum of 100 Pa (0.40” w.g.) at an airflow of 2.54 m/s (500 fpm).

Filter shall be warranted by manufacturer to last at least 8760 hours @ 1970 cfm and 250 Pa (1.0” w.g.), without the requirement of a pre-filter, under normal operating conditions in the case of up to 305 mm (12”) pocket depth; 13140 hours for a 330 - 560 mm (13”- 22”) depth pocket; twenty- four 17520 hours for a 580-810 mm (23” - 32”) depth. In all cases this warranty shall apply without the requirement of a pre-filter, and filter shall not exceed 250 Pa (1” w.g.) at an airflow of 2.54 m/s (500 fpm) at the end of these in-service periods. Filter shall further be warranted to maintain rated efficiency throughout its service life.

i. Supporting data:

A. Provide complete ASHRAE test report per ASHRAE Standard 52.2-2017 (or later revision) including full testing per Appendix J of this standard by an INDEPENDENT TESTING LABORATORY that participated in the ASHRAE Research Project RP-1088 (Coordinate and Analyze Interlaboratory Testing of Filters under ASHRAE Standard 52.2 to Determine the Adequacy of the Apparatus Qualification Tests).

j. Product shall be Camfil Hi-Flo ES or approved equal.

k. Filter Warranty Requirement:

A. If a bank of filters within the AHU causes the Pa to exceed 250 (w.g. to exceed 1.0”) at an airflow of 2.54 m/s (500 fpm), under normal operating conditions (as deemed by the Client's Operations staff) during the warranty period, a new set of filters of the same specification will be supplied to the Client at the Vendor’s expense. These filters will be warranted for the balance of the original warranty period.

l. Filter Frames:

A. Frames shall be constructed of 16-gauge galvanized steel at least 75 mm (3 in) deep and permanently assembled with solid rivets.
B. Where possible, the prefilters and final filters shall be installed in separate frames allowing the final filters to be replaced without having to remove the prefilters.
C. Closed cell gasketing shall be included allowing a tight seal to filter header/frame.

m. Magnehelic type differential pressure gauge with BACnet connectivity shall be provided across each air filter bank.

23 72 00 – Energy recovery equipment

1. Heat recovery systems which incorporate the transfer of energy between exhaust air and fresh air shall be provided.

23 82 29 – Radiators

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.
4. Provide a separate balancing valve for each radiator or group of radiators in series for the same building exposure.

23 83 13 – Snow melting

1. Provide snow melting systems where required by the Client, including on pedestrian and vehicle ramps. Refer to facility accessibility design standard, section 4.1.5 Entrances and 4.1.9 Ramps.

2. Electric snow melting cable shall come with a warranty of minimum 20 years after project substantial performance.

3. PEX tubing should carry a minimum 25-year warranty after project substantial performance.

4. Design requirements:

    a. The snow melting systems shall be designed to provide a snow-free area ratio of 1.0 as per ASHRAE Handbook-HVAC Applications.

5. The system shall be in idle mode but will automatically switch to melt mode when the outdoor ambient temperature drops below 0°C (32°F). Melt mode shall stay active until temperature rises above 0°C (32°F) or moisture is no longer present.

6. The hydronic snow melting manifold shall have visual flow gauges for each zone.

7. Hydronic fluid shall be suitable to withstand an ambient temperature of -35°C without freezing when stagnant.

8. Snow melt system thermal profile of the slab shall be verified by infrared thermography. Ensure uniform temperature profile across the extents of the pavement where the system is installed.

Appendix A – List of manufacturers

Plumbing

Page	Item Name	Manufacturers	Models (if Available) *Mandatory*
	Drinking Fountains	Elkay	N/A
		Haws	N/A
	Back Flow Preventers	Watts	N/A
	Battery Deck Faucets	Delta	590-PALGHDF  590TPA1190 
	Battery Deck Faucets (continued)		811DPA90  821DPA90  831DPA90

	Battery Deck Faucets (continued)		
		Moen	8559  8551  8553  CA8301  CA8302

	Battery Deck Faucets (continued)		
		Sloan	EBF-425-BAT-0.35GPM  EBF-85-BAT-0.35GPM  EBF-187-BAT-0.35GPM  EBF-775-BAT-0.35GPM  EBF-750-BAT-0.35GPM

			
	Lab Faucet Lab Faucet (continued)	Delta	W6600-9-C  W6700-9-C  W6635

	Lab Faucet (continued)		
		Moen	8106  8116 
		Delta	81T231BTA

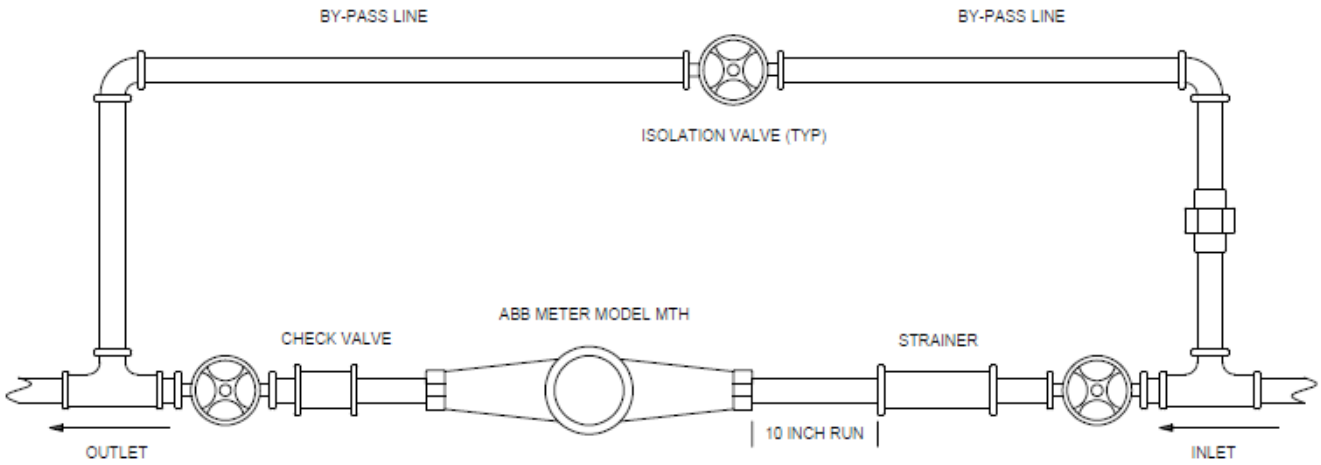
	Battery Exposed Flush Valves – Urinal		 81T231BTA-MMO 
	Battery Exposed Flush Valves - Urinal	Moen	8315 
		Sloan	G2 8186-0.5 
	Battery Exposed Flush Valves - Water Closet	Delta	81T201BTA 

	Battery Exposed Flush Valves – Water Closet (continued)		81T201BTA-MMO 
		Moen	8311 
		Sloan	G2 8111-1.28 

HVAC

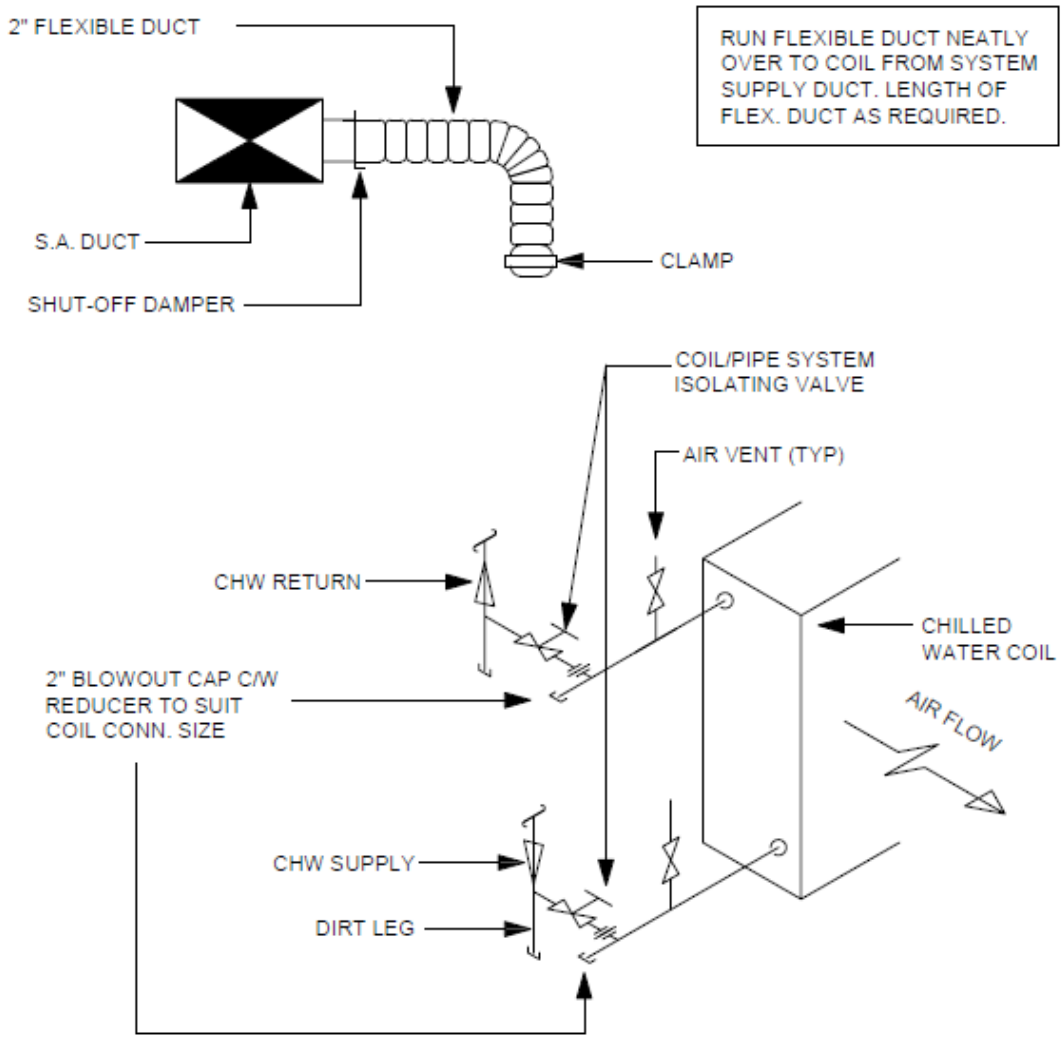
Page	Item # and Name	Manufacturers	Models (if Available) *Mandatory*
	Cooling Tower Control	Micrologics Control System	N/A
	Chemical Feed Pumps	Pulsatron	N/A

Appendix B – Installation of water or condensate meter

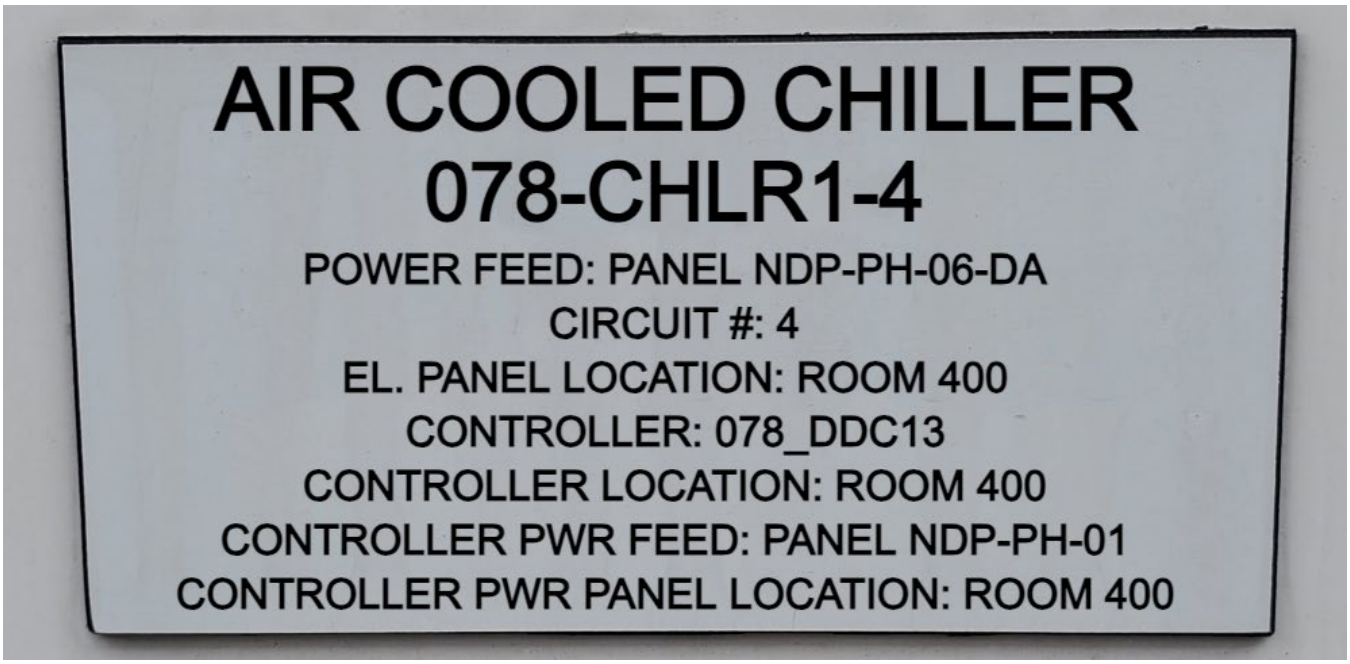


NOTE: ALLOW 10" MINIMUM STRAIGHT RUN ON INLET SIDE

Appendix C – Chilled water coil moisture evacuation



Appendix D – Exemplar identification tag



Appendix E – Cooling tower water treatment