



City Centre District Energy Utility

Technical Requirements for Onsite Discrete Cooling Plants

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Abbreviations

BAS	Building Automation System
CCDEU	City Centre District Energy Utility
CEP	Central Energy Plant
DCP	Discrete Cooling Plant
DDC	Direct Digital Control
DES	District Energy System
Delta T; ΔT	Temperature Difference
DEU	District Energy Utility
DHW	Domestic Hot Water
DPS	Distribution Piping System
EMT	Electrometallic Tubing
ETS	Energy Transfer Station
FDC	Future DEU Connection
GFA	Gross Floor Area
GHG	Greenhouse Gas
HEX	Heat Exchanger
HMI	Human Machine Interface
HVAC	Heating, Ventilation & Air-Conditioning
LIEC	Lulu Island Energy Company
MAU	Makeup Air Unit
MCC	Motor Control Centre
OAT	Outdoor Air Temperature
PLC	Programmable Logic Controller
RTD	Resistive Temperature Detector
UPS	Uninterrupted Power Supply
VFD	Variable-Frequency Drive

Definitions

Building (or Strata)	The shared owners of the common property and assets, on which the owner's possess individual lots.
City	The City of Richmond, including subsidiary Lulu Island Energy Corporation (LIEC) and the district energy service area City Centre District Energy Utility (CCDEU).
Customer	Refer to Building (Strata).
Developer	The party responsible for providing the majority of professional engineering work in the overall development of the DCP.
Discrete Cooling Plant (DCP)	A cooling plant located onsite that serves the single development.
District Energy (DE)	See section 2.1 in the Developer's Guidelines.
Energy Transfer Station (ETS)	The interface between the DCP and the Building (or Strata) HVAC.
Renewable	Energy sources that will be naturally renewed at a rate that is sustainable for continuous human exploitation.
Service Provider	The person or company contracted by the City to operate, maintain, and manager the DEU on behalf of the City.

1 Document Purpose

The City of Richmond (City) is committed to sustainability and reduced environmental impact. To this end, the City has created a new district energy service area in the City Centre neighbourhood. The new City Centre District Energy Utility (CCDEU) provides space heating, space cooling, and domestic hot water heating for buildings within the service area. Based on the address of the building and target connection date, LIEC will advise the developer on the required connection type. The CCDEU is owned and operated by the City's wholly owned subsidiary and district energy service provider Lulu Island Energy Company (LIEC).

Eventually, all buildings within the service area will be required to connect to the CCDEU to satisfy their thermal energy needs. To this end, the City requires that any new developments must be compatible with the CCDEU. Developments will have one of the following connection types:

- 1. Offsite District Heating and District Cooling Connection:** For developments whose heating and cooling services are supplied entirely from an off-site plant and transferred through an ETS for heating and cooling. Refer to the *Richmond City Centre District Energy Utility Service: A Design Guide for Connection to District Energy*.
- 2. DCP Cooling, Offsite District Heating Connection:** For developments whose cooling services are supplied from an on-site Energy Generation Plant but heating services are supplied from an off-site plant and transferred through an ETS for heating only. Refer to the *District Energy in Richmond City Centre: A Design Guide for Connection to District Energy* for ETS requirements and refer to this guideline for the DCP requirements.
- 3. Energy Generation Plant for Space Heating, DHW Heating, and Space Cooling:** For developments whose heating and cooling services are supplied entirely from an Energy Generation Plant located within the development. Refer to the *CCDEU Guideline for Onsite Low-Carbon Energy Systems* and *CCDEU Technical Requirements for Onsite Low-Carbon Energy Systems*.

The purpose of this document is to outline the technical requirements and expectations regarding design and construction of a DCP. It is expected that the information presented in this document will be used by developers, building owners, engineers, and architects to tailor their designs for optimal compatibility with LIEC's requirements and the CCDEU. This document shall be read in conjunction with the *City Centre District Energy Utility: A Guideline for On-Site Discrete Cooling Plants*, which gives a more general description of the DCP design and construction process, and responsibilities of all parties involved. LIEC will work closely with Developers and their design team throughout design and construction to ensure their design satisfies the intent.

Note that this document is only intended as a guideline to clarify the minimum set of standards acceptable to LIEC. This guideline does not constitute a design, and the Developer's design team still carries sole responsibility for the design and construction of the DCP in accordance with all applicable laws, codes, standards, and industry best practice. In some cases, the Developer's proposed design may require more stringent requirements than what is outlined in this document, and it is the Developer's responsibility to ensure those requirements are satisfied.

In accordance with the City of Richmond Bylaw 9895, it is mandatory that the developer collaborate with Corix and LIEC to ensure the design and operation meet the technical specifications of the Service Provider (LIEC) and Operator (Corix) prior to issuance of the Building Permit.

2 Design Standards and References

2.1 Design Standards and References

Designs shall conform to all applicable regulations, codes, and design standards. For convenience, a number of applicable reference documents are listed in Appendix B. The list should not be considered exhaustive. Compliance with codes, standards, and references not listed below, but required by law or best practice are still required. Unless noted otherwise, the most current edition of each reference shall be used.

3 General Requirements

General requirements for the system are listed in this section, with detailed technical requirements in the subsequent sections.

3.1 General Mechanical Room Requirements

1. Indoor spaces shall be climate controlled such that temperatures remain between 15°C minimum and 35°C maximum. Fresh air ventilation rates shall satisfy all regulatory and technical requirements. Refer to CSA B52, ASHRAE 62.1 and 90.1, and any other relevant standards. Outdoor spaces shall be provided with guardrails or equivalent such that fall arrest equipment is not required for routine operation and maintenance.
2. Spaces shall be illuminated in accordance with WorkSafeBC requirements, but not less than 150 lux. Provide adequate floor drains to facilitate typical operation and maintenance requirements. Sound levels at any location inside the plant shall not exceed 85 dBA during normal operation without prior written approval by LIEC. Provide adequate equipment isolation such that excessive noise and vibration is not transmitted to other portions of the building.
3. All spaces shall be included in the fire protection system for the base building including smoke/fire detection and fire suppression. The fire suppression system for the DCP shall be a double interlock release type pre-action system. The base building fire alarm control panel shall communicate alarm status to the DCP control panel. Refer to Section 6.5.1 for additional details.
4. Sound levels shall be attenuated to be in compliance with the City of Richmond Noise Regulation, Bylaw 8856.

3.2 Hydronic Fluid

The system will use treated water or an inhibited propylene glycol solution to suit the design. Regardless of the fluid chosen, the Developer must clearly indicate freeze protection measures for system components. Heat tracing is not acceptable as a primary solution for freeze protection. It is also not acceptable to drain down chillers, fluid coolers, or other outdoor equipment and piping systems as a means of freeze protection. In addition, the Developer shall employ the services of a water treatment subcontractor to provide the necessary chemicals, materials and supervision for a complete cleaning and flushing of all piping. Start-up and commissioning will only occur after acceptable water quality analysis results have been obtained. Certification from the water treatment contractor verifying that the water quality is adequate is required.

3.3 Technical Safety BC Registration

Where the proposed design contains equipment requiring registration with Technical Safety British Columbia (TSBC), the Developer is responsible for satisfying all application requirements including installation and operating permits, paying any applicable fees, and coordination with the TSBC representative. The Developer shall provide LIEC the CRN number.

CRNs shall be provided for all equipment, as required by CSA B51 and B52.

3.4 Design Temperatures

The minimum chilled water operating temperatures permitted at the DCP are shown in TABLE 1. The proposed temperatures are for peak demand periods. The supply temperatures may vary (warmer for cooling) based on an outdoor air temperature reset curve and expected cooling demands. Connected systems should be designed with this in mind.

TABLE 1: DCP SUPPLY TEMPERATURES (PLANT SIDE)

Service	Supply	Return	Differential
Chilled Water	7 °C	14 °C	7 °C

3.5 General DCP Requirements

The DCP design shall be based on a 2-pipe hydronic cooling system. Distributed water source heat pump systems and variable refrigerant systems are not acceptable alternatives. Below is a list of general design requirements for a typical DCP. In general, DCP systems shall be designed and selected for simplicity, ease of maintenance, and effectiveness in meeting the design requirements. Solutions that are unduly complex tend to cost more, fail sooner, and create more ongoing maintenance issues throughout the life of the building.

1. All equipment must be installed to meet manufacturers requirements. Major equipment must be able to be accessed for maintenance and removed without pipe disassembly.
2. Provide effective air separation and strainers in all hydronic systems.
3. Ensure flow rates are adequate and meet the equipment manufacturer's requirements under all possible operating conditions.
4. Ensure the DCP PLC based control system is compatible with the Corix SCADA and Controls Specifications.
5. Provide a dedicated BC Hydro meter for all electricity used by the DCP as well as all other LIEC equipment.
6. Ensure that the cooling plants can be controlled entirely by the local DCP control system. Equipment that runs to a reset temperature based on its own internal logic is not permitted, as these systems are difficult to fine tune for stable operation. These systems can also be difficult to stage. Note that unstable operation and inconsistent staging reduces equipment life.

7. Provide sufficient control points to monitor the system and diagnose any undesired operation.
8. Provide a floor drain and potable water hose bib in the room for washdown and maintenance purposes.
9. Provide proper water treatment to space cooling flows. Refer to section 6.5.4 for additional requirements.
10. Ensure design meets all applicable codes and standards, including CSA, BCBC & ASME.
11. Reduce the number of interactions between parts of the system. Systems with closely coupled components encourage unforeseen interactions that create issues and impede trouble shooting. For example, pumping systems should be carefully decoupled to prevent changes in flow in one part of the hydronic system from affecting flow in other parts of the system.
12. Avoid the use of three-way control valves in thermal plant design. Where three-way valves are required, consider using characterized three-way valves and balancing valves to ensure that flow control is consistent regardless of valve position.
13. Consider control linearity. Systems that modulate but have a non-linear responses to control input, such as pumping systems with multiple potential flow paths, should be avoided as they will introduce control instability.
14. Avoid opaque control systems. The control sequence and points list must be designed and written in tandem with the DCP design to ensure that the systems operate as intended. Avoid reliance on 'black-box' control systems provided by equipment manufacturers. The sequence should allow the controls contractor to control equipment operation, modulation, and staging as much as possible in order to avoid unintended outcomes. Do not leave the sequence entirely up to the control contractor. All possible operating modes should be clearly understood early in the mechanical design process.
15. Do not rely on heat trace as a primary means of freeze protection. Use continuous low-speed pumps circulation and rely on the heat tracing only for secondary freeze protection.
16. Hydronic Buffer Tanks shall meet the following requirements:
 - Hydronic buffer tanks shall be used to ensure that compressor cycle time is no less than 10 minutes during all loading conditions, or as required by the equipment manufacturer.
 - Tanks shall be arranged in a two-pipe configuration, with no more than two connections to the hydronic system. Three-pipe tanks do not allow sufficient temperature control, and four-pipe tanks encourage mixing that will short-circuit supply and return piping systems.
 - Utilize internal baffles in situations where the hydronic system connections are too close to allow for full use of the tank volume.

- For chiller systems, size tanks based on the minimum allowable cycle time for the smallest compressor stage or the lowest unloaded capacity. Refer to the manufacturer's requirements and ensure that the buffer tank sizing or configuration will not void the manufacturer's warranty.
 - Tanks shall have automatic air vents piped at the top and capped and valved drain connections at the bottom.
17. Hydronic systems that include chillers shall be designed for constant flow to each unit. Modular chillers that consist of multiple separate units that are piped together on common supply and return headers shall be designed for variable flow, but with discrete pre-set pump speeds or flow rates selected by the control system based on the number of modules operating.
 18. Hydronic loops that require variable fluid flow to ETS's must be primary/secondary loop systems, with the primary loop being the cooling source loop and the secondary loop being the load loop serving the ETS's. A decoupling line separates the two loops, which will include a buffer tank to prevent short cycling. Variable flow primary-only systems, where flow in the chillers varies based on the building load, are not permitted as these systems are more difficult to control effectively and can result in reduced equipment service lives.
 19. Full-size air separators shall be installed on all hydronic loops, even if those loops also have buffer tanks. The air separators must be installed on the suction side of the main circulator pumps where the system pressure is lowest. This should also be the point where the fill system and expansion tank are connected to maintains static pressure.
 20. All hydronic cooling systems shall operate with temperature reset based on demand. The demand-based reset will progressively relax the loop temperature setpoint until the most demanding zone is flowing between 90% and 95% of it's design flow rate.
 21. Natural gas or propane fired cooling systems are not permitted. All chillers must be electrically powered.
 22. Typical process and instrumentation diagrams for various equipment, showing all required components, are attached.

3.6 General ETS Design Requirements

Below is a list of general design requirements for a typical ETS:

1. Size the heat exchangers according to the peak flow demands of the Building (or Strata) system as defined in the energy modelling report prepared for the development. Plate and Frame or brazed plate heat exchangers are acceptable for space cooling service. Heat exchangers must have AHRI Certification and CRN.
2. Control valves for each heat exchanger must be sized to ensure proper valve authority, close-off pressure, and allowable differential pressure for modulating service.

3. Provide bypasses immediately before the isolation valves to the ETS, on both the DCP and Building (or Strata) mechanical sides of the heat exchanger, to facilitate flushing and chemical cleaning of the connected piping. Flushing and chemical cleaning through an ETS is not permitted. Provide strainers on both sides of each heat exchanger to limit fouling.
4. Provide a floor drain and potable water hose bib in the room for washdown and maintenance purposes.
5. Circulation pump on/off status should be provided to the ETS control panel through current sensors monitoring pump status.
6. If located in a different location than the DCP, the ETS shall have a local control panel with a dedicated communication conduit linking it to the central control panel in the DCP.
7. A typical process and instrumentation diagram for an ETS, showing all required components, is attached.

3.7 General Piping Design Requirements

Below is a list of general design requirements for piping:

1. Chilled water piping to be field-insulated carbon steel piping installed indoors and above-grade within the development.
2. Pipe insulation shall conform to ASHRAE 90.1. Chilled water pipes must have continuous vapour barrier.
3. All piping must be flushed and tested in accordance with ASME codes.
4. Developer to account for thermal and seismic stresses on the piping, in addition to regular operating loads when designing the piping. If TSBC registration is required, it is the responsibility of the developer to obtain the CRN and provide it to LIEC.
5. Any underground piping must be pre-insulated welded steel pipe rated, designed, and installed to EN 253.

3.8 General Future DEU Room Connection Requirements

The FDC is the space where LIEC will install heat exchangers and pumps in the future, to serve the building. Below is a list of general design requirements for a typical FDC:

1. The designer shall ensure that the development's space cooling system can be serviced by the FDC without any assistance from the DCP.
2. Provide 2-pipe connections from the DCP to the future FDC location, including isolation valves at the FDC location that can be connected into in the future. Piping connections shall be sized for 100% of the development's peak demand according to the load calculations performed by the mechanical Engineer of Record. Interconnecting piping shall be filled with nitrogen to reduce corrosion. Provide bypasses immediately before the isolation valves to the FDC, with blind flanges.

3. Provide 1x 50mm communication conduit with pull wire between FDC and DCP.
4. The FDC shall be located near ground level, but above the flood plain elevation.
5. The building's mechanical system shall be designed such that the entire building space cooling demand is supplied by the DCP can be switched to being supplied by the CCDEU via the FDC.
6. Pumping between the FDC and the DCP will be provided by future pumps that will be installed by LIEC.
7. Provide a clear route for the external CCDEU piping and communication conduit to connect into the FDC room.
8. Provide a floor drain and potable water hose bib in the room for washdown and maintenance purposes.
9. Provide power for the following connections:
 - Pump power: a sufficient electrical service to run chilled water circulator pumps to serve the full building cooling load capacities. These pumps will be installed between the FDC and the DCP as part of a future project. The pumps shall operate in duty/standby configuration.
 - Control power connection: A 120/240V power feed for FDC equipment will be required, including a 20 A 2P breaker in a nearby load centre, a 30 A lockable disconnect switch complete with viewing window and NEMA 1 surface mount enclosure; and three #12 in 16 mm conduit (EMT or RPVS as required from the breaker to the disconnect switch).
- A typical process and instrumentation diagram for an FDC, showing all required components, is attached.

3.9 Space Cooling Design Strategies

The cooling system shall provide space cooling and make-up air cooling to all suites, hallways, stairwells, and common areas of the building (or strata) as required. The building (or strata) space cooling system must be based on a hydronic style concept, designed to suit the DCP operating temperatures.

3.9.1 HVAC Terminal Equipment

The types of equipment provided in TABLE 2 along with their typical application are suitable for use in the Building's (or Strata's) HVAC system. Note that other systems not included in this section, such as distributed heat pumps or variable refrigerant flow systems, are not permitted.

TABLE 2: ACCEPTABLE HVAC TERMINAL UNITS

Equipment	Type	Description
Hydronic Fan Coils	Cooling	2-pipe or 4-pipe fan coil units, mounted on interior wall, suitable for cooling in suites.
Ventilation Make-Up Air Units	Cooling	Building (or Strata) make up air requirements shall be provided by air handling units with a water/glycol coil. The coils shall be provided with freeze protection.

3.9.2 Supplemental Energy Sources

All thermal energy demands for new developments within the CCDEU service area shall be satisfied by the CCDEU for heating and a DCP for cooling where cooling is not provided by the CCDEU. Supplemental thermal energy sources such as in-suite heat pump or hybrid heat pump terminal units, etc., are not permitted for use in developments within the CCDEU boundary. Note that heat recovery on the air side of the Building HVAC System is acceptable.

3.9.3 Pumping and Control

Delivery of secondary side cooling hydronic fluid to the HVAC equipment described above shall be via two-pipe, variable flow rate distribution, with a temperature reset curve based on outdoor air temperature and control valve position. All control valves shall be two-way modulating or on/off. Three-way valves are prohibited in instances in which they will reduce the secondary side Delta T. Developer shall select 2-way valves on terminal equipment along with variable flow secondary pumps. Only one three-way valve is permitted per pump loop if required by the design. Do not install 3-way valves in a bypass configuration, only mixing configurations are permitted.

3.9.4 System Hydronic Fluid

The hydronic fluid used in Building (or Strata) HVAC system may either be a treated water or glycol solution. The Developer's engineer is responsible for system and equipment freeze protection. The services of a water treatment subcontractor shall be used to provide the necessary chemicals, materials and supervision for a complete cleaning and flushing of all piping in the Building (or Strata) HVAC system. All ETS's must be bypassed during flushing.

Building owners (or Strata) will manage the make-up, expansion, and water/glycol quality on the building side of the ETS, and LIEC will manage it for the DCP. It is recommended that the Building (or Strata) regularly monitor levels of inhibitor, pH, and glycol concentration (where applicable) to ensure their mechanical system is properly maintained. LIEC will require future submissions of water quality tests to ensure the building's (or strata's) hydronic systems are being properly maintained.

3.10 Redundancy

A minimum of two chillers and, where applicable, two fluid coolers must be provided to meet the building cooling loads. Pumps paired directly with chillers or fluid coolers need not be provided with redundancy. However, secondary pumps between the plant systems and the ETS heat exchangers must be provided with N+1 redundancy.

4 Space and Access Requirements

4.1 General

As operator of the DCP, LIEC shall be granted access to all system components at all times without confined space constraints. The developer shall confirm that all equipment will be installed as per manufacturer's guidelines, with the required clearances for maintenance and operation. All mechanical rooms must be located above the floodplain elevation. The Developer shall provide floor plans indicating the location of each system component, the dimensioned space dedicated to each DCP component, and shall clearly detail how LIEC operations and maintenance personnel will access each component including but not limited to:

1. The DCP mechanical room.
2. The FDC mechanical room.
3. Any remote equipment (rooftop or similar) permitted by LIEC.
4. Each ETS Mechanical room.
5. All DCP piping.
6. The CCDEU service branch connecting the FDC to the CCDEU.

Adequate room for access to any piece of equipment for operation and maintenance, and the ability to remove an individual piece of equipment while maintaining operation of the plant (at a reduced capacity) is required. Access to space shall accommodate removal of largest component or piece of equipment that may have to be replaced through permanent access doors or hatches. Monorails may be required by LIEC depending on individual equipment accessibility.

The location of all DCP components within the development shall be approved by LIEC. Mechanical rooms and access corridors shall have a minimum opening dimension of 2.0 m x 2.0 m (or larger as required to pass the largest piece of equipment or removable part of equipment) to facilitate installation or removal of equipment. All equipment shall be installed on housekeeping pads. Guard rails or similar shall be provided around rooftop equipment such that fall arrest equipment is not required for routine maintenance. All equipment, including rooftop equipment, must be accessible by freight elevator. The size, location, and layout of all spaces related to the DCP must be reviewed and approved by LIEC during the building permit stage. Any deviations from these requirements shall be highlighted to LIEC for approval.

4.2 DCP

In general, all DCP equipment shall be installed in one room (or adjacent rooms) and can be co-located with other mechanical equipment unrelated to the DCP. LIEC may grant an exception where the equipment has specific space requirements, such as air-source equipment being located on a roof. However, there is a strong preference for all equipment to be placed in one location, so the Developer must provide adequate justification to install equipment in remote locations.

4.3 ETS

The ETS can be co-located with other mechanical equipment or installed in a dedicated room.

4.4 FDC

The FDC is to be located above the floodplain elevation in the customer building, but it shall be no higher than 4.0 m above ground level to ensure adequate system pressure on the CCDEU side of the heat exchanger. The FDC can be co-located with other mechanical equipment or installed in a dedicated room. An allowance must also be made for the entry of the CCDEU service branch into the building and two 50 mm communication conduits linking the DCP with LIEC's central operations centre.

The mechanical room containing the FDC must be located on the exterior wall of a development, and sufficiently large to allow for access, inspection, maintenance, removal, and repair of equipment. The access corridor to FDC room shall have a minimum opening dimension of 2.0 m high x 1.8 m wide (or larger as required to pass the largest piece of equipment or removable part of equipment) to facilitate installation or removal of equipment.

Provide a preliminary layout for the FDC equipment, allowing for one heat exchanger sized for the full building cooling capacity, as well as pumps (duty and standby) and controls. A minimum area of 4 m x 6 m with a minimum room height of 2.5 m is required for the cooling FDC. No other equipment or piping shall be located within this space.

The FDC room size, location, and layout, including the future DPS route to connect to the CCDEU must be reviewed and approved by LIEC during the development permit process.

5 Mechanical Equipment

5.1 General

This section identifies the minimum acceptable standards for major pieces of mechanical equipment.

5.1.1 Quality Assurance

1. All products shall be new, undamaged, and free from rust and defects.
2. All products of a similar nature shall be the product of a single manufacturer.
3. Rotating parts to be statically and dynamically balanced.
4. All equipment shall be CSA approved or approved by other agency acceptable to Technical Safety BC (TSBC) including: CGA, ULC, ITS, ETL, cUL, cMET. The manufacturer shall have a representative for the equipment in the Greater Vancouver area, British Columbia.
5. The manufacturer shall have a minimum of ten (10) years' experience in fabrication of their supplied equipment with a quality assurance program approved by LIEC.
6. Equipment shall be hydrostatically tested, including submission of test report.
7. LIEC may require factory testing for select equipment.
8. ETL listed in accordance with UL Standard 1995, certified per CSA C22.2 No. 236 standard.
9. CSA C22.2 No. 0.4-17 Bonding of electrical equipment.

5.1.2 Warranty and Maintenance

1. All equipment shall be provided with a minimum three (3) year full parts and labour warranty starting from the occupancy date of the Plant. Extended parts only warranties are required for certain equipment as outlined in specific equipment sections below.
2. The equipment manufacturer must demonstrate that there is a local service organization qualified to service the equipment which shall:
 - Have a well-equipped maintenance shop within the Greater Vancouver Area of British Columbia.
 - Be in existence long enough to have an established reputation with references for backup.
 - Have a number of qualified employees with the ability to respond 24/7 to service calls.
 - Have commonly required spare parts in stock locally, or readily available.

5.1.3 Submittals

1. Manufacturer's specifications and technical data including partial performance data, materials of construction, methods of fabrication, and quality assurance program.
2. Major equipment will be required for shop drawing review prior to ordering equipment. Other equipment may be requested at the discretion of LIEC. At a minimum, submit the following shop drawings for review:
 - Control systems and equipment, including detailed sequences of operation.
 - Circulator pumps.
 - Chillers.
 - Heat rejection systems
 - Buffer tanks.
 - Heat exchangers.
3. Refer to Section 12 regarding record drawings and operation and maintenance manual requirements.
4. Testing, cleaning, and maintenance instructions.
5. Personnel operating instructions.
6. Maintenance materials list.
7. Parts list/Diagram.
8. Certified test reports indicating compliance with specified performance requirements.
9. Factory test procedures and test report.
10. Local Service Organization information, experience, and references.

5.1.4 Health and Safety

1. Safety power cut-off switch available at each equipment for maintenance lock-out.

5.2 Air-Cooled Chillers

This section outlines the requirements for chillers.

5.2.1 Technical Requirements

1. Two-Pipe configuration designed for cooling operation.
2. Equipment and attachment to building designed to resist loads in accordance with the building code.
3. Minimum turndown of 15% without prior approval from LIEC.
4. Refrigerant type shall be in compliance with local regulatory requirements.
5. Compressors shall include high discharge pressure and low suction pressure cut-outs.

6. The equipment shall be equipped with vibration isolators.
7. Capable of interfacing with plant automation system using Modbus communication protocols.
8. The equipment shall be provided with a sound dampened enclosure rated for outdoor service with noise levels compliant with Noise Regulation Bylaw.
9. Engraved stainless-steel nameplate on each module.
10. Enclosure complete with access doors for access to all interior equipment, with adequate clearance in front of access doors to permit access. Adequate space for ladder access to fans and motors.
11. Meet local seismic and wind loading requirements.
12. Performance in accordance with AHRI 550/590 and ASHRAE 90.1-2019.
13. Typical schematic for an chiller plant installation provided at end of document, refer to the attached figure.
14. A data sheet shall be provided which lists, as a minimum:
 - Cooling efficiency in EER (Btu/Wh) at full load and part loads as well as kW/ton at full load and part loads.
 - Nominal, minimum, and maximum flows per unit with the corresponding pressure drops.
 - Electrical power per motor.
 - Sound levels, in 'dB', at 1.0 m away from the unit.
 - Equipment weight and dimensions.
 - Minimum clearance requirements for operation and maintenance.
 - Refrigerant type and weight.
 - Minimum turndown.
15. Units shall be supplied with certified test reports indicating compliance with specified performance for design operating conditions plus partial load performance at 25%, 50%, and 75% capacity.
16. Compressors shall include a minimum five (5) year parts only warranty.

The equipment shall have AHRI certification and have a CRN number registered with the local authority having jurisdiction.

5.2.2 Controls and Electrical

1. Chillers to include a standalone control panel that allows the optimization of individual modules/units to run in cooling only mode. Compressor staging or capacity modulation shall be controlled directly by the PLC system and shall not be based on internal temperature reset controls.
2. Control panel shall allow remote connectivity to change set points and relay all available data and alarms generated by the chillers.
3. Inlet and outlet temperature sensors.
4. Differential pressure sensors across inlet and outlet.
5. Refrigerant temperature sensors.
6. High/low pressure alarms.
7. Integrated control panel system capable of staging modules to satisfy demands.

5.2.3 Standard of Acceptance

1. Climacool.
2. Smardt
3. Aermec.

On a special-case basis, equivalent alternatives may be reviewed and approved at the sole discretion of LIEC and its Representatives.

5.3 Water-Cooled Chillers

This section outlines the requirements for water-cooled chillers.

5.3.1 Technical Requirements

1. Four-Pipe configuration designed for parallel flow of chilled and condenser water piping.
2. Equipment and attachment to building designed to resist loads in accordance with the building code.
3. Minimum turndown of 15% without prior approval from LIEC.
4. Refrigerant type shall be in compliance with local regulatory requirements.
5. Shell and Tube type Heat Exchangers, use a fouling factor in accordance with AHRI Guideline E. Brazed plate heat exchangers may be acceptable as an alternative when equipment capacities limit availability. Obtain written approval from LIEC.
6. Compressors shall include high discharge pressure and low suction pressure cut-outs.
7. The equipment shall be equipped with vibration isolators.
8. Capable of interfacing with plant automation system using Modbus communication protocols.
9. Engraved stainless-steel nameplate on each module.

10. Safety power cut-off switch available at each unit for maintenance lock-out.
11. Chillers to meet local seismic and wind loading requirements.
12. Performance in accordance with AHRI 550/590 and ASHRAE 90.1-2019.
13. Typical schematic for an chiller plant installation provided at end of document, refer to the attached figure.
14. A data sheet shall be provided which lists, as a minimum:
 - Cooling efficiency in EER (Btu/Wh) at full load and part loads as well as kW/ton at full load and part loads. Nominal, minimum, and maximum flows per unit with the corresponding pressure drops.
 - Electrical power per motor.
 - Sound levels, in 'dB', at 1.0 m away from the unit.
 - Equipment weight and dimensions.
 - Minimum clearance requirements for operation and maintenance.
 - Refrigerant type and weight.
 - Minimum turndown.
15. Units shall be supplied with certified test reports indicating compliance with specified performance for design operating conditions plus partial load performance at 25%, 50%, and 75% capacity with a constant condenser water temperature at design point.
16. Compressors shall include a minimum five (5) year parts only warranty.
17. The equipment shall have AHRI certification and have a CRN number registered with the local authority having jurisdiction.

5.3.2 Controls and Electrical

1. Chillers to include a standalone control panel that allows the optimization of individual modules/units. Compressor staging or capacity modulation shall be controlled directly by the PLC system and shall not be based on internal temperature reset controls.
2. Control panel shall allow remote connectivity to change set points and relay all available data and alarms generated by the chillers.
3. Inlet and outlet temperature sensors.
4. Differential pressure sensors across inlet and outlet.
5. Refrigerant temperature sensors.
6. High/low pressure alarms.
7. Integrated control panel system capable of staging modules to satisfy demands.

5.3.3 Standard of Acceptance

1. SMARDT.
2. Daikin.
3. Trane.

On a special-case basis, equivalent alternatives may be reviewed and approved at the sole discretion of LIEC and its Representatives.

5.4 Fluid Coolers

This section outlines the requirements for Cooling Towers/Fluid Coolers.

5.4.1 General

1. Fluid Coolers shall be designed, fabricated, and tested in accordance to the AHRI and CTI Standards.
2. Work shall be carried out only by qualified tradesmen.
3. Thermal performance of the fluid cooler shall confirm to minimum efficiency per ASHRAE Standard 90.1-2019.
4. Provide an induced-draft, cross flow or counter flow type, factory assembled, closed circuit, wet fluid coolers.
5. All products shall be new, undamaged, and free from rust and defects.
6. Statically and dynamically balance rotating parts.
7. Structure to meet local BC seismic and wind loading conditions.
8. Construction shall permit complete servicing without breaking piping or motor connections.
9. Ladders and suitable access hatches shall be furnished to allow access to all components.
10. Maximum flame spread rating of 25.
11. Vibration isolation/vibration cut off switch.
12. Capable of interfacing with plant automation system using Modbus communication protocol.
13. The equipment shall be provided with a sound dampened enclosure rated for outdoor service.
14. Engraved stainless-steel nameplate on each module.
15. Safety power cut-off switch available at each unit for maintenance lock-out.

16. A data sheet shall be provided listing, as a minimum, the following information:

- Efficiency at the design operating entering temperature.
- Nominal, minimum, and maximum flows per unit with the corresponding pressure drops.
- Electrical power information per motor.
- Sound level, in 'dB', at 1.0 m away from the unit.
- Equipment weight and dimensions.
- Minimum clearance requirements for operation and maintenance.

17. Maximum sound levels to meet local jurisdictional requirements.

18. Provide lifting hooks on all equipment.

5.4.2 Coil

1. Fully welded box headers with serpentine tube circuits.
2. Hot dip galvanized as one unit after fabrication (copper may be approved with dielectric isolation).
3. Coil shall be designed to allow for free drainage of fluid.

5.4.3 Fan

1. Heavy duty, axial or centrifugal design.
2. Blades shall be aluminum alloy attached to a hot dip galvanized steel hub with U-bolts. Hubs shall be factory statically balanced.
3. Blades shall be individually adjustable.
4. Bearings shall be rated at L10A service life of 40,000 hours minimum.
5. Provide an air seal disc (cover) to prevent air circulation at the fan hub.
6. Refer to section 8.16 for fan motor requirements.
7. Refer to section 8.14 for fan VFD requirements.

5.4.4 Vibration Limit Switch

1. Provide vibration limit switch for each cell.
2. Switch designed to shut down fan on excessive vibration.
3. Adjustable for sensitivity.
4. Remote manual reset; reset button to be located on fan deck, near the fan motor.
5. Double (DPDT) contact output.
6. NEMA 4 enclosure.

5.4.5 Fill

1. Film-type thermoformed of heavy-duty PVC.

5.4.6 Drift Eliminators

1. Design of drift eliminators shall limit drift loss to a maximum of 0.005% of the circulated water flow rate.
2. Cooling Tower/fluid cooler design shall meet the drift eliminator manufacturer's requirements.
3. Eliminators to be fabricated from heavy duty PVC with a minimum of three (3) changes in air direction.
4. Flame spread rating of 25 or less.
5. Section is to be removable.

5.4.7 Inlet Louvers

1. Designed to minimize water splashing and eliminate direct sun light.
2. Coil air-inlet louvers shall be a minimum of 0'-5" air travel, triple-pass PVC to limit water splash out and prevent direct sunlight from entering the collection basin.
3. PVC louvers shall be easily removable for access to the coil(s).
4. The minimum number of changes in air direction in a louvers shall be three.

5.4.8 Pumps and Motor (water recirculation for fluid coolers only)

1. Select pumps to meet the final intended use meeting the specifications herein.

5.4.9 Water Level Control

1. Provide a water level control system including a NEMA 4X control panel, water level probes and probe stilling chamber.
2. The control system shall monitor the water level in the cold-water basin to determine level events used for cold-water make-up, high and low alarms and/or pump shut down.
3. The control panel shall use electromechanical relays providing power for the make-up solenoid and electrical contacts for alarm and pump shutdown control circuits.

4. Probes shall be contained in a vertical stilling chamber to stabilize the water in the cold-water basin. Probes shall have replaceable stainless-steel tips and level height shall be field-adjustable.
5. Provide control and injection systems that introduce alternating doses of differing biocide chemicals. Biocides shall be organic, broad spectrum, both oxidizing and non-oxidizing, of a type that breaks down to non-toxic chemicals at the end of service life. The biocide product shall contain multiple active chemicals as required for treatment of biological material determined by test.

5.4.10 Nameplate

Each Cooling Tower/fluid cooler unit shall have a stainless-steel nameplate located in an easily visible location near floor level. The nameplate shall include at least the following data:

1. Manufacturer's name.
2. Year of manufacture.
3. Model number.
4. Serial number.
5. Rated capacity.
6. Nominal flows.

5.4.11 Controls and Electrical

1. Each cell of the Cooling Tower or the fluid cooler shall be equipped with a UL/CUL 508 listed control panel in a NEMA 4 outdoor enclosure designed specifically for this application.
2. The panel shall include a main thermal magnetic circuit breaker disconnect with an external operating handle, lockable in the off position for safety.
3. For spray pump operation use of a full voltage non-reversing magnetic starter with manual ON and OFF control via a door mounted selector switch shall be provided.
4. Dry status contacts wired to user terminal points indicating typical alarm and status events shall be provided.
5. Two safety circuits for the spray pump, low water cut off preventing a dry run pump and a pump shut down upon approaching freezing temperatures in the cold-water basin shall be provided.
6. Available Options to be included: Water level control with various combinations of make-up, high alarm, low alarm, high cut off and low cut-off events.
7. Power for damper actuator motor.
8. The power connection shall be 600 V / 3-phase / 60 Hz.

5.4.12 Freeze Protection

1. Basin heater controller with low water cut out: The system shall consist of one or more stainless-steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 enclosure shall house a magnetic contactor to energize heaters; a

transformer to provide 24-volt control circuit power; and a solid-state circuit board for temperature and low water cut-off. Other freeze protection subject to LIEC approval.

2. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 4 °C water temperature at an ambient air temperature of -9 °C.
3. Spray pump heat trace circuit: Recirculating pump(s) shall be fitted with heat trace cable and insulated.

5.4.13 Preapproved Manufacturers

1. BAC.
2. Evapco.
3. SPX / Marley.

On a special-case basis, equivalent alternatives may be reviewed and approved at the sole discretion of LIEC and its Representatives.

5.5 Pumps

This section outlines the requirements for Pumps.

5.5.1 Quality Assurance and Reference Standards

1. Pumps shall be designed, fabricated, and tested in accordance with Hydraulic Institute (HI) Standards.
2. Work shall be carried out only by qualified tradesmen.
3. Pumps above 0.75 kW (1 HP) shall be either base-mounted or split-coupled vertical inline.
4. Multiple pumps shall be configured either in a lead standby arrangement or in a staged lead/lag arrangement. Where multiple pumps are intended to operate together to meet the design flow, they must be balanced in simultaneous operation.
5. Coupled pumps shall be aligned by a qualified millwright and alignment certified.
6. Each pump shall have common tubing connected with isolation valves to the supply and return sides of the pump, as well as upstream of the strainer. A single pressure gauge and a single combination instrument tapping (Pete's Plug) shall be provided for each pump.
7. Ensure pumps operate at specified system fluid temperatures without vapour binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.
8. Each pump shall be tested in accordance with Hydraulic Institute (HI) standards for Rotodynamic Pumps for Hydraulic Performance Acceptance Tests for measurement of flow, head, power input to the pump, and Net Positive Suction Head Required. The substitution of a model pump for the test will not be acceptable. Pumps shall meet Hydraulic Institute performance tolerance B.

5.5.2 Submittals

1. Submit list of recommended spare parts with current prices for pumps and equipment.
2. Submit with shop drawings certified pump curves showing pump performance characteristics with pump and system operating point plotted for constant speed pumps. For variable speed pumps, provide curves at 25%, 50%, 75% and 100% of maximum speed.
3. Show the following points on the pump curves: minimum flow, operating point, best efficiency point, and maximum flow. For variable speed pumps show the curve for the following % speed (35, 50 75, 100).
4. Show pump operating weights, dimensions, clearance for operation and maintenance, motor and pump operating efficiencies and electrical power characteristics.
5. Where pumps are operated in conjunction with others such as parallel pumps, show all operating points on the pump curve.
6. Motor general arrangement drawing, terminal box for power wiring and terminal box for thermistor connection.

5.5.3 General

1. All products shall be new, undamaged, and free from rust and defects.
2. All products of a similar nature shall be the product of a single manufacturer.
3. Statically and dynamically balance rotating parts.
4. Construction shall permit complete servicing without breaking piping or motor connections.
5. Provide lifting hooks on all equipment.
6. Mechanical seal, replaceable without removing the motor. Designed for closed system with positive suction pressure. Select for temperature, pressure and service as recommended by the manufacturer.
7. Where applicable, flexible spacer type coupling. Allow the removal from pump and motor shafts, leaving enough space between the shafts to replace the mechanical seal components without disturbing the pump or motor.
8. Select pump and motor for continuous operation at 40°C.
9. Factory primed and painted with epoxy or enamel suitable to design temperature.
10. Designed for vertical-mounting applications.
11. Size the motor to be non-overloading for the entire pump curve.
12. The pumps shall be controlled by a variable frequency drive where indicated.
13. Provide stainless-steel nameplate stating all ratings including bearing data, as well as manufacturer's name, year of manufacture and model number.

14. Provide cable entry terminal box and ground lug on motor frame.
15. Pump selection shall allow for a 10% increase in flow by changing the impeller but not changing the motor.
16. The pump curve shall be drooping with the duty point between the mid curve and the best efficiency point.
17. Refer to Section 8.16 on motors and Section 8.14 on VFDs.

5.5.4 Preapproved Manufacturers

1. Bell & Gossett.
2. Armstrong.
3. Grundfos.

On a special-case basis, equivalent alternatives may be reviewed and approved at the sole discretion of LIEC and its Representatives.

5.6 Heat Exchangers (HEX)

This section outlines the requirements for Heat Exchangers.

5.6.1 General

1. Compliant with both CSA B51 and ASME Boiler and Pressure Vessel Code.
2. Canadian registration number (CRN).
3. Pressure tested to 1.5 times the working pressure in accordance with CSA B51-19.
4. Sized to minimize approach temperature differential.
5. Engraved stainless-steel nameplate listing including the following information for both sides of the heat exchanger: design flow, design temperatures, pressure drop for design flow.
6. Self-supporting and anchored to resist expected loading (live loads, seismic, and others as relevant). Piping connected to HEX nozzles shall be designed such that loads applied to nozzles do not exceed allowable loads specified by the manufacturer.
7. Lifting lugs designed to lift the entire unit.
8. ANSI Class 150 or 300 flanged, or stud nozzle connections preferred. (Threaded connections will be considered for nozzles 2" and below).
9. 316 stainless steel corrugated flow plates optimized for counter flow arrangement with minimum 0.35 mm thickness, 316 SS cover plates, copper brazing where applicable, EPDM gaskets, and stainless-steel bolts nuts and washers.
10. Plate and frame HEX shall allow for plate removal of any plate in the stack without removal of other plates and provide movable back plate with roller bearing for this purpose. Frame shall be factory baked epoxy enamel carbon steel, bolted construction (welding is prohibited).

11. Plate and frame HEX shall be used for cooling.
12. All heat exchangers should be protected with strainers.
13. HEX servicing DHW service shall be of double-wall construction to prevent cross contamination of fluid streams. Units shall be complete with individual channel leak detectors. Units shall be furnished with a drip tray and a moisture detector.
14. Plate and frame HEX frame shall allow for a 10% increase in capacity by adding more plates. Brazed HEX shall be oversized by 10%.
15. Ensure HEX is bypassed from system during flushing.
16. HEX shall be factory or field insulated.

5.6.2 Preapproved Manufacturers

1. Alfa Laval.
2. Armstrong.
3. Bell and Gosset / Xylem.

On a special-case basis, equivalent alternatives may be reviewed and approved at the sole discretion of LIEC and its Representatives.

6 Piping, Fittings, Valves, and Appurtenances

6.1 Piping and Fittings

This section outlines the requirements for Piping and Fittings.

6.1.1 General

1. All hydronic cooling piping associated with the DCP shall be field-insulated carbon steel piping designed and installed in accordance with ASME B31.1 or in accordance with ASME B31.9 where pressure permits. Note that any piping connected directly to the CCDEU and not on the building side of the ETS heat exchanger shall in all circumstances be designed and installed in accordance with ASME B31.1.
2. The future CCDEU service connection piping will be pre-insulated carbon steel piping in accordance with EN 253, designed and installed in accordance with ASME B31.1 or in accordance with ASME B31.9 where temperature and pressure permit.
3. Grooved couplings and fittings may be used provided:
 - All fittings, couplings, and accessories are by Victaulic.
 - The installer's site-specific crew are certified and trained by Victaulic.
 - Regular site inspections are provided by Victaulic.
4. At a minimum, it is expected that the Building (or Strata) side space cooling piping will be field-insulated carbon steel installed in accordance with ASME B31.9.
5. At a minimum, it is expected that the Building (or Strata) side domestic hot water piping will be field-insulated stainless-steel, or copper designed and installed in accordance with ASME B31.9 with materials and equipment conforming to NSF 61.
6. For other services within the DCP not explicitly listed above, it is expected that materials and construction will be in accordance with industry best practice and relevant design codes.

6.1.2 Carbon Steel (50 mm diameter and smaller)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 80 wall thickness, material conforming to ASTM A53 grade B or ASTM A105 grade A.
2. Joints: socket weld or threaded in accordance with ASME B1.20.1.
3. Fittings: socket welded or threaded in accordance with ASME B16.11, material conforming to ASTM A105.
4. Coating: At a minimum, indoor uninsulated installations in an air-conditioned space shall be coated with an alkyd primer to a minimum dry film thickness of 3 mils, and if installed outdoors (insulated or not) or in an unconditioned space an epoxy topcoat with a minimum dry film thickness of 3 mils is also required. All coatings shall be suitable for the service conditions and temperature.

6.1.3 Carbon Steel (larger than 50 mm diameter)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 40 wall thickness, material conforming to ASTM A53 grade B or ASTM A105 grade A.
2. Joints: full penetration butt weld, flanged, or threaded.
3. Fittings: butt weld in accordance with ASME B16.9 with material conforming to ASTM A105.
4. Flanges: Mild steel ASTM A105 grade B, raised face (except use flat face when connecting to flat faced equipment), weld-neck to ASME B16.5.
5. Coating: At a minimum, indoor uninsulated installations in an air-conditioned space shall be coated with an alkyd primer to a minimum dry film thickness of 3 mils, and if installed outdoors (insulated or not) or in an unconditioned space an epoxy topcoat with a minimum dry film thickness of 3 mils is also required. All coatings shall be suitable for the service conditions and temperature.

6.1.4 Stainless Steel (50 mm diameter and smaller)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 40S wall thickness, material conforming to ASTM A312, grade 304L or 316L.
2. Joints: socket weld or threaded in accordance with ASME B1.20.1.
3. Fittings: socket welded or threaded in accordance with ASME B16.11, material conforming to ASTM 403.
4. Coating: None required, pickle and passivate in accordance with ASTM A380 prior to delivery to site.

6.1.5 Stainless Steel (larger than 50 mm diameter)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 10S wall thickness, material conforming to ASTM A312, grade 304L or 316L.
2. Joints: full penetration butt weld, flanged, or threaded.
3. Fittings: butt weld in accordance with ASME B16.9 with material conforming to ASTM A403 grade 304L or 316L.
4. Flanges: Stainless steel ASTM A182 Grade 304L or 316L, raised face (except use flat face when connecting to flat faced equipment), slip-on or weld-neck to ASME B16.5.
5. Coating: None required, pickle and passivate in accordance with ASTM A380 prior to delivery to site.

6.1.6 Copper

1. Pipe: ASTM B88 Type L annealed temper.
2. Joints: Soldered, brazed, flared, press-connect, or push-fit. ASTM B32 alloy Sn50 shall not be used.
3. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, and ASME B16.50.
4. Flanges: shall be in accordance with ASME B16.24.
5. Coating: none required.

6.1.7 Joints

1. Other flange styles and dimensional standards may be required to mate with equipment connections.
2. Raised-face flanges shall not be used to mate with equipment using flat-faced flanges; flat-faced flanges should be used in this case.
3. Flange gaskets shall conform to ASME B16.21 constructed of materials suited for the proposed service.
4. Provide flange isolation type gaskets (or a dielectric union) at any connection between dissimilar metals.
5. Where flanges will regularly be exposed to damp conditions, 304 stainless steel bolts, nuts, and washers (where required) shall be used.
6. Welded joints shall be 100% visually inspected by a qualified welding inspector, and at least 20% of welded joints shall undergo radiographic examination in accordance with ASME B31.1 requirements. All NDT test results shall be fully documented with copies included in the owner's manual.

6.1.8 Alternates

1. The wall thicknesses and materials listed in this section are the minimum acceptable requirements. More stringent requirements may be required to suit the Developer's design. The Developer is responsible for confirming that materials and wall thicknesses satisfy design requirements.
2. Alternate piping systems, offering similar or superior performance, will be considered. Submit alternate systems for approval. Plastic piping is not permitted.

6.2 Valves

This section outlines the requirements for Valves.

6.2.1 General

1. All valves shall meet the requirements of B31.1 or B31.9 where temperature and pressure permit.
2. Valves shall be in accordance with relevant MSS SP standards.
3. All valves installed 2.4 m above floor level shall have a chain operator.

6.2.2 Gate Valves

1. Cast carbon steel, metal seat, pressure-temperature ratings in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5.

6.2.3 Globe Valves

1. Materials to suit application, pressure-temperature ratings in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5, screwed ends in accordance with ASME B1.20.1.

6.2.4 Ball Valves (Main line)

1. Flanged or welded ends, valves shall be pressure-temperature rated in accordance with ASME B16.34 with flanged ends in accordance with ASME B16.5. Stainless steel ball, stainless steel blow-out proof stem, and EPDM elastomers.
2. Ball valves shall be used for critical and essential isolation on systems that require regular shut-down.

6.2.5 Ball Valves (Drains, vents, and misc.)

1. Two-piece, full port, 1,000 psi WOG, threaded ends, carbon steel, bronze, or stainless steel.

6.2.6 Butterfly Valves

1. Class 150 lug or flanged style. The valve shall be a high-performance double-offset, metal seated design with stainless steel disk, stainless-steel blowout proof one-piece stem, and EPDM seat.
2. Butterfly valves shall be used for non-essential isolation on systems that do not require regular shut-down.

6.2.7 Check Valves

1. Pressure-temperature rated in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5.

6.2.8 Needle Valves

1. Carbon steel body, stainless steel stem, Teflon packing with NPT ends. Rated for 69,000 kPa at 93 °C (10,000 psi at 200 °F). Body shall be stainless-steel for potable water and domestic hot water applications.

6.2.9 Pressure Relief Valve

1. Direct-operated, spring loaded, resilient seated pressure relief valve with brass/bronze base/body/bonnet, stainless steel warn ring/disk, and NPT ends. For potable water and domestic hot water use, all components shall be stainless steel, or use a brass/bronze valve certified to NSF 61 for potable water service. Valve selection shall comply with the requirements of ASME Section VIII, Div. 1 and ASME B31.1 where required.

6.2.10 Balancing Valve

1. Brass or ductile iron body and bonnet, stainless steel spring, EPDM elastomers, threaded or flanged ends. Valve shall incorporate the ability to balance, pre-set, measure, and shut-off. Balancing valves shall be TA series valves by Victaulic.

6.2.11 Reduced Pressure Principle Backflow Device

1. Epoxy coated cast or ductile iron check valve bodies with stainless steel internals in accordance with AWWA C511, CSA B64.5, NSF 61, and NSF 372. Provide air gap assembly for relief valve drain connection.

6.2.12 Gas Pressure Regulator

1. Ductile iron or steel body in accordance with CSA 6.18, ANSI Z21.78/CSA 6.20, or ANSI Z21.80/CSA 6.22 as appropriate for intended service.

6.2.13 Triple Duty Valve

1. Avoid triple duty valves. Instead, provide separate shut-off, check, and balancing valves.

6.2.14 Suction Diffuser

1. Ductile iron body and guide vanes, stainless steel strainer and mesh, or other materials to suit application. Suction diffuser shall include a strainer and guide vanes to condition flow upstream of the pump. Refer to straining requirements in section 6.3.1. Provide 6 mm tapping ports for gauge connections.

6.2.15 Modulating Control Valves

1. Modulating control valves shall be either globe style modulating type or characterized ball type with equal flow characteristics with ANSI Class 150 or 300 raised face flanges and a minimum shut-off pressure of 150 psi. Valve shall include 316 SS trim, Teflon packing, and a physical valve position indicator.
2. Modulating valves shall be selected for a valve authority of A-0.5, or as recommended by the valve manufacturer for the application.
3. Alternate valves for modulating control with similar performance will be considered.

4. Actuators shall be sized for 1.25 times maximum torque requirements of shut-off pressure rating and rated for at least 600 starts per hour. The power and controls terminals shall be segregated, and the actuator shall use 4-20 mA or 0-10 VDC position command input and position feedback output signals. The starter shall be solid state type where applicable. The actuator shall be shipped from the factory including manual hand wheel, allowing for manual operation in the event of power or control failures, and limit switches.
5. Standard of Acceptance:
 - Siemens.

6.2.16 On/Off Control Valves

1. On/Off control valves to suit application. Use ball valves, double- or triple-offset butterfly valves, gate valves, or globe valves as appropriate.
2. Actuators shall be sized for 1.25 times maximum torque requirements of shut-off pressure rating and rated for at least 120 starts per hour. The power and controls terminals shall be segregated, and the actuator shall use 4-20 mA or 0-10 VDC position command input and position feedback output signals. The starter shall be solid state type where applicable. The actuator shall be shipped from the factory including manual hand wheel, allowing for manual operation in the event of power or control failures, and limit switches.

6.2.17 Automatic Air Release Valve

1. Automatic air release valves are required at all high points in the system. Lever type valve sized to meet service requirements; valve discharge piping shall be routed to floor. Provide isolation valve between air release valve and service pipe.

6.3 Appurtenances

This section outlines the requirements for various miscellaneous Appurtenances.

6.3.1 Strainers

1. Strainers shall be provided upstream of ALL pumps, heat exchangers, and other equipment if required by the manufacturer.
2. Strainers should have flanged or welded connections and be coated carbon steel in a wye type configuration. For potable water applications the strainer certified for potable water use per NSF 61 or be of full stainless-steel construction.
3. At a minimum, the screen shall be a 3.5 mm (5/32 inch) stainless steel complete with #30 stainless steel mesh and an effective screen area at least 2.5 times the pipe size. Smaller mesh sizes may be required to protect downstream equipment as required by the equipment manufacturer.

6.3.2 Expansion Tanks

1. Expansion tanks shall be designed and constructed in accordance with ASME, Section VIII, Division 1 and have a Canadian Registration Number (CRN).
2. Carbon steel construction with epoxy coating and lining.
3. Engraved stainless-steel name plate with registration numbers, tank size, and pressure rating at a minimum.
4. Pre-charged bladder type expansion tanks preferred. Bladders shall be replaceable and be complete with membrane rupture detector, fill pressure indicator with isolation valve, and charging valve.
5. Tank shall be seismically restrained and be provided with a drain valve.

6.3.3 Insulation

1. Piping insulation thickness shall be in accordance with ASHRAE 90.1.
2. Insulation for chilled service (SC) shall be mineral fibre in accordance with ASTM C547 or closed cell elastomeric in accordance with ASTM C547.
3. Interior insulated piping shall be covered with pre-formed PVC jacketing. Jacketing over chilled water piping shall be adhesive type. Pin or tack fasteners are not permitted on cold piping as they may damage the vapour barrier.
4. Exterior insulated piping shall be covered with embossed aluminum cladding.
5. Ensure that all cold piping has a complete and intact vapour barrier.
6. Provide removable insulation blankets for flanged or irregularly shaped equipment such as valves, strainers, heat exchangers, pumps, and others.
7. The Fire/Smoke spread rating for the insulation system shall not exceed 25/50 in accordance with CAN/ULC-S102-M.
8. The thermal conductivity of the insulation shall not exceed 0.035 W/m°C when tested at 24°C in accordance with ASTM C335.
9. Ensure integrity of vapour barrier is maintained for cold service insulation.
10. Alternate insulation systems offering equivalent or superior performance will be considered.

6.3.4 Pressure Gauges

1. Pressure gauges shall be provided at all locations required to facilitate operation and maintenance of the facilities, and at any other location deemed necessary by LIEC.
2. Pressure gauges shall be of stainless-steel construction, silicon liquid filled, dual scale (kPa and psi) with a 100 mm diameter gauge face and a needle valve for isolation from service.

3. Standard of Acceptance:

- Winters.
- Wika.

6.3.5 Temperature Gauges

1. Temperature gauges shall be provided adjacent to all temperature sensors as a means of confirming sensor measurements, and at any other location where the LIEC deems it necessary for operation of the facility.
2. Gauges shall be of stainless-steel construction, Metric, or dual scale (°C and °F) with an adjustable viewing angle and 125 mm diameter gauge face.
3. Temperature gauges shall be installed in ½" NPT stainless steel thermowells protruding 40% to 60% into the pipe cross-section with an extension length equal to the insulation thickness and filled with thermal gel.
4. Standard of Acceptance:
 - Winters.
 - Wika.

6.3.6 Drains and Air Management

1. Piping shall be installed such that the system can be fully and completely drained, slope piping to low points and provide manual drains at all low points for this purpose.
2. At all system high points where air pockets can be expected to form, provide Automatic air release valves to facilitate purging of air from the system. The automatic air release valves shall be provided with a shut-off valve to isolate it from service and, if possible, piped back to the makeup water or glycol fill tank.
3. Provide an air separator upstream of all main circulator pumps. The air separator shall be constructed of coated carbon steel in accordance with ASME Section VIII, Division 1. Separator shall be complete with blow-down valve, stainless-steel strainer, automatic air vent, and bypass.
4. Standard of Acceptance:
 - Spirotherm.
 - Armstrong.

6.4 Piping and Equipment Supports

1. Consider all load effects including but not limited to dead, live, wind, snow, thermal expansion, differential settlement (where relevant), and seismic events.
2. Supports, guides, and anchors shall not transmit unacceptable heat and vibration to the building.
3. All piping and equipment shall be designed to resist the effects of seismic forces and effects.

4. Piping and equipment supports shall be in accordance with relevant MSS-SP standards.
5. Provide housekeeping pads under all floor-mounted equipment, minimum 100 mm thick.
6. Oversize pipe hangers to be installed over insulation where a vapour barrier needs to be maintained, utilize inserts and saddles accordingly.
7. All concrete anchors shall be seismically rated, assume cracked concrete unless it can be proven otherwise.

6.5 Ancillary Systems

6.5.1 Fire Suppression System

1. The fire suppression system within DCP space shall be an extension of the base building fire suppression system. All sprinkler heads servicing the DCP space shall be serviced by a double interlock release type pre-action system. The pre-action system shall be triggered by the activation of fire alarm initiating device (manual pull station or heat detector) within the plant floor space and the activation of a sprinkler head on system piping.
1. The opening of the deluge valve shall not be dependent on the order of activation of the release devices, only that both devices must activate before the deluge valve will open. The pre-action system shall be provided with all necessary appurtenances to complete the system and be in conformance with the current edition of NFPA 13: Standard for Installation of Sprinkler Systems.

6.5.2 Make-Up Water System

1. Hydronic water systems shall be provided with a make-up water connection to refill water lost from the system. Do not connect a make-up water system to a hydronic glycol system.
2. At a minimum, the make-up system shall be directly connected to the hydronic water system and be composed of:
 - A reduced pressure principal backflow prevention device.
 - A pressure reducing valve to set system pressure.
 - A mainline strainer upstream of the backflow prevention device and pressure reducing valve.
 - A flowmeter with 4-20 mA signal output to indicate when the system is filling, and the volume added to the system.
 - Pressure gauges upstream and downstream of the pressure reducing valve.
 - Isolation valves to facilitate regular maintenance of the system.
3. Any piping or valves installed upstream of the backflow prevention device shall be appropriate for potable water use and ANSI/NSF 61 approved.

6.5.3 Make-Up Glycol System

1. Hydronic glycol systems shall be provided with a make-up glycol package to refill glycol solution lost from the system. Do not connect a make-up glycol system to a treated water system.
2. At a minimum, the make-up glycol system shall be directly connected to the hydronic glycol system and be composed of:
 - A storage and mixing tank.
 - An accumulator tank with pressure diaphragm and manual diverter valve for purging air and agitating contents.
 - A pump to pressurize accumulator tank complete with pressure switch, thermal cut-out switch and low-level pump cut-out.
 - A pressure-reducing valve capable of setting set system pressure to between 35 and 380 kPa (5 to 55 psi) complete with pressure gauge, check valve, and system isolation valve.
 - A low-level alarm with remote monitoring dry contacts and audible alarm.

6.5.4 Water Quality Control

1. Each closed loop hydronic piping system shall be equipped with a chemical injection pumps, corrosion coupon rack, and a side stream filter.
2. The chemicals will be pumped from manufacture provided barrels or buckets and shall accommodate system chemical addition. Size unit to suit system size and provide isolation valves.
3. The corrosion coupon rack shall be complete with one coupon sample for each material group comprising the system (carbon steel, copper, etc.). In addition, the rack shall be furnished with a flow indicator, globe valve or balancing valve, sample port, and isolation valves.
4. The side stream filter shall be of the replaceable cartridge type. The filter captured particle size and unit flow capacity shall be in accordance with industry best practice. The filter shall be complete with flow indicator, balancing valve, drain valve, and isolation valves. Alternate configurations for system filtering will be considered.
5. Open systems (such as cooling towers) shall have an automatic chemical dosing system with chemical storage for one (1) corrosion inhibitor and two (2) biocides.

6.5.5 Lifting Equipment

1. Where cranes are used for equipment removal, they shall be designed and installed in accordance with the following standards:
 - CAN/CSA B167 Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Jib Cranes.
 - CAN/CSA Z256-M87 Safety Code for Material Hoist.
 - CAN/CSA B1967 CMAA Specification No. 70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Travelling Cranes.
 - CISC Crane Supporting Steel Structures: Design Guide.
2. Welding shall be completed by certified welders in accordance with applicable standards. All fabricated components shall be factory coated 'extra caution orange' with capacities clearly indicated on the hoist and crane. One litre of touch-up coating shall be supplied with the crane.

7 Electrical

7.1 General Requirements

This section outlines the general requirements for Electrical work.

7.1.1 Definitions

1. Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.
2. Certification agency: an organization accredited by the Standards Council of Canada under the Standards Council of Canada Act as an organization engaged in conformity assessment.
3. Certification mark: a stamp, mark, seal, label, tag, or other identification of a certification agency, certifying that the regulated product to which it is affixed or attached meets the standard that the product must meet for certification.
4. Certified equipment: Regulated products which meet the standards that the product must meet for certification and are identified as such by a certification mark.
5. Provide: Supply and install.
6. AFF: Above Finished Floor
7. Electrical equipment: includes apparatus, conduits, plant, pipes, poles, works and any other regulated product that is used, designed, or intended for use in conjunction with the generation, transmission, supply, distribution, or use of electrical energy for any purpose.
8. Electrical work: regulated work in respect of electrical equipment.
9. Utility: a person who owns or operates equipment or facilities in BC for the generation, transmission or distribution of electricity or communication signals that are for sale.
10. Rough wiring: a phase of construction in which an electrical installation is fully accessible for inspection.

7.1.2 Design Requirements

11. Operating voltages: to CAN3-C235.
12. Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard.
13. Equipment to operate in extreme operating conditions established in above standard without damage to equipment.

7.1.3 Submittals

1. Submittals shall include catalog sheets, manufacturer's bulletins, wiring diagrams, dimensional data and operating descriptions of all items listed in the Specification.
2. Submittals shall include interconnection diagrams showing terminal numbers, number of conductors between components and requirements of inter-wiring conductors. This shall include any requirements for shielding, twisting of pairs, minimum and maximum resistance, capacitance, reactance, etc.
3. Submit breaker trip curves and fuse curves for all breakers or fuses of more than 50 Ampere rating.
4. Refer to Section 12 regarding record drawings and operation and maintenance manual requirements.

7.1.4 Warranty

1. Unless otherwise specified all equipment, materials supplied, and labour shall be provided with a warranty for a minimum of three (3) year from occupancy.

7.1.5 Materials and Equipment

1. Provide new and certified equipment, free of defects and approved for electrical installations. Factory seconds will not be accepted.
2. All electrical equipment shall carry a CSA approval label or labels from other agencies (acceptable to Technical Safety BC) considered equivalent to CSA. Other agencies are as follows:
 - ULC – Underwriter Laboratories of Canada.
 - ITS – Intertek Testing Services NA Ltd., (ITS - Canadian Divisions) formerly Warnock Hersey Professional Services Ltd. (label is still a stylized WH).
 - ETL – Intertek Testing Services NA Inc., (ITS - US Division) formerly ETL Testing Laboratories (label is still ETL).
 - cUL – Underwriters Laboratories Inc.
 - cMET – MET Laboratories Inc.
3. Control Panels: the above-mentioned certification marks (labels) shall be affixed to the various pieces of equipment and components within a control panel, and the complete control panel assembly shall also have a certification mark.
4. Install all materials and equipment in accordance with the manufacturer's recommendations.
5. Fire alarm system shall meet all ULC standards pertaining to fire alarm equipment and installation.
6. All equipment and systems shall meet WorkSafe BC (WSBC) requirements.
7. Provide WHMIS data sheets on all equipment and material, where required by WSBC.

7.1.6 Equipment Identification

1. All electrical equipment shall be clearly identified with lamicoïd labels. Tape labels are not acceptable.
2. Instrumentation devices shall be identified with engraved Stainless-Steel tags. Tape labels are not acceptable.
3. Label and tag names shall be as indicated on the drawings.
4. Lamicoïd identification labels shall have minimum 3 mm white letters on a black background. Submit list for approval with shop drawings.
5. Lamicoïd identification labels installed on control panel doors, MCC starter doors or similar enclosure doors shall be mechanically fastened to the door(s) with stainless steel self-tapping screws.
6. Lamicoïd identification labels for equipment mounted inside control panels, MCC starters or similar enclosures shall not be directly installed on the electrical equipment; rather, they should be installed beside or above the equipment and be fastened to the enclosure back-pan.
7. Ensure manufacturer's nameplates, certification labels and identification nameplates are visible and legible after equipment is installed.

7.1.7 Conduit and Cable Identification

1. Provide strap on cable/conduit markers (Raychem CM-SCE-TP or equivalent) with indelible marking. Tape labels are not acceptable. Labelling directly on conduit and cables with felt pen is not acceptable.
2. All conduits and cables (power and control) shall be clearly identified with numbers as shown on the drawings. Labels shall be installed at starters, MCC or Control Panel(s), and at points of termination.
3. Conduits and cables shall be labelled at least once on every building floor.

7.1.8 Testing

1. All electrical power, control and alarm systems shall be tested and calibrated to ensure that they are operating in accordance with the intent of the drawings and specifications.
2. The tests shall include:
 - Insulation resistance tests in accordance with the Canadian Electrical Code before energization of any circuits or equipment.
 - All tests as recommended in manufacturer's instructions.
 - Phase rotation tests on circuits, motors, etc.
 - Tests of adequacy of grounding system and connections.
 - Complete functional test of all electrical and control systems.

3. Once the Engineer of record is completely satisfied that all systems/equipment are completely operational they shall inform LIEC and LIEC's engineer that they are ready for start-up. The Engineer of Record shall submit the test report to LIEC at this time.

7.1.9 Test Report

1. The test report shall include all calibration calculations and shall show all setpoints as left. It shall include the following data on motors:
 - Nameplate full load current.
 - Measured current at maximum load.
 - Cat. No. and current range of installed O/L heater.
 - Settings of circuit breakers and Motor Circuit Protectors (MCPs).
 - Settings of all protective relays.
2. The test report shall include confirmation of manufacturer's and supplier's recommended procedures. It shall also include all requested manufacturer's certificates of inspection. It shall include the following data on all instrumentation:
 - All calibration calculations.
 - All calibration setpoints as left.
 - All pressure gauge readings.
 - All pressure switch settings.
 - All flowmeter readings.
 - All flow controller setpoints.
 - All temperature gauge readings.
 - All thermostat settings.
 - All level meter or gauge readings.
 - All level control setpoints.
 - All conductivity probe elevations.
 - Current levels at setpoints on current loops.
 - Breaker instantaneous trip settings.
 - All other relevant and similar data.

7.1.10 System Startup

1. The start-up tests shall include but not be limited by the generality of the following:
 - Motor control.
 - All alarm points.
 - All interlocks.
 - All shutdowns.
 - All meters.
 - All protective relay settings.
 - All control pushbuttons and switches.
 - All pilot lights.
 - Ampere readings on all motors.
 - Instrumentation.
 - All setpoints.
 - All display devices.

- All control functions.
- All pressure readings.
- All temperature readings.
- All flow readings.

2. Alarm Systems:

- Each actuating device.
- Each signalling device.
- Interlocks.

7.1.11 Special Areas

1. The design shall follow accepted practices and code regulations in the following areas:

- Hazardous locations.
- Areas subject to corrosive liquids or vapours.
- Areas subject to excessive moisture.
- Areas requiring weatherproof construction.
- Areas subject to extreme temperatures or vibrations.

7.1.12 Workmanship

1. Work shall be completed in accordance with good practice.
2. The Engineer shall determine whether workmanship is acceptable. Work approved by the Electrical Inspector or other authorities may still be rejected by the Engineer.
3. Grounds for rejection shall be any one of, but not limited to, the following:
 - Equipment installed in contravention of the Canadian Electrical Code.
 - Poor appearance.
 - Poor quality materials.
 - Conduit or wiring connections incompatible with standard of enclosures used.
 - Insufficient support or fastenings.
 - Materials installed in a manner or location that will impede other trades or make future maintenance awkward, costly, or impossible.

7.1.13 Seismic Restraint

1. Provide seismic restraint for electrical equipment as detailed in the Electrical Contractors' Association of British Columbia Seismic Restraint Standards Manual – Guidelines for Electrical Systems. Where the guidelines do not provide detail for specific equipment, obtain seismic restraint details from a Professional Engineer registered in British Columbia who specializes in such designs.

7.1.14 Fire Stopping

1. Provide firestop systems consisting of a material, or combination of materials, installed to retain the integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and/or hot gases through penetrations, blank openings, construction joints, or at perimeter fire containment in or adjacent to fire-rated barriers in accordance with the requirements of the Building Code for this project.
2. Retain a Professional Engineer licensed in the Province of British Columbia to perform required field reviews and submittal reviews of installed fire stopping system. Engineer shall provide Schedule S-B and S-C to Engineer of Record at completion of project to demonstrate compliance.
3. Field Review Engineer will follow guidelines for onsite inspection as outlined in ASTM E2174, "Standard Practice for On Site Inspection of Installed Fire Stops" or joint systems in accordance with ASTM E2393, "Standard Practice for On Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers".

8 Electrical Equipment Requirements

This section identifies the minimum acceptable standard for major pieces of electrical equipment.

8.1 Conduit

1. Provide galvanized steel Electrical Metallic Tubing (EMT) in all areas, except where direct buried or exposed to mechanical damage. EMT shall be installed with watertight fittings for outdoor applications.
2. Provide rigid PVC conduit (DB2) CSA 22.2 No. 211.1 (R2016) where direct buried or encased in concrete for conduit size 53 mm and larger. Use approved jointing cement.
3. Provide rigid hot dipped galvanized steel conduit in areas where exposed to mechanical damage.

Areas where conduit is exposed to mechanical damage are as follows:

- Surface mounted outdoors, from 600 mm below ground to 1,600 mm above ground.
 - Stubbed up through floor to motors and control pilot devices.
4. Exposed conduit shall be parallel or perpendicular to building lines.
 5. Support conduit to eliminate visible deflection.
 6. Conduit entering an electrical enclosure or kiosk shall have locknut and washer on both sides of the enclosure or kiosk panel. Connection shall be to the standard of the enclosure.

8.2 Flexible Conduit

1. Flexible conduit shall be Liquid-Tight Flexible metal conduit with extruded PVC jacket.
2. Provide flexible conduit for last 500 mm of connection to motors, solenoid valves, pressure switches and similar devices. Flexible conduit shall only be used where flexibility is required for future equipment changes or small equipment movement.

8.3 Telephone Service Duct

1. Provide 53 mm orange PVC in accordance with telephone utility requirements.

8.4 Secondary Distribution Duct

1. Provide 103 mm PVC where direct buried or encased in concrete.
2. Adapt to rigid galvanized steel where exposed to mechanical damage.

8.5 Wire

1. Provide stranded copper conductor unless otherwise noted.
2. Provide solid copper conductor for lighting and receptacle circuits.
3. Provide minimum #12 AWG for lighting, heating, and receptacle circuits.
4. Provide RW90 X LINK polyethylene insulated wire unless otherwise noted.
5. Wiring at 120/208 volts shall be 300 Vinsulated.
6. Wiring at 600 volts shall be 600 V insulated.
7. Any wiring sharing ducts or cable trays with 600 V circuits shall be 600 V insulated.

8.6 Teck Cable

1. Teck cable shall be aluminum armoured copper conductor with X link insulation complete with fire retardant PVC jacket overall. Voltage rating shall be minimum 600 V.
2. Provide appropriately sized PVC conduit sleeve in concrete for Teck cable entrances into buildings. Seal with duct seal.
3. Teck connectors shall be rain tight. Provide Thomas & Betts 'Spin-On Series II' connectors.

8.7 Instrumentation and Communication Cable

1. Provide shielded twisted pairs with individual and overall shields.

8.8 Cable Tray

1. Provide cable tray for multiple runs of Teck cable in buildings.
2. Provide aluminum ladder-type cables tray with 300 mm-rung spacing, supported in accordance with manufacturer's recommendations. Size to ensure 1 cable diameter between all power cables.
3. Provide factory fabricated tee, elbow, angle, and special fittings as required.
4. Provide barrier between instrument cable and other cable.
5. Install tray after piping and/or ducting has been installed.
6. Suspend cable tray with minimum 3/8" Redi-Rod. Attach to concrete ceiling with Hilti drop in anchors. Install as per manufacturer's recommendation.
7. Provide seismic restraint in accordance with the Electrical Contractor's Association of BC Seismic Restraint Manual.
8. Separate 600 V cables from 120 V cables. 24 V cable shall be separated by a barrier.
9. Ensure all tray is grounded and bonded in accordance with CEC requirements.

8.9 Connectors

1. Connectors shall match the NEMA standard of the box, fitting or enclosure they enter.

8.10 Duct Seal

1. Provide duct sealant in all ducts.

8.11 Flame Stop Sealant

1. Provide flame safe firestop compound where conduits penetrate firewalls.

8.12 Junction Boxes

1. Provide hinged NEMA 4 enclosures with latching handle. Enclosures shall be steel, phosphatized and finished with a re-coatable powder inside and out of ANSI 61 smooth Gray. Enclosures shall be complete with back panel and terminal blocks as necessary to make all connections within.
2. Junction boxes with multiple voltages contained within shall be provided with partitions to maintain separation of control wiring, 120 V wiring and 600 V wiring.
3. Enclosures shall be sized to accommodate existing wiring connections with capacity for an additional 20%. Provide Hammond Eclipse Series or approved equal.

8.13 Rigid Steel Conduit to PVC Conduit Adapter

1. Provide PVC female adapter fitting. Rigid Steel conduit shall be threaded into female adapter at points of transition.

8.14 Variable-Frequency Drive (VFD)

1. The VFDs shall be sized and selected in accordance with the motor horsepower.
2. Minimum efficiency at full load: 96%.
3. Technology: IGBT with digital microprocessor.
4. Line/Load Conditioners: Include AC line and load reactors if required in accordance with manufacturer's recommendations for the specific application conditions.
5. Standard of acceptance:
 - Danfoss.
 - Allen-Bradley.

8.15 Motor Starters

1. All starter components shall be co-ordinated for the full range of current values from normal running loads to maximum available fault current. Starters shall be combination type with circuit breakers with 22,000 amp RMS asymmetrical interrupting capacity, with magnetic only trip.
2. The external operating handle of the circuit breaker shall be interlocked with the door, so that the handle must be in the off position before the door can be opened. There shall be a facility for padlocking this handle in the open position with up to three padlocks. It shall not be possible to close the disconnect by any means if the disconnect handle is locked open. When the disconnect is closed, it shall be possible, using a semi-secret defeater screw mechanism, to open the starter door, for testing purposes.
3. Starters shall have solid state overload relay:
 - With monitoring on three phases.
 - Which has a Form C alarm contact.
 - Which is ambient compensated.
 - Which is manually reset.
4. Starters shall have 120 volt coils.
5. Starters in MCC shall be connected to the vertical bus by means of stab connectors plated with the same material as the bus.
6. Control power circuit shall be from individual control transformers in each starter complete with two primary and one secondary fuse sized for all components connected plus 100% capacity for future devices.

8.16 Motors

8.16.1 General

1. This specification covers the furnishing of motors, including all materials, supervision, labour, and services, to design, manufacture, shop test, deliver, install, commission, test, and guarantee the motors, in accordance with the information and data shown herein.
2. Motors shall be of a high efficiency design and conform to BC Hydro efficiency standards.
3. Three-phase motors shall be of a squirrel cage induction design.

8.16.2 Standards

1. Equipment shall be built to applicable EEMAC, NEMA and IEEE standards.
2. Equipment shall be CSA approved and carry a CSA label.
3. Motors used with variable frequency drives (VFDs) shall be certified as Inverter Duty and meet the requirements for inverter duty motors, in accordance with NEMA MG1 Part 31.
4. Unless otherwise required by the equipment manufacturer, motors shall be designed to the NEMA type B torque characteristics.

8.16.3 Performance Requirements

1. Motors to be used in a VFD application shall be suitable for use with pulse width modulated variable frequency controllers with IGBT or GTO outputs and no output reactors.
2. Motors shall have adequate cooling, including cooling at all speeds when used in conjunction with a VFD.
3. Motors shall be 1.15 service factor at Class F temperature rise. Motors used in conjunction with a VFD shall not have the harmonic heating cause any reduction in the service factor.
4. Motors shall be capable of continuous reverse rotation to 125% speed.

8.16.4 Motor Features

1. Motors for outdoor or indoor use shall be TEFC unless otherwise required by the equipment manufacturer.
2. Motors shall be T frame, up to 250 hp at 1,800 rpm standards. T frame motors shall have a cast iron frame.
3. Shaft length shall be standard.
4. Bearings shall be anti-friction, ball or roller, grease lubricated, rated for 100,000 hours of continuous duty.
5. Main terminal boxes shall be diagonally split, and oversized i.e., adequately sized to allow the customer's termination, with consideration given to the customer typically needing to derate cables 50% from the Canadian Electrical Code Table II. Terminal boxes shall be suitable for rotation by 360 degrees in steps at 90 degrees. Terminal boxes shall be cast iron. Terminal boxes shall be gasketed.
6. Motors above T frame in size shall be provided with anti-condensation heaters, rated for 120 VAC nominal power.
7. Motors larger than 500 hp at 1,800 rpm shall be provided with 100 Ω platinum RTDs, three (3) in the windings, at the calculated hot spot, and two (2) for the bearings.
8. Separate terminal boxes shall be provided for space heaters and RTDs. Boxes shall be labelled.
9. Motors shall be designed for use in the axial or horizontal mode, as determined by the installation requirements.
10. Stator insulation shall be Class F, non-hygroscopic. Insulation shall be such as to allow the use of the motor with a PWM VFD without output filters, located up to 1,000 feet from the drive. Motor insulation shall comply with standard NEMA MG1 – Part 31 when the motor will be used in conjunction with a VFD.
11. Motors used in conjunction with VFDs shall be fitted with suitable shaft grounding rings.
12. Stainless steel nameplates shall be provided.

13. Motors to be used in conjunction with a VFD shall show performance under VFD power and state suitability for use with VFD power.
14. Motors above T frame sizes shall be provided with factory mounted vibration switches.
15. Motor stator windings shall be double dipped, vacuum pressure impregnated.

8.16.5 Warranty

1. T frame motors shall have a three (3) year warranty.
2. Above T frame, motors shall have a one (1) year warranty.

8.17 Motor Control Centre (MCC)

8.17.1 General Construction

1. Compartmentalized vertical sections with common power busbars.
2. Floor mounting, free standing, enclosed dead front.
3. Indoor NEMA 1 enclosure, front mounting.
4. Wiring: Class I, Type B.
5. Busbars.
6. Main horizontal and branch vertical, three phase high conductivity tin plated copper busbars in separate compartment, bare, self-cooled, extending entire width and height of motor control centre, supported on insulators, and rated:
 - Vertical bus shall be rated at a minimum of 400 amps.
 - Horizontal bus shall be rated as suitable for the anticipated load.
7. Branch vertical busbars for distribution of power to units in vertical sections.
8. No other cables, wires, equipment in main and branch busbar compartments.
9. Brace buswork to withstand effects of the available short-circuit current.
10. Bus supports: with high dielectric strength, low moisture absorption, high impact material and long creepage surface designed to discourage collection of dust.
11. Ground Bus.
12. Copper ground bus extending entire width of motor control centre.
13. Vertical ground bus strap, full height of section, tied to horizontal ground bus, engaged by plug-in unit ground stab.
14. Provide a 6 mm x 50 mm horizontal copper ground bus running the length of the MCC.
Provide lugs for connecting cables/conductors.
15. All units, except those too heavy or bulky to manipulate, shall be plug in.

16. Each unit shall be automatically connected through a grounding finger to a vertical ground bus as it is inserted.
17. The MCC shall be painted ASA Grey 61.
18. Individual compartments shall be barriered so as to minimize the possibility of ionization occurring within a compartment spreading to other compartments.
19. There shall be provision for top and bottom entry of cables and conduit and there shall be entry plate for bottom of each section.
20. Plastic tubular wire markers shall be used throughout.
21. Control wiring terminals shall be labelled.
22. Pushbuttons, pilot lights and selector switches, etc., shall be heavy duty oil tight. They shall be identified with lamicoïd nameplates.
23. Standard of Acceptance:
 - Allen Bradley.
 - Schneider.
 - Eaton.

8.17.2 Detailed Description

1. The Motor Control Centre shall contain the following:
 - Utility - one incoming utility section, if required, complete with pull box, CT section, meter, and main lugs suitable for copper conductor sized for the expected electrical load.
 - Motor starters.
 - Feeder breakers.
 - Main Breaker, which shall be:
 - o Moulded case.
 - o 'Visible break', with windows over contacts.
 - o Solid state tripping element.
 - o Interrupting rating suitable for the anticipated available short circuit as calculated by a Professional Engineer.
 - o Adjustable rating plug, capable of adjusting the trip setting from 70% to 100% of the plug nameplate rating.
 - o Built in ground fault protection.

8.18 Metering and Instruments

1. Provide customer metering, including meters, selector switches, instrument transformers and fusing. Instruments shall be flush (semi flush) mounting, and similar types shall have matching faces.
2. All metering and instrumentation must be reasonably accessible by an operator.
3. Provide customer metering capable of measuring and displaying:
 - Volts.
 - Amps.
 - Kilowatts.
 - Kilowatt-hours.
4. Provide ammeter: 115 mm scale.
5. Provide Power Quality Protection with the following features:
 - Phase reversal protection, to open output relay when two phases are reversed for more than two cycles.
 - Phase loss protection, to open output relay when one phase drops below 70% of nominal voltage setting.
 - Phase imbalance protection, to open output relay when imbalance exceeds 4% average. Provide adjustable time delay for this feature.
 - Under voltage protection to open output relay when voltage drops below an adjustable pre-set value. Provide adjustable time delay up to 60 seconds. Output relay for d) shall be different than for a), b), and c).

8.19 Feeder Cubicles

1. The feeder cubicle components shall be co-ordinated for the full range of current values from normal running loads to maximum available fault current.
2. Feeder cubicles shall contain circuit breakers with minimum interrupting capacity higher than available as calculated by a Professional Engineer.
3. The external operating handle of the circuit breaker shall be interlocked with the door, so that the handle must be in the "off" position before the door can be opened. There shall be a facility for padlocking this handle in the open position for up to three padlocks. It shall not be possible to close the disconnect by any means if the disconnect handle is locked open. When the disconnect is closed, it shall be possible using a semi-secret defeater screw mechanism, to open the starter door for testing purposes.

8.20 Transformers

1. Transformers to be housed in enclosures suitable for the environment where they will be installed.
2. Transformers shall have full capacity primary taps; 4 - 2.5% above 5 kVA for single-phase; 4 - 2.5% above 9 kVA for 3-phase.
3. Transformers shall be sized to carry 135% of the connected load.

8.21 Emergency Stop Button

1. Provide Emergency Stop push buttons at all plant exits with the following characteristics:
 - Red mushroom head actuator with 'Emergency Stop' lettering.
 - 1 N.O. and 1 N.C. contacts.
 - Maintained push-to-stop position; switch must be twisted and pulled to return to normal position.
 - Switch shall be mounted in a yellow, NEMA4 rated, surface mount PVC box and be complete with a guarding mechanism to protect against accidental operation.
 - Switch shall also have a NEMA4 rating as required.

8.22 Pull and Junction Boxes

1. Provide pull and junction boxes appropriately sized where required.
2. Provide CSA approved, pressed steel construction, hot dip galvanized, except larger boxes may be enamelled, complete with grounding lugs, and screw on or hinged cover and sized per Canadian Electrical Code requirements, where conduit is concealed.
3. Provide cast FS type boxes of same material as conduit, where conduit is surface run.
4. Provide labelled terminals in all control junction boxes with more than four (4) junctions.
5. For control and instrumentation, provide labelled DIN rail mounted terminals in all control junction boxes with more than four (4) junctions. Junction box shall be NEMA4 or NEMA4X as required.

8.23 Receptacle and Switch Boxes

1. Size boxes to suit the number of conductors and connections required therein.
2. Use gang boxes as required for the number of switches.
3. Receptacle and switch boxes installed in concrete shall be of a type specifically designed and approved for this application. 87mm deep type MB boxes may be used in concrete and masonry.
4. Provide switch and receptacle boxes suitable for installation required.
5. In areas where conduit is surface run provide type F.S. boxes, constructed of same material as conduit.

9 Controls and Instrumentation

9.1 General

1. The intent of this section is to ensure that the control system is based around an industrial PLC separate from the building management system to help establish and maintain a clear line of responsibility for installation, maintenance, and future upgrades. Refer to Corix Utilities District Energy Utility SCADA and Controls Design Standards and Guidelines.
2. This document is to be used in conjunction with the above-mentioned guideline.
3. Where discrepancies exist between this document and the above-mentioned guideline, the Corix guideline shall take precedence.
4. The Developer shall ensure that all equipment within the DCP can communicate with the central control panel located in the DCP and that the central control panel can communicate with LIEC's VTScada-based central operations centre. In general, this shall include, but not be limited to:
 - A central (master) control panel located in the DCP mechanical room.
 - A remote (slave) control panel located in each ETS mechanical rooms.
 - One 50 mm communication conduit complete with pull wire from the DCP to the building exterior, conduit penetration should be adjacent to the future CCDEU service connection.
 - One 50 mm communication conduit and wiring from the DCP to the building exterior for the outdoor air temperature sensor. The conduit location shall be suitable for installing the outdoor air temperature sensor on the north face of the building at a location that is accessible to service personnel but not the general public.
 - One 50 mm communication conduit and wiring between the DCP and the FDC.
 - One 50 mm communication conduit and wiring between the DCP and each ETS.
 - One 50 mm communication conduit and wiring between the DCP and each piece of remote equipment, if any.
5. The communication systems enable LIEC to remotely monitor operation of the DCP, adjust operational parameters, monitor energy meter readings, and record operation data for trending purposes. The communication protocol should be based on the Modbus standard, must be approved by LIEC, and must be compatible with VTScada.

9.2 Billing Energy Meter

1. The energy meter shall be utility-grade consisting of a flow meter, supply and return temperature sensors (paired), and a calculator unit to calculate and record energy use for billing purposes.
2. All energy calculator components shall comply with EN 1434, and all components shall be factory calibrated, sealed, and supplied with corresponding calibration certificates.
3. Thermal energy meters must be approved, examined, and certified as meeting requirements of Measurements Canada Weights and Measures Act and Weights and Measures Regulations.
 - Meters must contain notice of approval.
 - Certification from EN 1434 and CSA 900-1.
 - Undergo examination from a measurement Canada authorized service provider.
4. The energy meter shall be installed on the return side piping for each ETS.
5. The flow meter shall be magnetic tube type.
6. The temperature sensors shall be paired Resistive Temperature Detector (RTD) probes in accordance with Section 9.7 except that they shall be 4-wire type with accuracy, repeatability, and linearity not to exceed $\pm 0.15\%$ of calibrated span and the transmitter shall be calibrated for 4 wire PT 500 ohm platinum RTD input.
7. Standard of Acceptance:
 - Kamstrup.
 - Endress + Hauser.
 - Emerson Rosemount.

9.3 Flowmeters

1. ANSI Class 150 or 300 raised face flanges conforming to ANSI B16.1.
2. Approved by Measurement Canada.
3. Include a local display (2-line minimum) and remote configuration feature.
4. Minimum accuracy shall be $\pm 0.5\%$ of reading for velocities from 0.3 to 10 m/s.
5. Electrical power shall be 120 VAC at 60 Hz and the output signal shall be 4-20 mA.
6. Install the meter with sufficient straight piping to satisfy minimum requirements dictated by the manufacturer.
7. Standard of Acceptance:
 - Please refer to Corix DEU SCADA and Controls Specifications.

9.4 Flow Switch

1. Thermal dispersion type flow switch with CRN.
2. 316 SS wetted parts and NEMA 4 enclosure.
3. Adjustable set point between 0.003 and 1.5 m/s and an adjustable response time from 1 to 10 seconds.
4. Standard of Acceptance:
 - Dwyer TDFS2 series.
 - Magnetrol TD2 series.

9.5 Differential Pressure Transmitters

1. Differential pressure transmitters shall include 316SS wetted parts and manifold with a NEMA 4 enclosure and diaphragm isolation with adjustable internal damping.
2. The unit shall include voltage surge protection and over pressure protection to 1.5 times the design pressure.
3. The unit shall be capable of operator zero and span adjustment (positively or negatively) and include remote configuration and a local display.
4. Accuracy shall be at least $\pm 0.5\%$ of calibrated span including the combined effect of repeatability and hysteresis, and the drift (over six months) and drift (due to temperature) shall be less than $\pm 0.3\%$ and $\pm 0.5\%$ of calibrated span respectively.
5. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.
6. Standard of Acceptance:
 - ABB.
 - Endress-Hauser.
 - Rosemount.

9.6 Pressure Transmitters

1. Pressure transmitters shall include 316SS wetted parts with a $\frac{1}{2}$ " NPT connection in a NEMA 4 enclosure.
2. The unit shall include voltage surge protection and over pressure protection to 1.5 times the design pressure.
3. The unit shall be capable of operator zero and span adjustment (positively or negatively) and include remote configuration and a local display.
4. Accuracy shall be at least $\pm 0.5\%$ of calibrated span including the combined effect of repeatability and hysteresis, and the drift (over six months) and drift (due to temperature) shall be less than $\pm 0.3\%$ and $\pm 0.5\%$ of calibrated span respectively.

5. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.
6. Standard of Acceptance:
 - ABB.
 - Endress-Hauser.
 - Rosemount.

9.7 Temperature Transmitters

1. General purpose temperature transmitters shall be spring-loaded 3-wire resistive temperature detector (RTD) probes with 316 SS sheath and NEMA 4 enclosure.
2. The accuracy, repeatability, and linearity shall be to $\pm 0.25\%$ of calibrated span and the transmitter shall be calibrated for 3-wire PT 100 ohm platinum RTD input.
3. Temperature transmitters shall be installed in $\frac{1}{2}$ " NPT stainless steel thermowells protruding 40 to 60 per cent into the pipe cross-section with an extension length equal to the insulation thickness.
4. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.
5. Standard of Acceptance:
 - ABB.
 - Endress-Hauser.
 - Rosemount.

9.8 Ambient (Indoor or Outdoor) Temperature Transmitter

1. Air temperature sensors shall be wall mounted with an operating range of at least -30°C to 50°C .
2. Sensors installed outdoors shall have housing specifically designed for outdoor use.
3. Accuracy shall be at least $\pm 0.5^{\circ}\text{C}$ at 0°C .
4. Electrical power shall be 120 VAC or 24VDC and the output signal shall be 4-20 mA.
5. Standard of Acceptance:
 - Greystone.
 - Dwyer.
 - BAPI.

9.9 Refrigerant Leak Detection

1. The refrigerant gas detector shall be an infrared type capable of detecting all refrigerants used in the plant.
2. The detector shall have a 1 ppm resolution with a measurement range of at least 0 to 1,000 ppm and a minimum accuracy of $\pm 10\%$ of measured value.
3. The detector shall be suitable for indoor ambient conditions from 0 to 40°C and 5% to 90% RH (non-condensing) humidity.
4. The detection system shall be certified to CSA C22.2 No. 61010-1.
5. Standard of Acceptance:
 - Emerson MRLDS-250 series.
 - Critical Environment Technologies ART series.

9.10 Gas (CH₄ & CO) Detection

1. Wall mounted dual-gas monitor with ability to detect CH₄ and CO and shall include at least two alarm relays plus 4-20 mA output signal.
2. CH₄ detection shall have a 0.5% LEL resolution with a range of 0 to 100% LEL.
3. CO detection shall have a 1 ppm resolution with a 0 to 250 ppm range.
4. The accuracy of both sensors shall be at least $\pm 3.0\%$ of full scale at 25°C.
5. The detection system shall be certified to CSA C22.2 No. 61010-1.
6. Standard of Acceptance:
 - Critical Environment Technologies.
 - Emerson.

9.11 Local Alarm Indication

1. Local alarm indication shall include a strobe light and audible alarm in excess of 85 dBA at 3 m.
2. The indication shall be installed in the DCP and be triggered by detection of refrigerant, CO, or fire/smoke.
3. Provide as many strobe lights and horns/buzzers as required such that an alarm can be seen and/or heard from any location in the plant with all equipment operating.
4. Alarm indication shall also be installed outside the main plant entrance door.

9.12 Intrusion Switch

1. Provide intrusion door switches on all exterior doors, wire into PLC for alarm monitoring.

9.13 Programming and Alarms

9.13.1 Programming

1. Provide all programming required for a completely automated control system. Programming shall be as directed by LIEC.
2. Programming shall include but not be limited to Variable Frequency Drives, Programmable logic controllers, remote terminal units & energy meters.

9.13.2 Alarms

1. Programming for alarms shall include but not be limited to equipment failures, values outside normal operating parameters, fire, intrusion, and power fault and failure.

10 Equipment Identification and Tagging Standards

All equipment, instrumentation, and valves shall be given a unique identification number. The Developer shall submit their proposed identification numbers to LIEC for approval. In addition, all identification numbers shall be physically affixed (tagged) to the corresponding piece of equipment for identification in the field.

All identification numbers shall correspond with the process and instrumentation diagrams. It is preferred that identification numbers and process and instrumentation diagrams conform to ISA 5.1 standard. Where equipment is installed in more than one mechanical room, it is preferred that identification numbers are grouped by location. For example, numbers in the 100-199 range would correspond to equipment located in the DCP, 200-299 series numbers would correspond to equipment installed in the main ETS room, and so on for any other mechanical rooms.

10.1 Equipment

Equipment shall be clearly labelled using lamicoid labels with minimum 10 mm high white letters on black background. Tape labels are not acceptable. An equipment schedule shall be provided.

10.2 Valves

Provide engraved stainless-steel identification tags for all valves with minimum 5 mm high lettering. Tags shall be affixed with stainless steel cable or ball chain. A valve schedule shall be provided.

10.3 Instrumentation

Provide engraved stainless-steel identification tags for all instrumentation with minimum 5 mm high lettering. Tags shall be affixed with stainless steel cable or ball chain. An instrumentation schedule shall be provided.

10.4 Piping

All piping shall be provided with identification labels indicating service and flow direction. Provide markers at 2 m nominal spacing, but at least one marker per pipe run. Service identification letters should correspond with the abbreviations used in the process and instrumentation diagrams. Use vinyl cloth markers (Brady B500, B946, or equivalent) with letter heights as follows:

1. 19 to 32 mm pipe diameter: 12 mm lettering height.
2. 38 to 50 mm pipe diameter: 19 mm lettering height.
3. 65 to 150 mm pipe diameter: 32 mm lettering height.
4. 200 to 250 mm pipe diameter: 65 mm lettering height.
5. 250 to 450 mm pipe diameter: 75 mm lettering height.

10.5 Electrical Cable Tags

All cables and wires shall be affixed with a slip-on tag indicating voltage, source, and destination. Tags shall be machine printed and permanently attached to the cable or wire. Two examples of cable tag identifiers are provided for reference:

1. 600V-MCC-DS101 (600 volt cable from the MCC to Disconnect Switch 101).
2. 24V-CP-FS101 (24 volt from Control Panel to Flow Switch 101).

10.6 Signage

Provide warning and identification signs in accordance with regulatory requirements and industry best practice. Signs shall conform to CSA Z321, ANSI Z535.1, ANSI Z535.2, and ISO Standard 3864. Signage shall include, but not be limited to, exits, fire extinguisher, fire alarm pull station, emergency stop button, and others as required.

11 Commissioning and Start-up

11.1 Commissioning Agent

The Developer shall retain the services of a third-party commissioning agent acceptable to LIEC. The commissioning agent shall have a minimum of 10 years related experience and have their CCP, CBCP, or CPMP designations. Submit the commissioning agent's qualifications to LIEC for review. Qualifications shall include related experience and at least three (3) references from previous commissioning projects.

11.2 Pre-Commissioning Requirements

Prior to commissioning, all equipment shall be tested and found to be operating normally. The manufacturer's service representative shall be present for all equipment start-up, and the manufacturer's start-up sheets shall be completed and provided in the O&M manual. Non-standard start-up sheets are not acceptable. Submit start-up sheets to LIEC.

The hydronic system shall be flushed, pressure tested, and chemically cleaned and passivated prior to commissioning. The developer shall retain the services of a chemical treatment technician for this purpose. The hydrostatic pressure test shall be to a minimum of 1.5 times the maximum system design pressure or 1,551 kPa (225 psi), whichever is greater. Submit water quality test report and hydrostatic test results to LIEC.

Equipment assets list complete with all equipment installed including type, manufacturer make, model, tag, and serial numbers as well as a list of spare parts should be by manufacturers submitted prior to commissioning.

11.3 Commissioning Requirements

Commissioning shall be conducted in accordance with industry best practice:

1. CSA Z320.
2. ASHRAE 202.
3. ASHRAE Guideline 0.
4. ASHRAE Guideline 1.1.
5. ASHRAE Guideline 1.5.
6. NFPA 3.
7. Building Commissioning Association: Building Commissioning Handbook.
8. Building Commissioning Association: New Construction Building Commissioning Best Practices.

11.4 Mechanical Systems to be Commissioned

1. Chillers.
2. Cooling towers.
3. Pumps.
4. Hydronic systems.
5. Chemical treatment and make-up systems.
6. Energy transfer stations.
7. DCP HVAC system.

11.5 Electrical Systems to be Commissioned

1. Secondary service electrical systems.
2. Motor control centers.
3. Distribution and branch circuit panel boards.
4. Lighting fixtures and controls.
5. Lightning protection equipment and lightning protection systems.
6. Equipment monitoring.
7. Fire alarm equipment/fire alarm equipment monitoring system.
8. AC motors.
9. Grounding equipment and building grounding system.
10. Security system.
11. Emergency generators and distribution system.
12. Uninterruptible power systems.
13. Control devices.
14. Electrically actuated valves.
15. Control programming.

11.6 Submittals

1. Contractor shall prepare Pre-functional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Pre-functional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.
2. Contractor shall provide Owner with documentation required for Commissioning work. At minimum, documentation shall include Detailed Start-up procedures, Full sequences of operation, Operating and Maintenance data, Performance data, Functional Performance Test Procedures, Control Drawings, and details of Owner-Contracted tests.
3. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.
4. Contractor shall review and approve other relative documentation for impact on FPTs of the systems:

- Shop Drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
- Incorporate manufacturer's Start-up procedures with Pre-functional checklists.
- Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPTs.
- Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation; subcontractor performing the test will review the documentation prior to commencing with the scheduled FPTs.
- Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: to validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

12 Owner's Manual

For any DCP, LIEC shall be provided with an Owner's Manual detailing various aspects of the plants design, construction, operation, and maintenance. Provide three (3) bound hard copies plus one (1) electronic copy in PDF format. The Manual shall be complete with title page, table of contents, dividers, and divided into two major sections.

12.1 Operations and Maintenance Manual

Manufacturers' maintenance instructions and operating manuals shall be supplied showing each major piece of equipment and/or equipment designated by the Engineer. Instructions and manuals shall be complete with the following:

1. Manufacturer maintenance instructions, operating manuals, and spare parts lists.
2. Catalog details of all equipment installed, including schematic drawings, layouts, and maintenance data as applicable.
3. Balancing reports.
4. Shop drawings bearing engineer's stamp and comments.
5. Water quality test reports.
6. Hydrotest, flushing, and cleaning reports.
7. Material testing reports.
8. Commissioning reports.
9. System descriptions.
10. Equipment warranties and start-up reports.
11. WHMIS data sheets for equipment and material where required by WorkSafe BC.
12. Equipment asset list.
13. O&M manuals shall also contain the following:
 - Copy of permits and final inspection reports by the Authorities Having Jurisdiction.
 - List of spare parts that may be required complete with equipment supplier contact information.
 - Contact information.

12.2 Design and Construction Documents

1. Record Drawings:
 - Markups shall be to the same standard and detail as the contract drawings. Markups shall be to scale, or dimensions shall be noted. They shall show all changes made by the Engineer, Owner, and Contractor.
2. Specifications.
3. Process control narrative.
4. Equipment, valves, and instrumentation lists with corresponding unique identification tag.
5. Alarm tables.
6. Welder qualifications, welding procedures, weld map, and NDT reports.
7. Engineering field review reports.
8. Performance validation plan.
9. BC building code letters of assurance.
10. Sealed letter from the Developer's Engineer of Record confirming that the DCP and connected Building (or Strata) mechanical systems have been designed, constructed, and installed in full compliance with the drawings and specifications approved and agreed to in the Development Permit and subsequent Building Permit review stages.

12.3 Spare Parts

At hand-over to the LIEC, the DCP shall be furnished with all manufacturers recommended spare parts and spare fuses for all equipment. The developer shall provide a hand-over check list of spare parts for sign-off by LIEC.

13 CCDEU Contact Information

For more information on the CCDEU and requirements of customer buildings, please contact:

Christopher David PEng, PMP
Lulu Island Energy Company
Phone: 604-247-4902
Email: cdauid@luluslandenergy.ca

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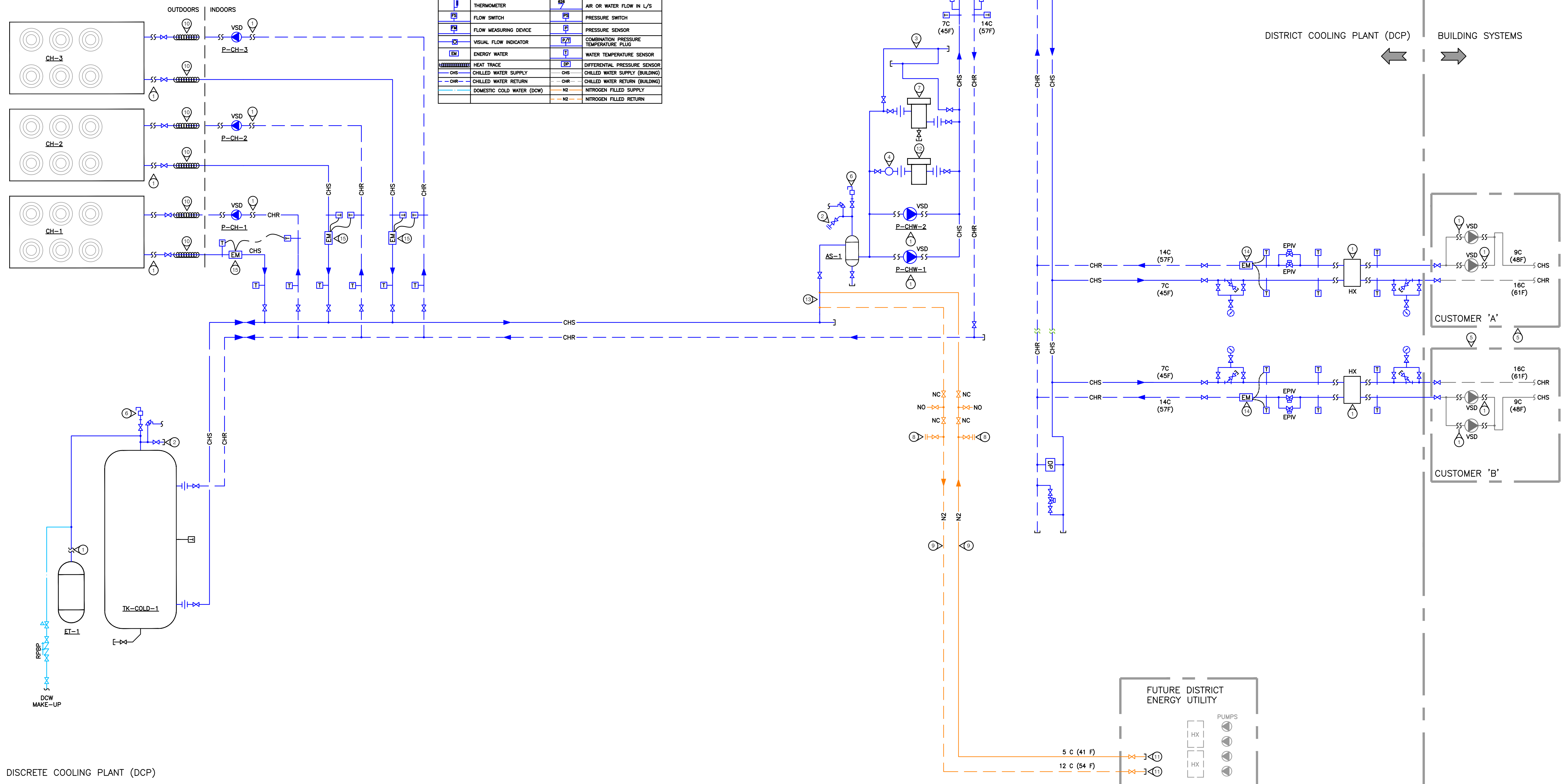
14 Appendix A: Typical DCP Schematic

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 23123.001 - SCHEMATIC.dwg

- DRAWING NOTES APPLY WHERE INDICATED:
- | | | |
|--|---|--|
| 1. REFER TO DETAIL. | 6. AUTOMATIC AIR VENT. | 11. CAP FOR FUTURE DISTRICT ENERGY UTILITY CONNECTION. |
| 2. HOSE END MANUAL AIR VENT WITH CAP. | 7. CHEMICAL POT FEEDER. | 12. SIDESTREAM FILTER C/W SIGHT GLASS. |
| 3. CORROSION COUPON. | 8. NITROGEN (N2) FILL VALVE. | 13. CLOSELY SPACED TEE. |
| 4. SIGHT GLASS. | 9. PROVIDE PIPE WITH NITROGEN (N2) FOR CORROSION PREVENTION UNTIL FUTURE CONNECTION TO DEU. | 14. UTILITY GRADE ENERGY METER. |
| 5. BUILDING HYDRONIC AND DOMESTIC WATER SYSTEMS BY OTHERS. | 10. ELECTRIC HEAT TRACE C/W EMERGENCY POWER CONNECTION. | 15. INFORMATION GRADE ENERGY METER. |

HVAC AND PLUMBING SYMBOLS AND ABBREVIATIONS			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ELBOW DROPPING		CHECK VALVE
	ELBOW RISING		BACKFLOW PREVENTOR
	ISOLATION VALVE		STRAINER
	CONTROL VALVES		REDUCERS
	SAFETY RELIEF VALVE		PUMP
	ELECTRONIC PRESSURE INDEPENDENT CONTROL VALVE		PRESSURE INDEPENDENT CONSTANT FLOW VALVE (AUTO-FLOW VALVE)
	COMBINATION BALANCE AND METERING VALVE (CIRCUIT SETTER)		FLEXIBLE CONNECTION
	MANUAL AIR VENT		AUTOMATIC AIR VENT
	UNION OR FLANGE FITTING		PRESSURE GAUGE
	THERMOMETER		AIR OR WATER FLOW IN L/S
	FLOW SWITCH		PRESSURE SWITCH
	FLOW MEASURING DEVICE		COMPRESSION SENSOR
	VISUAL FLOW INDICATOR		COMBINATION PRESSURE TEMPERATURE PLUG
	ENERGY WATER		WATER TEMPERATURE SENSOR
	HEAT TRACE		DIFFERENTIAL PRESSURE SENSOR
	CHILLED WATER SUPPLY (BUILDING)		CHILLED WATER RETURN (BUILDING)
	DOMESTIC COLD WATER (DCW)		NITROGEN FILLED SUPPLY
	NITROGEN FILLED RETURN		NITROGEN FILLED RETURN

- GENERAL NOTES:
- SYSTEM SCHEMATIC FOR GENERAL REFERENCE ONLY. DEVELOPER CONSULTANT SHALL BE RESPONSIBLE FOR ALL DESIGN AND ENGINEERING OF DISCRETE COOLING PLANT (DCP).
 - SYSTEM SCHEMATIC IS A GENERAL CONCEPT FOR CONNECTING TWO CUSTOMERS TO ONE DISCRETE COOLING PLANT (DCP).

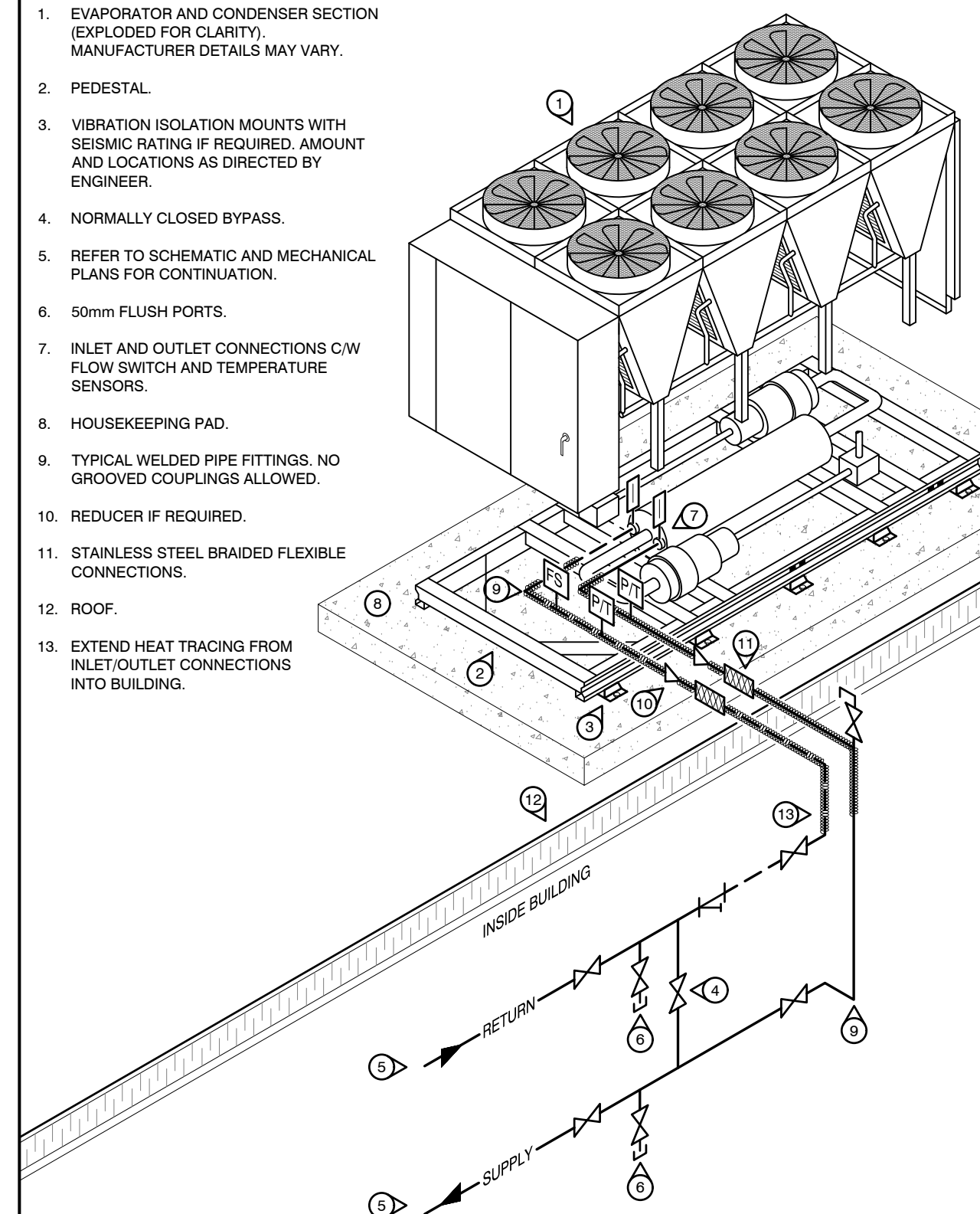


<p>KERR WOOD LEIDAL consulting engineers 200 - 4185A Still Creek Drive Burnaby, BC V5C 6G9 T (604) 294-2088 F (604) 294-2090 E mail@kwl.ca</p>	<p>CORIX LuluIsland ENERGY COMPANY</p>	<p>FALCON ENGINEERING INGENUITY DELIVERED 210-1715 Dickson Ave. Kelowna, BC V1Y 9G6 250.762.9993 www.falcon.ca Permit To Practice 1001295</p>	<p>THIS DRAWING TO BE PLOTTED IN COLOUR</p>																																				
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Rev	Date	Des	Dwn	Chk	Description																																		
<p>CLIENT: CCDEU DCP SAMPLE CONNECTION DESIGN</p> <p>DRAWING: AIR COOLED CHILLER SYSTEM SCHEMATIC</p> <p>Project No. 23123.001 Drawing No. M1.0 Rev. A</p> <p>Group: MECHANICAL</p>																																							

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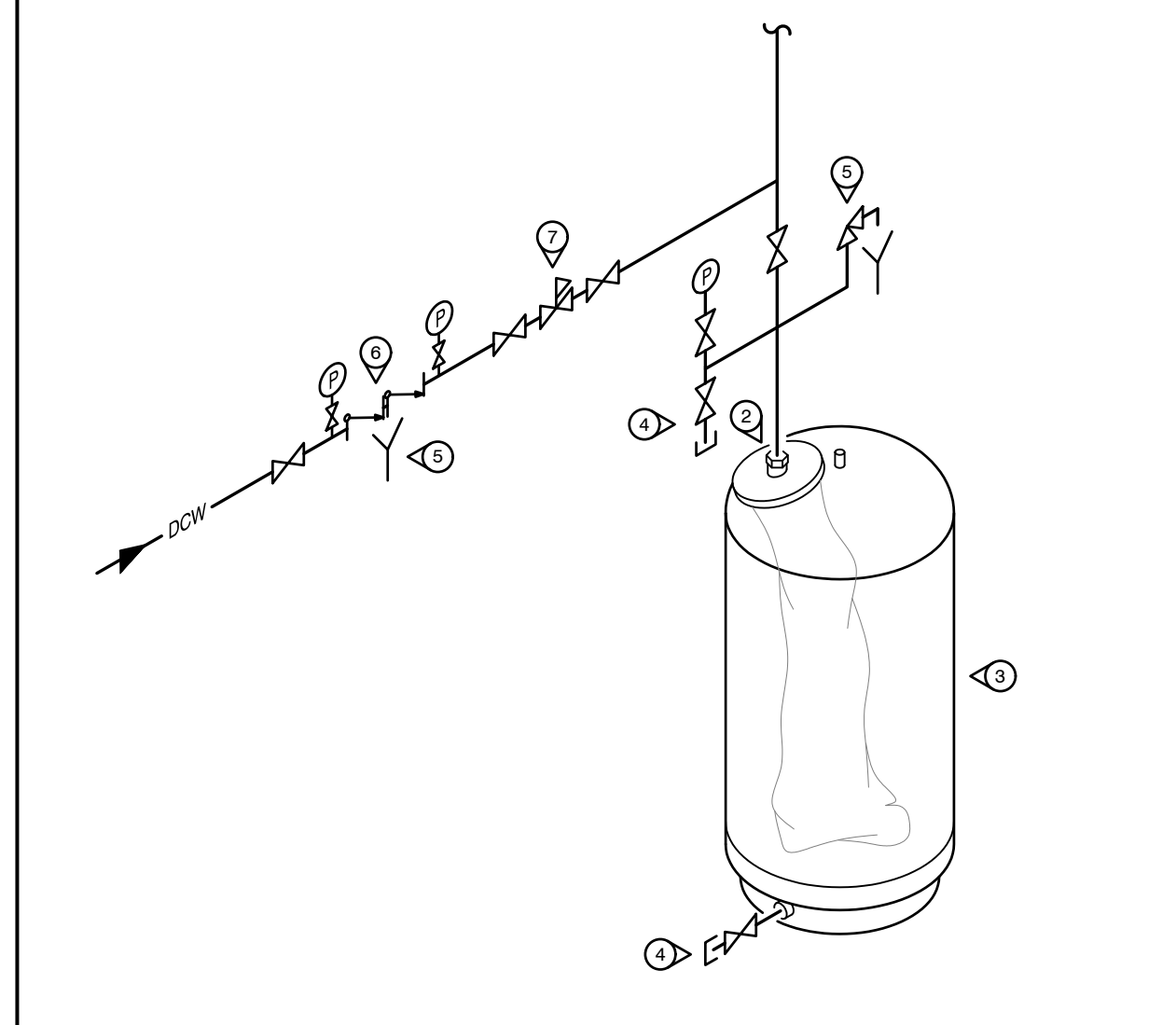
1. EVAPORATOR AND CONDENSER SECTION (EXPLODED FOR CLARITY). MANUFACTURER DETAILS MAY VARY.
2. PEDESTAL.
3. VIBRATION ISOLATION MOUNTS WITH SEISMIC RATING IF REQUIRED. AMOUNT AND LOCATIONS AS DIRECTED BY ENGINEER.
4. NORMALLY CLOSED BYPASS.
5. REFER TO SCHEMATIC AND MECHANICAL PLANS FOR CONTINUATION.
6. 50mm FLUSH PORTS.
7. INLET AND OUTLET CONNECTIONS C/W FLOW SWITCH AND TEMPERATURE SENSORS.
8. HOUSEKEEPING PAD.
9. TYPICAL WELDED PIPE FITTINGS. NO GROOVED COUPLINGS ALLOWED.
10. REDUCER IF REQUIRED.
11. STAINLESS STEEL BRAIDED FLEXIBLE CONNECTIONS.
12. ROOF.
13. EXTEND HEAT TRACING FROM INLET/OUTLET CONNECTIONS INTO BUILDING.



1 AIR COOLED CHILLER

DRAWING NOTES APPLY WHERE INDICATED:

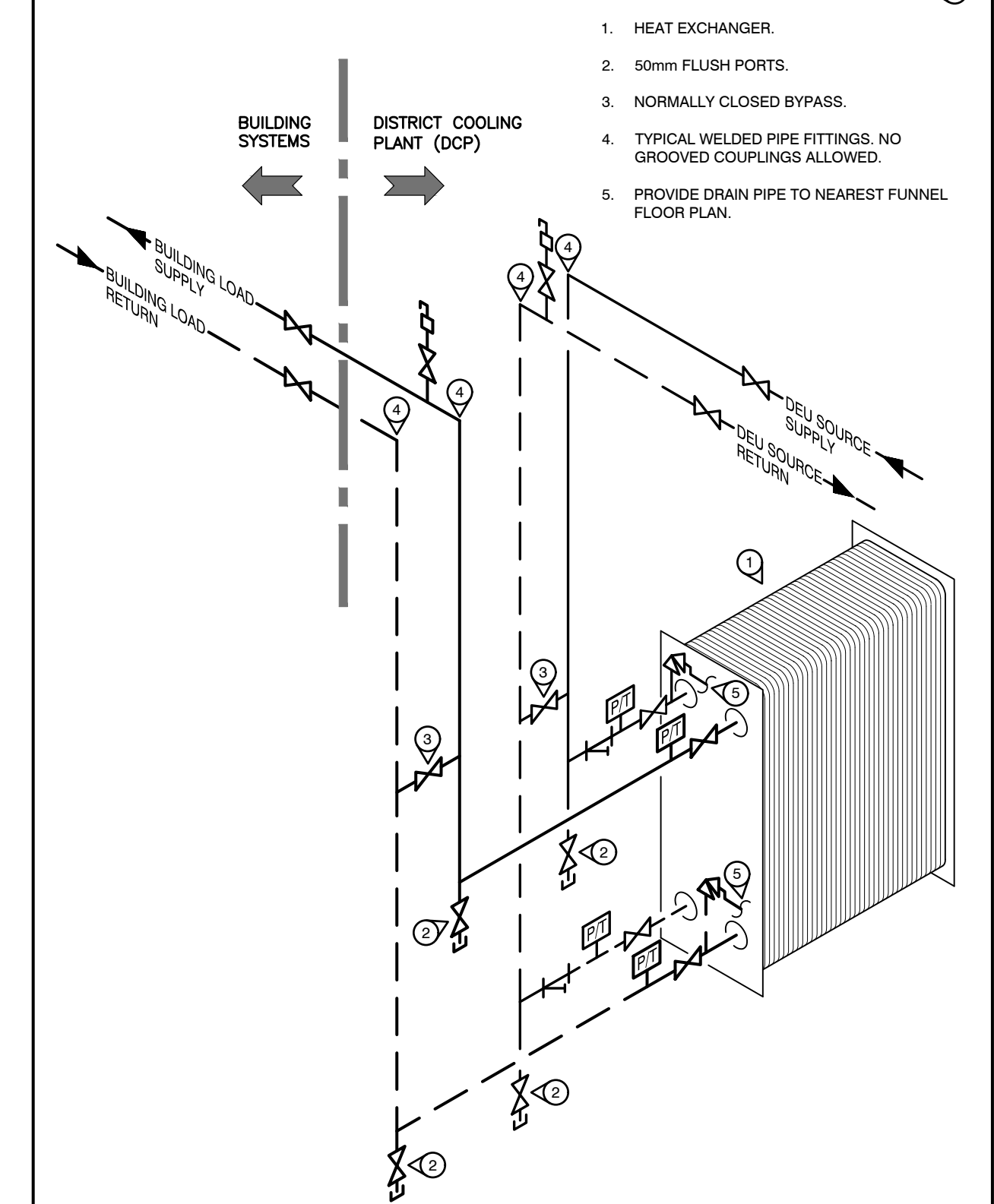
1. EXPANSION TANK.
2. UNION.
3. FULL-ACCEPTANCE HYDRONIC EXPANSION TANK.
4. DRAIN WITH HOSE CONNECTION AND CAP WITH CHAIN.
5. PRESSURE RELIEF VALVE.
6. REDUCED PRESSURE BACKFLOW ASSEMBLY.
7. PRESSURE REDUCING VALVE.



2 EXPANSION TANK - WATER SUPPLY

DRAWING NOTES APPLY WHERE INDICATED:

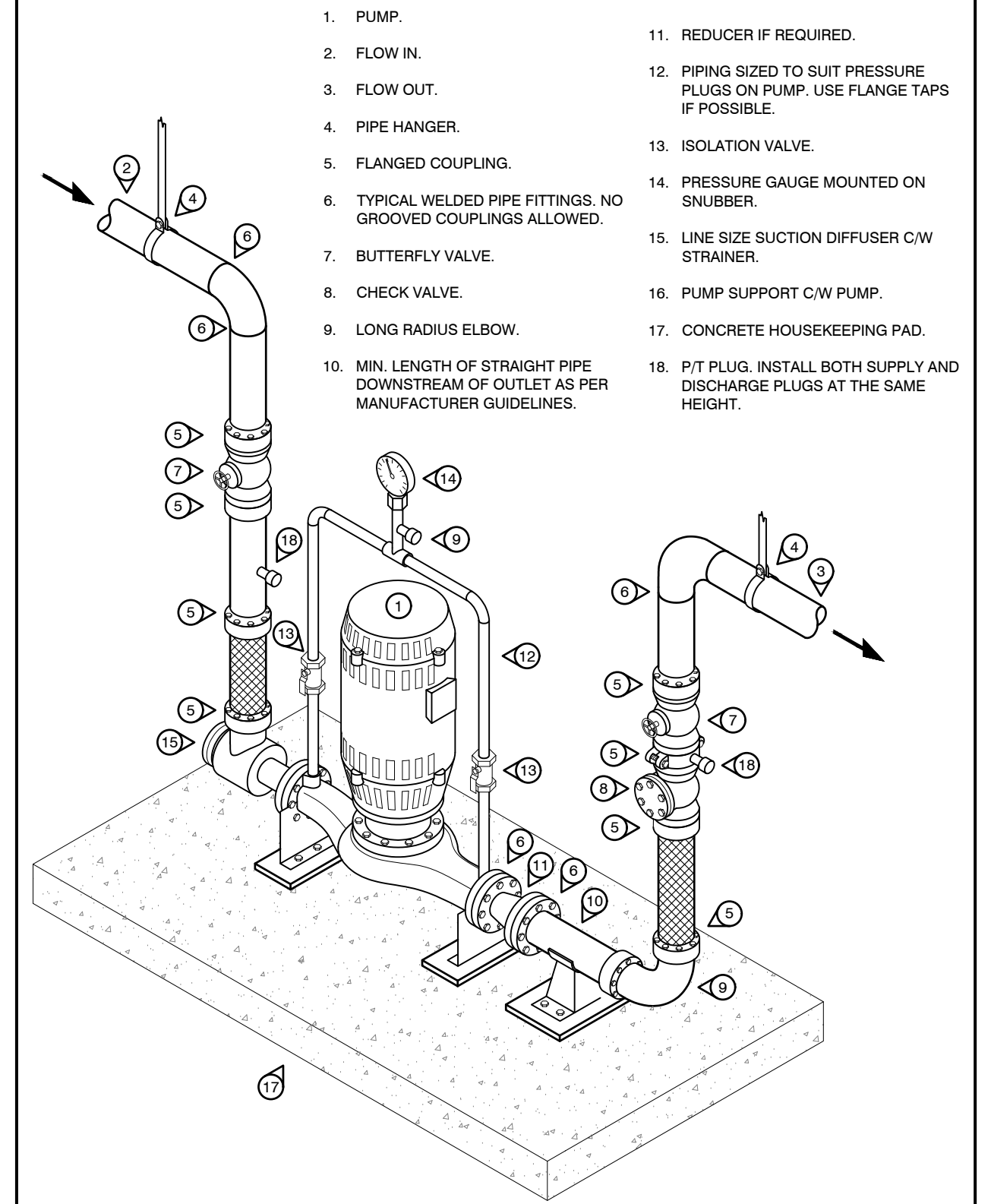
1. HEAT EXCHANGER.
2. 50mm FLUSH PORTS.
3. NORMALLY CLOSED BYPASS.
4. TYPICAL WELDED PIPE FITTINGS. NO GROOVED COUPLINGS ALLOWED.
5. PROVIDE DRAIN PIPE TO NEAREST FUNNEL FLOOR PLAN.



3 HEAT EXCHANGER

DRAWING NOTES APPLY WHERE INDICATED:

1. PUMP.
2. FLOW IN.
3. FLOW OUT.
4. PIPE HANGER.
5. FLANGED COUPLING.
6. TYPICAL WELDED PIPE FITTINGS. NO GROOVED COUPLINGS ALLOWED.
7. BUTTERFLY VALVE.
8. CHECK VALVE.
9. LONG RADIUS ELBOW.
10. MIN. LENGTH OF STRAIGHT PIPE DOWNSTREAM OF OUTLET AS PER MANUFACTURER GUIDELINES.
11. REDUCER IF REQUIRED.
12. PIPING SIZED TO SUIT PRESSURE PLUGS ON PUMP. USE FLANGE TAPS IF POSSIBLE.
13. ISOLATION VALVE.
14. PRESSURE GAUGE MOUNTED ON SNUBBER.
15. LINE SIZE SUCTION DIFFUSER C/W STRAINER.
16. PUMP SUPPORT C/W PUMP.
17. CONCRETE HOUSEKEEPING PAD.



4 PUMP - VERTICAL INLINE

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Permit To Practice 1001295

Rev	Date	Des	Dwn	Chk	Description
1	2023-09-13	AL	JB	AS	ISSUED FOR CLIENT INFORMATION
2	2023-09-22	AL	JB	AS	ISSUED FOR PROGRESS
3	2023-11-30	AL	JB	AS	ISSUED FOR CLIENT INFORMATION

Rev	Date	Des	Dwn	Chk	Description

Project No.	23123.001	Drawing No.	M2.0	Rev.	A
Group	MECHANICAL				

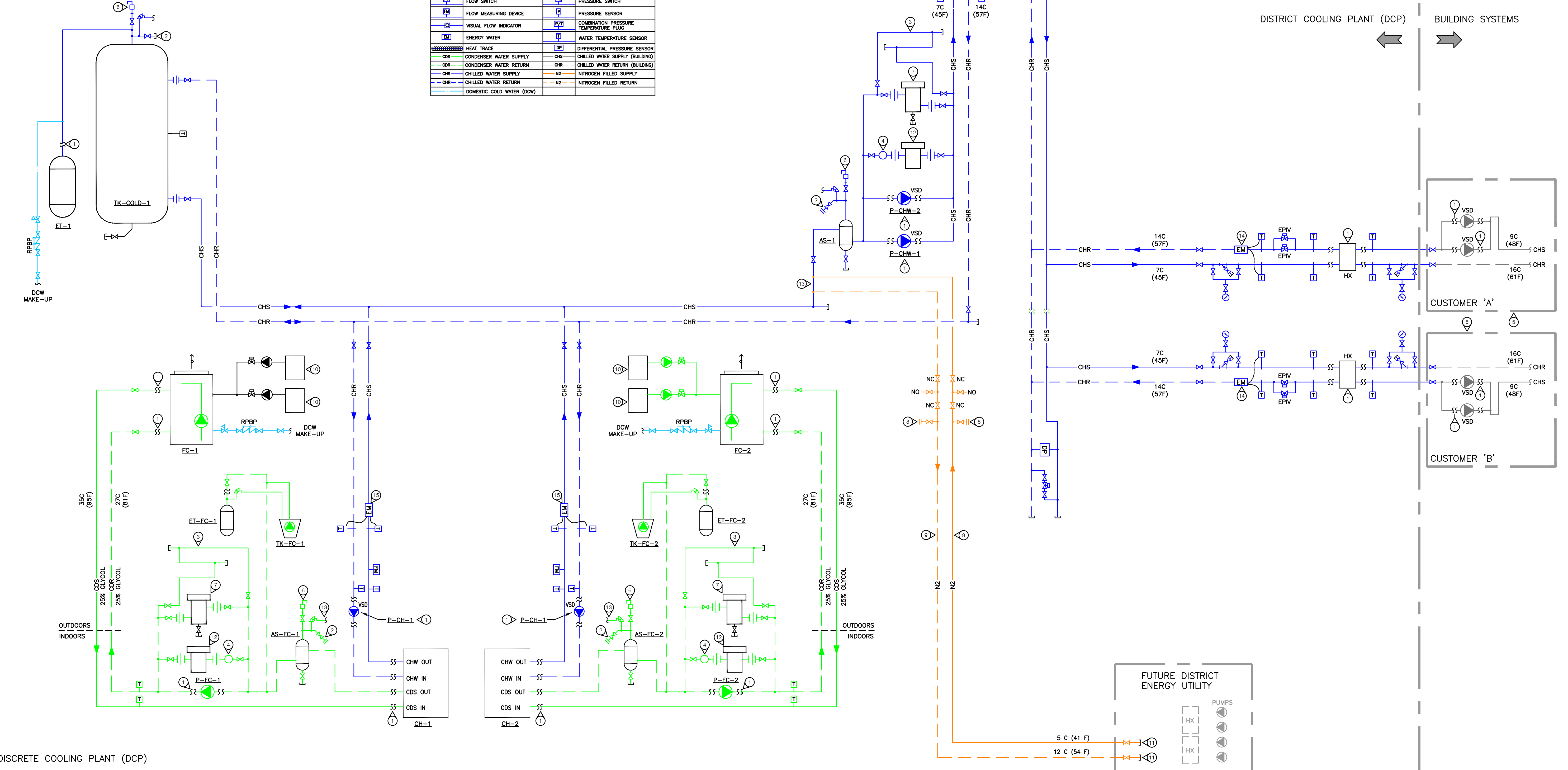
CLIENT
CCDEU DCP SAMPLE CONNECTION DESIGN DETAILS

Project: 23123.DWG, 23123-001, Technical Requirements/Drawings, Mechanical/23123-001, SCHEMATIC 2.dwg
 Saved: 2023/11/30 10:16 AM
 Paper Size: ANSI D
 A1 Full Size: This border measures 520 mm x 800 mm

- DRAWING NOTES APPLY WHERE INDICATED:
- REFER TO DETAIL.
 - HOSE END MANUAL AIR VENT WITH CAP.
 - CORROSION COUPON.
 - SIGHT GLASS.
 - BUILDING HYDRONIC AND DOMESTIC WATER SYSTEMS BY OTHERS.
 - AUTOMATIC AIR VENT.
 - CHEMICAL POT FEEDER.
 - NITROGEN (N2) FILL VALVE.
 - PROVIDE PIPE WITH NITROGEN (N2) FOR CORROSION PREVENTION UNTIL FUTURE CONNECTION TO DEU.
 - FLUID COOLER CHEMICAL TREATMENT SYSTEM.
 - CAP FOR FUTURE DISTRICT ENERGY UTILITY CONNECTION.
 - SIDESTREAM FILTER C/W SIGHT GLASS.
 - CLOSELY SPACED TEE.
 - UTILITY GRADE ENERGY METER.
 - INFORMATION GRADE ENERGY METER.

HVAC AND PLUMBING SYMBOLS AND ABBREVIATIONS			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ELBOW DROPPING		CHECK VALVE
	ELBOW RISING		BACKFLOW PREVENTOR
	ISOLATION VALVE		STRAINER
	CONTROL VALVES		REDUCERS
	SAFETY RELIEF VALVE		PUMP
	EPW		PRESSURE INDEPENDENT CONSTANT FLOW VALVE (AUTO-FLOW VALVE)
	ELECTRONIC PRESSURE INDEPENDENT CONTROL VALVE		FLEXIBLE CONNECTION
	COMBINATION BALANCE AND METERING VALVE (CIRCUIT SETTER)		AUTOMATIC AIR VENT
	MANUAL AIR VENT		PRESSURE GAUGE
	UNION OR FLANGE FITTING		AIR OR WATER FLOW IN L/S
	THERMOMETER		PRESSURE SWITCH
	FLOW SWITCH		PRESSURE SENSOR
	FLOW MEASURING DEVICE		COMBINATION PRESSURE TEMPERATURE PLUG
	VISUAL FLOW INDICATOR		WATER TEMPERATURE SENSOR
	ENERGY WATER		DIFFERENTIAL PRESSURE SENSOR
	HEAT TRACE		CHILLED WATER SUPPLY (BUILDING)
	CONDENSER WATER SUPPLY		CHILLED WATER RETURN (BUILDING)
	CONDENSER WATER RETURN		NITROGEN FILLED SUPPLY
	CHILLED WATER SUPPLY		NITROGEN FILLED RETURN
	CHILLED WATER RETURN		DOMESTIC COLD WATER (DCW)

- GENERAL NOTES:
- SYSTEM SCHEMATIC FOR GENERAL REFERENCE ONLY. DEVELOPER CONSULTANT SHALL BE RESPONSIBLE FOR ALL DESIGN AND ENGINEERING OF DISCRETE COOLING PLANT (DCP).
 - SYSTEM SCHEMATIC IS A GENERAL CONCEPT FOR CONNECTING TWO CUSTOMERS TO ONE DISCRETE COOLING PLANT (DCP).



DISCRETE COOLING PLANT (DCP)

<p>KERR WOOD LEIDAL consulting engineers 200 - 4185A Still Creek Drive Burnaby, BC V5C 6G9 T (604) 294-2088 F (604) 294-2090 E mail@kwl.ca</p>	<p>CORIX ENERGY COMPANY</p>	<p>FALCON ENGINEERING INGENUITY DELIVERED 210-1715 Dickson Ave. Kelowna, BC V1Y 9G6 250.762.9993 www.falcon.ca Permit To Practice 1001295</p>	<p>THIS DRAWING TO BE PLOTTED IN COLOUR</p>	<p>Rev 1 2023-09-13 AL JB AS ISSUED FOR CLIENT INFORMATION</p> <p>Rev 2 2023-09-22 AL JB AS ISSUED FOR PROGRESS</p> <p>Rev 3 2023-11-30 AL JB AS ISSUED FOR CLIENT INFORMATION</p>	<p>Rev 1 2023-09-13 AL JB AS ISSUED FOR CLIENT INFORMATION</p> <p>Rev 2 2023-09-22 AL JB AS ISSUED FOR PROGRESS</p> <p>Rev 3 2023-11-30 AL JB AS ISSUED FOR CLIENT INFORMATION</p>	<p>CLIENT: CCDEU DCP SAMPLE CONNECTION DESIGN</p> <p>DRAWING: CHILLER SYSTEM SCHEMATIC</p> <p>Project No. 23123.001 Drawing No. M1.0 Rev. A</p> <p>Group MECHANICAL</p>
				<p>200 - 4185A Still Creek Drive Burnaby, BC V5C 6G9 T (604) 294-2088 F (604) 294-2090 E mail@kwl.ca</p>		

15 Appendix B: List of Reference Standards

Designs shall conform to all applicable regulations, codes, and design standards. For convenience, a number of applicable reference documents are listed below. The list should not be considered exhaustive. Compliance with codes, standards, and references not listed below, but required by law or best practice are still required. Unless noted otherwise, the most current edition of each reference shall be used.

15.1 General

1. British Columbia Building Code.
2. British Columbia Fire Code.
3. British Columbia Plumbing Code.
4. EGBC Professional Practice Guidelines.
5. ASME Boiler and Pressure Vessel Code, Section VIII.
6. ASHRAE Handbooks: Refrigeration, Fundamentals, HVAC Systems and Equipment, HVAC Applications.
7. ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality.
8. ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.
9. AWWA M14 Backflow Prevention and Cross-Contamination Control.
10. CSA A23.1 Concrete Materials and Methods of Concrete Construction.
11. CSA A23.2 Test Methods and Standard Practices for Concrete.
12. CSA A23.3 Design of Concrete Structures.
13. CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
14. CSA B52 Mechanical Refrigeration Code.
15. CEN – EN 1434-1 Heat Meters – Part 1: General Requirements.
16. CSA C900.1 Heat Meters – Part 1: General Requirements.
17. CSA G40.20 General Requirements for Rolled or Welded Structural Quality Steel.
18. CSA G40.21 Structural Quality Steel.
19. CSA O86 Engineering Design in Wood.
20. CSA S16 Design of Steel Structures.
21. CSA W47.1 Certification of Companies for Fusion Welding of Steel Structures.
22. CSA W48 Electrodes and Filler Metals Certification.

23. CSA W59-M Welded Steel Construction (Metal Arc Welding).
24. CSA W178.1 Welding Inspection Organizations Company Certifications.
25. CSA W178.2 Welding Inspector Certification.
26. NFPA 13 Standard for the Installation of Sprinkler Systems.
27. NFPA 214 Standard on Water-Cooling Towers.
28. NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
29. NSF 61 Drinking Water System Components.
30. NSF 372 Drinking Water Components – Lead Content.
31. SMACNA 006 HVAC Duct Construction Standards.
32. Workers Compensation Act; Occupational Health and Safety Regulation.
33. CSA CAN3-Z229 Quality Assurance Program.
34. CSA B149.2 Propane Storage and Handling Code.

15.2 Equipment

1. AHRI 370 Sound Performance Rating of Large Air-Cooled Outdoor Refrigerating and Air-Conditioning Equipment.
2. AHRI 550/590 Performance Rating of Water-Chilling and Heat Pump Water Heating Packages Using the Vapour Compression Cycle.
3. AHRI 575 Method of Measuring Machinery Sound Within Enclosure Space.
4. ASHRAE 15 Safety Standard for Refrigeration Systems.
5. ASHRAE 34 Designation and Classification of Refrigerants.
6. ASHRAE 90.1-2019 Energy Standard For Buildings Except Low-Rise Residential Buildings.
7. ASHRAE 147 Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.
8. EPS 1/RA/2 Environmental Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.
9. HI - Hydraulic Institute Standards.
10. CSA B167 Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Jib Cranes.
11. CSA B1967 CMAA Specification No. 70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Travelling Cranes.

12. CSA Z256-M87 Safety Code for Material Hoist.
13. ANSI/NSF P453 Cooling Tower Water Systems – Treatment, Operation, and Maintenance to Prevent Legionella's.

15.3 Electrical

1. CSA C22.1 Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations.
2. CSA C22.2 Canadian Electrical Code, Part 2, General Requirements.
3. CSA C22.2 No. 141 Emergency Lighting Equipment.
4. CSA C22.2 No. 236/ UL 1995 Heating and Cooling Equipment.
5. CAN3-C235-83 Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
6. CSA Z462 Workplace Electrical Safety.
7. Electrical Contractor's Association of British Columbia: Seismic Restraint Manual, Guideline for Electrical Systems.

15.4 Piping and Fittings

1. ASME B31.1 Power Piping.
2. ASME B31.3 Process Piping.
3. ASME B31.5 Refrigeration Piping and Heat Transfer Components.
4. ASME B31.9 Building Services Piping.
5. ASME B1.20.1 Pipe Threads, General Purpose, Inch.
6. ASME B16.5 Standards for Pipes and Fittings.
7. ASME B16.9 Factory Made Wrought Butt-welding Fittings.
8. ASME B16.11 Forged Fittings, Socket-Welding and Threaded.
9. ASME B16.18 Cast Copper Alloy Solder Joints Pressure Fittings.
10. ASME B16.21 Non-metallic Flat Gaskets for Pipe Flanges.
11. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
12. ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.
13. ASME B16.50 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.
14. ASME B32.1 Metal Products.
15. ASME B36.10 Welded and Seamless Wrought Steel Pipe.
16. EN 253 District Heating Pipes – Pre-insulated Bonded Pipe System for Directly Buried Hot Water Networks.

17. MSS SP-58 Pipe Hangers and Supports – Materials, Design, and Manufacture.
18. MSS SP-69 Pipe Hangers and Supports – Selection and Application.
19. MSS SP-77 Guidelines for Pipe Support Contractual Relationship.
20. MSS SP-89 Pipe Hangers and Supports – Fabrication and Installation Practices.
21. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports.
22. MSS SP-127 Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.
23. ASTM C547 Standard Specification for Mineral Fibre Pipe Insulation.

15.5 Valves

2. ASME B16.34 Valves Flanged, Threaded, and Welding End.
3. AWWA C508 Swing-Check Valves for Waterworks Service.
4. AWWA C511 Reduced Pressure Principle Backflow Prevention Assembly.
5. AWWA C515 Reduced-Wall, Resilient-Seated Gate Valves Water Supply Service.
6. AWWA C517 Resilient-Seated Cast-Iron Plug Valves.
7. AWWA C550 Protective Interior Coatings for Valves and Hydrants.
8. CSA B64 Backflow Preventers and Vacuum Breakers.
9. MSS SP-6 Standard Finishes for Contact Faces of Pipe Flanges of Valves and Fittings.
10. MSS SP-25 Standard Marking System for Valves, Fittings, Flanges and Unions.
11. MSS SP-42 Class 150 Corrosion Resistant Gate, Globe, Angle, and Check Valves with Flanged and Butt Weld Ends.
12. MSS SP-55 Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components.
13. MSS SP-61 Hydrostatic Testing of Steel Valves.
14. MSS SP-99 Instrument Valves.