

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 23 07 00 Insulation for HVAC
- .4 23 20 00 HVAC Piping and Pumps
- .5 23 80 00 Decentralized HVAC Equipment
- .6 Division 25

1.2. General Notes

- .1 The requirements of Division 0 and Division 1 of these specifications apply to all section of these specifications.
- .2 It is the intent of these specifications to describe a complete working HVAC system, conforming to all applicable codes and standards. All work shall be provided in such a manner as to provide a complete and working system.
- .3 These specifications shall be read in conjunction with all other specifications for this project and all drawings sketches.
- .4 Perform work to the following standards:
 - .1 National Building Code 2016
 - .2 Canadian Electrical Code 2015

1.3. Inspection of Site

- .1 The contractor shall visit the site and thoroughly review all existing conditions. It is expected that any work caused by existing conditions which could have been reviewed at the time of tender shall be included in the tender price. This includes, but is not limited to, re-routing of existing services, reconnecting to existing services, relocation or removal of superfluous materials.

1.4. Cooperation

- .1 The drawings are diagrammatic in nature and cannot show all the details of the installation. The contractor is responsible for interpreting the drawings and providing suitable installations as best as possible based on the intent of the drawings.
- .2 If dimensions are provided in the drawings or specifications, the implications shall be field checked before ordering any material. Notify the Departmental representative immediately if any interferences or discrepancies arise due to design parameters. Coordinate with all other contractors with respect to any changes required in the contract documents for equipment or material installation.
- .3 Store materials out of the way of other contractors and keep all work areas clean daily.

1.5. Shop Drawings

- .1 Refer to Divisions 0 and 1 for additional shop drawings requirements.
- .2 Submit within two business days of award, a list of all equipment to be provided, complete with manufacturer and model number. Identify all equipment with expected long lead times.
- .3 Shop drawings shall be reviewed and returned electronically.
- .4 Shop drawings shall be specific to the project – generic shop drawings will be returned not reviewed. Shop drawings must provide all relevant performance data, dimensions and weight.

All options must be selected. Shop drawings must be carefully reviewed by the Contractor and before being submitted for review.

- .5 All applicable approvals shall be shown, such as CSA, ULC, FM, etc.
- .6 Equipment and materials shall not be ordered until the Departmental representative as returned a shop drawing marked "reviewed" or "reviewed as modified". The Contractor shall assume all responsibility to ensure all modifications are made to shop drawings marked "reviewed as modified" before ordering equipment or materials.

1.6. Insurance

- .1 The contractor shall obtain and maintain insurance which will fully protect themselves and the Departmental representative for any and all claims.

1.7. Codes, Fees and Certificates

- .1 The contractor shall procure and pay all fees for all work required by these specifications, unless specifically noted otherwise.
- .2 All work done by the contractor shall be done in the strictest adherence with all applicable codes and standards.
- .3 All changes required by the Authority having jurisdiction shall be made at no cost to the Departmental representative.

1.8. Extras and Credits

- .1 The contractor shall make any claims for extras in writing to the Departmental representative. Claims shall be accompanied with detailed descriptions and drawings as applicable to back-up the claim for additional costs. Where extras arise from interference with new or existing construction, a detailed dimensioned drawing to scale with site verified dimensions shall be provided.
- .2 The contractor shall note any extras due to omissions on the drawings immediately after noticing the error. A fair adjustment in the contract price shall be negotiated with the Departmental representative and Departmental representative.

1.9. Supports

- .1 Provide steel or concrete supports as required for all equipment and materials. The contractor is responsible for all anchoring and setting of supports, unless specifically noted otherwise.

1.10. Penetrations

- .1 Penetrations through wall, roofs, floors, etc shall be done by methods which do not allow the material to rub or wear on the building structure.
- .2 For masonry and concrete penetrations, provide sleeves through the structure. For other penetrations, provide opening and protect the piping with wrap or insulation. Where insulation is specified, ensure the penetration or sleeve is of adequate size to allow the insulation to be continuous through the penetration.
- .3 All penetrations through fire rated structures shall be properly fire-stopped to a listed assembly.

1.11. Demolition

- .1 The contractor shall remove all superfluous materials and materials shown to be removed which relevant to these specifications.
- .2 Cap all connection no longer required. Protect all equipment and material which are to remain.

1.12. Trial Period

- .1 It is understood that the systems, equipment and materials installed under this contract are under a trial period until fully accepted by the Departmental representative. Certificate of substantial performance is not acceptance of the system by the Departmental representative.

1.13. Start-up

- .1 The contractor shall start-up all equipment as per the manufacturer's instruction.
- .2 Complete all manufacturer's recommended start-up procedures and paperwork, and include the information in the operation and maintenance manual.
- .3 Equipment shall be operated for a minimum of 1 week by the contractor before handing over to the Departmental representative.
- .4 Notify the Departmental representative and Departmental representative before start-up tests are scheduled and allow the Departmental representative and/or Departmental representative to witness the start-up.

1.14. Testing and Commissioning

- .1 Notify the Departmental representative before commissioning tests are scheduled and allow the Departmental representative to witness the testing. Provide copy of the testing to the departmental representative prior to the commissioning and the completed test reports.
- .2 Test the equipment through all operations. Ensure proper operation and set-up of all equipment.
- .3 Make record of any deficiencies in the operation and take measures to immediately correct deficiencies.

1.15. Testing, Adjusting and Balancing

- .1 Provide the services of a NEBB or AABC certified testing and balancing company (TAB) to adjust and balance all equipment and systems.
- .2 Testing, adjusting and balancing shall be conducted as soon as possible after the installation of the systems, but shall be cognizant of incomplete systems which could affect the final results.
- .3 The TAB report shall include all the following information, where relevant:
 - Equipment Tag/Number
 - Manufacturer
 - Model
 - Motor HP
 - Operating BHP, Amperage, Voltage, RPM
 - Equipment curves
 - Discharge and inlet pressures
 - Discharge and inlet temperatures

1.16. Training

- .1 The contractor shall provide a minimum of 2 hours of training on the operation and maintenance of all newly installed equipment and systems.
- .2 Training shall include changes and operation of the building management's system integration with the new systems.
- .3 The contractor shall, at the request of the departmental representative, engage a factory representative for the training.
- .4 Timing of the training shall be coordinated with the departmental representative and shall be scheduled at the departmental representative's convenience.

- .5 The contractor shall keep record of all information provided during the training and all persons who attended the training.
- .6 The training shall be recorded in a standard video format and be included in the O&M manuals.

1.17. Deficiencies

- .1 The Contractor shall review their own work and make deficiency lists prior to review by the Departmental representative. Deficiencies are to be corrected when possible before the Departmental representative review, otherwise, the list shall be provided to the Departmental representative before the Departmental representative's review.
- .2 The Departmental representative shall provide deficiency reports. The contractor shall correct all deficiencies in a timely manner and report the results to the Departmental representative. Photographic proof shall be provided for all final deficiencies.

1.18. Record Drawings

- .1 The contractor shall keep a clean and neat record of all deviations made from the contract drawings.
- .2 Provide to the Departmental representative a clean set of drawings marked "As Built".

1.19. Operating & Maintenance

- .1 Provide to the Departmental representative, at the completion of the project, two complete sets of operation and maintenance manuals (O&M).
- .2 Manuals shall include:
 - .1 All shop drawings. Where shop drawings were marked "reviewed as modified", the Contractor shall update the shop drawing for the O&M manual.
 - .2 All operating manuals for all equipment.
 - .3 As-built drawing
 - .4 List of valve and control valve with tag numbers
 - .1 Coordinate with departmental representative for appropriate tag numbers.
 - .5 Key plan with valve numbers located on the drawings.
 - .1 Contractor may, with permission from the Departmental representative, update an existing key plan.
 - .6 TAB Report
 - .7 Start-up Reports
 - .8 Training material
- .3 The manual shall be provided in a 3-D-ring binder, complete with index. The binder shall not be more than 80% full.

1.20. Guarantees and Warranties

- .1 The contractor shall guarantee the Departmental representative a labour and materials warranty for all equipment, material and systems provided as part of this contract for a period of one year from the date of substantial performance unless otherwise specified.

2. Products

2.1. Identification

- .1 Provide lamicoid or metal engraved name plate for all equipment. Name plates shall include tag number and all major performance data.

- .2 Provide snap-around plastic labels for all piping. Labels shall provide the service and direction of flow. Lettering shall be a minimum of 50mm (2").

3. Execution

3.1. Identification

- .1 Provide identification for all piping. Provide labels on each side of all penetrations and at minimum every 3 m (10') in concealed areas and 6 m (20') where easily visible.
- .2 Provide all equipment with nameplates.
- .3 Provide a list and key plan showing the location of all numbered valves installed.

3.2. Testing, Adjusting and Balancing

- .1 All flows shall be balanced to +/-5% of design flows.

3.3. Fire-stopping

- .1 Contractor to identify all fire separations and provide fire-stopping for all penetrations through the fire separations.
- .2 Fire stopping shall meet the requirements of the National Building Code.

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 Division 21
- .4 23 05 00 Common Work Results for HVAC
- .5 23 20 00 HVAC Piping and Pumps
- .6 23 80 00 Decentralized HVAC Equipment
- .7 Division 25

1.2. Submittals

- .1 Provide submittals for all insulation materials. Mark the intended service and thickness for each material.

1.3. Flame Spread and Smoke Development Ratings

- .1 All materials as provided shall meet the 50/25 flame spread and smoke development ratings in accordance with ASTM and ULC.

2. Products

2.1. Insulation for Piping

- .1 Provide fibreglass type insulation with factory applied vapour retarding jacket and pressure sensitive lap sealing system. Jacket shall be high-density, white kraft bonded to an aluminum foil reinforced with fibreglass.

2.2. Coverings

- .1 PVC covering shall be molded fitted cover, taped or glued joints. PVC shall be minimum thickness of 0.5mm (0.020").

2.3. Adhesives and Sealants

- .1 Provide coatings, adhesives and sealants as recommended by the manufacturer of the insulation.

3. Execution

3.1. General

- .1 Insulation thicknesses are based on standard RSI-28/m at 24°C ambient temperature. Variations of this thermal resistant shall require a revision in the minimum thickness applied.
- .2 Ensure piping is dry and clean before applying insulation.
- .3 All pressure tests shall be conducted and passed before applying insulation.
- .4 Insulation shall be continuous through penetrations. Protect insulation by means of sleeves or other acceptable means. Fire separations shall be provided with a listed penetration detail.
- .5 Protect insulation using galvanized sheet steel where hangers support insulated piping. Use blocking of the thickness of the insulation to support the piping without crushing the insulation.
- .6 Finish product shall be neat and clean.

- .7 Where insulation has been removed for tie-ins to existing piping, restore existing insulation and covering.
- .8 Ensure the final finish for all coverings have a flame spread rating 25 or lower and smoke index is 50 or lower.

3.2. Insulation for Piping

- .1 Provide the following thickness for piping service:
 - .1 Chilled Water:
 - .1 Up to 32mm pipe size: 25mm
 - .2 40mm or larger pipe size: 40mm
 - .2 Drain (Condensate) Piping:
 - .1 25mm
- .2 Install insulation as per manufacturer's recommendations.

3.3. Coverings

- .1 Do not install covering until the insulation has been inspected by the Departmental representative.
- .2 Provide PVC covering for all piping.

3.4. Existing Work

- .1 Make good any insulation removed or damaged as a result of new work.

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1.2. Submittals

- .1 Valves
- .2 Gauges

2. Products

2.1. Hydronic Piping

- .1 Provide ASTM A53 grade B, schedule 40 ERW black steel pipe for 50mm and greater. Provide ASTM A53 continuously-welded steel piping for under 50mm.
- .2 Where pipe sizes are shown with metric values, the corresponding imperial pipe size is required to be provided. Do not provide metric sized pipe.

2.2. Drain Piping

- .1 Type L Copper.

2.3. Fittings

- .1 Metal piping shall be connected with threaded fittings for 50mm or smaller. For larger connections, flanged or welded.
- .2 Copper piping shall have sweat connections.
- .3 Grooved fittings are acceptable for steel piping only.
- .4 Provide union connections or flange connections to all equipment.
- .5 Fittings shall be rated for 1.0 MPa (150 PSI).

2.4. Valves

- .1 Valves 50mm and smaller shall be Class 150 or better. Larger valves shall be Class 300 or better.
- .2 Ball valves shall have stainless steel trim.
- .3 Balancing valves shall be rated for positive shut-off and be provided with lockable maximum memory setting. Balancing valves shall be capable of providing pressure measurement for accurate flow readings.

2.5. Gauges

- .1 Provide 230mm adjustable stem thermometers with unbreakable glass, dual scale and separable socket and well, with contrasting fluid.

2.6. Hangers

- .1 Hangers shall be manufactured items and rated for the service type and size provided.
- .2 Provide steel channel supports for groups of piping or ductwork.

2.7. Vibration Isolation

- .1 Vibration equipment shall be as recommended by the vibration equipment manufacture.
- .2 Flexible piping shall be rated for at least twice the maximum design pressure of the system.

2.8. Accessories

- .1 Strainers shall be cast iron, semi-steel or bronze Y type. Screens shall have 1mm (1/32") perforations. Provide drain with cap and chain.
- .2 Mist eliminators shall be manual type complete with ball valve with stainless steel trim and screwdriver operated.

3. Execution

3.1. Piping

- .1 Slope water piping and provide drains at low points.
- .2 Install to maintain adequate access to valves and equipment. Ensure proper spacing to allow for installation of insulation.

3.2. Fittings

- .1 Use dielectric fittings when connecting dissimilar metals.
- .2 For threaded connections, use dope or Teflon tape.
- .3 Gaskets shall be 2mm thick.
- .4 Use 95-5 hard solder for piping up to 75mm and Sil-Fos for larger piping.
- .5 Use flexible hoses to connect to equipment.
- .6 Make grooved connection following manufacturer's instructions.
- .7 Where connection sizes to equipment differs from the pipe size, use reducers at the equipment.
- .8 Connect to equipment using unions or flanges.

3.3. Gauges

- .1 Provide gauges where shown on the drawings.
- .2 Locate gauges so they can easily be read from the floor in a convenient location.

3.4. Valves

- .1 Provide types of valves shown on the drawings. Valve shall be line-sized unless otherwise noted.
- .2 Provide valves where shown on the drawings, and on both sides of all equipment for isolation at a minimum, regardless if shown or not.
- .3 Valve 2" and under shall be soldered or threaded. Larger valves shall be flanged or grooved.

3.5. Hangers

- .1 Where implied from the drawings, hang equipment and material from the structure. Provide suitable hangers rods and beam clamps or insert.
- .2 Hang equipment and material from structural elements only.
- .3 Attach to the top chord only when hanging from joists.

- .4 Provide supports for piping 32mm and smaller at no less than 2.5m intervals. Larger piping shall be supported no less than 3m intervals.

3.6. Vibration Isolation

- .1 Provide vibration isolation for all equipment.
- .2 Provide flexible piping for connections to all equipment.

3.7. Accessories

- .1 Provide mist eliminators at all high points and where shown on the drawings.
- .2 Strainers shall be installed horizontal unless specifically design for vertical installation.
- .3 Locate air vents at all high points.

End of Section

1. General

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1.2. Submittals

- .1 Precision Cooling Unit

2. Products

2.1. Precision Cooling Unit

- .1 General
 - .1 These specifications describe requirements for a precision cooling system. The system shall be designed to control temperature and humidity conditions in rooms containing electronic equipment. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements of the room.
- .2 Design Requirements
 - .1 The precision cooling unit shall be a self-contained, factory-assembled unit. Standard 60 Hz units shall be CSA-certified.
 - .2 The system performance shall be AHRI Certified™, the trusted mark of performance assurance for heating, ventilation, air conditioning and commercial refrigeration equipment, using AHRI Standard 1360.
- .3 Serviceability and Access
 - .1 The cabinet shall be designed so that all components are easily accessible for service and maintenance through the unit's side and front.
 - .2 Refer to drawings for handling and available services clearance space.
- .4 Frame
 - .1 The frame shall be constructed of welded tubular steel. It shall be painted for corrosion protection.
- .2 Upflow Air-flow Configurations
 - .1 The supply air shall exit from the top of the cabinet through a plenum and grille with the air throw toward the front.
 - .2 The return air shall enter the unit from the front of the cabinet through factory-installed grilles. Grilles shall be painted black.
 - .3 The exterior panels shall be insulated with a minimum 25 mm, 0.68 kg density fiber insulation.
 - .4 The main front panel shall have captive quarter-turn fasteners.
- .5 Filters

- .1 The filter chambers shall be located within the cabinet and serviceable from an accessible side of the unit.
- .2 Filters shall be deep-pleated 50mm (2-in.) filters, minimum efficiency reporting value of 8 or better.
- .3 Provide 2 extra sets of filters per system (4 sets total).
- .6 Locking Disconnect Switch
 - .1 The manual disconnect switch shall be mounted in the high-voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the door closed, and prevent access to the high-voltage electrical components until switched to the "OFF" position.
- .7 Short-circuit Current Rating
 - .1 The electrical panel shall provide at least 65,000A SCCR (60hz) or 5000A SCCR (50 Hz).
 - .2 Short-circuit current rating (SCCR) is the maximum short-circuit current a component or assembly can safely withstand when protected by a specific overcurrent protective device(s) or for a specified time.
- .8 Fan Section
 - .1 The fans shall be plug/plenum type, single-inlet and shall be dynamically balanced. The drive package shall be direct drive, electronically commutated and variable speed. The fans shall be located to draw air over the Aframe coil to ensure even air distribution and maximum coil performance.
 - .2 Electrically communicated (EC) fans shall be available on upflow models and fans shall operate outside the unit in a factory-provided plenum.
- .9 Discharge Air Plenum
 - .1 The air plenum shall be constructed of 20-gauge steel, powder coated to match unit color. Discharge air grilles shall be painted black and shall be included on the front of the plenum.
- .1 Chilled Water Control Valve
 - .1 The water circuit shall include a 3-way modulating valve. The valve shall be designed for up to 2758 kPa water pressure. The unit controller shall position the valve in response to room conditions.
 - .2 Cooling capacity shall be controlled by by-passing chilled water around the coil.
- .2 Evaporator Coil
 - .1 The evaporator coil shall be A-frame design for upflow units.
 - .2 The coil shall be controlled by a 3-way modulating control valve. It shall be constructed of copper tubes and aluminum fins and have a maximum face velocity of 2.5 m/s.
 - .3 The entire coil assembly shall be mounted in a stainless steel-condensate drain pan.
- .3 Condensate Pump
 - .1 A condensate pump for each unit is provided on-site. Contractor to integrate the pump controls and operation into the new AC unit.
- .4 Low-voltage Terminal Package
 - .1 Remote Shutdown Terminals - 2 additional pairs of terminals provide the customer with additional locations to remotely shut-down the unit by field-installed devices or controls.
 - .2 Extra Common-Alarm Contacts - 2 additional pairs of terminals provide the customer with normally-open contacts for remote indication of unit alarms.
 - .3 Main-Fan Auxiliary Switch - 1 set of normally-open contacts wired to the EC-fan motor contactor will close when EC-fan operation is required.

- .4 Unit shall be provided with self-contained controls for operation based on a local thermostat to be provided with the unit. Building management system will enable/disable the units for lead/lag operation.
- .5 Schedule:
 - .1 Both AC-1 and AC-2 to be provided with performance as follows:

COOLING CAPACITY	43.3 kW
ENTERING WATER TEMPERATURE	7.2 °C
LEAVING WATER TEMPRATURE	12.7 °C
FLOW RATE	3.0 L/s
PRESSURE DROP	148 kPa
ENTERING AIR TEMPERATURE	23.9 °C DB
	16.1 °C WB
EXTERNAL STATIC PRESSURE	50 Pa
AIRFLOW	2,260 L/s
MOTOR SIZE	7.5 HP
ELECTRICAL	575 V
	4.8 FLA
	6.0 MCA
	15 OPD
PHYSICAL DIMENSIONS (WITH PLENUM BOX)	
WIDTH	853 mm
LENGTH	1209 mm
HEIGHT	2400 mm
PHYSICAL DIMENSIONS (WITHOUT PLENUM BOX)	
WIDTH	853 mm
LENGTH	1209 mm
HEIGHT	1930 mm

2.2. In-line Pump

- .1 The pumps shall be of a horizontal, permanently lubricated type, specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, in cast iron bronze fitted construction. The pump internals shall be capable of being serviced without disturbing piping connections.
- .2 The pumps shall be composed of three separable components a motor, bearing assembly, and pump end. The motor shaft shall be connected to the pump shaft via a replaceable flexible coupler.
- .3 The pumps shall have a solid SAE1144 steel shaft supported by two sealed ball bearings. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
- .4 Pump shall be equipped with an internally-flushed mechanical seal assembly. Seal assembly shall be the unitized type with stainless steel drive tabs, EPR bellows and seat gasket, stainless

- steel spring, and be of a carbon silicon-carbide design with the carbon face rotating against a stationary silicon-carbide face.
- .5 Bearing assembly shaft shall connect to either a cast bronze impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.
 - .6 A flexible type coupling shall be employed between the pump and motor.
 - .7 Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
 - .8 Pump volute shall be of cast iron design for heating systems or cast bronze for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles, and vent and drain ports.
 - .9 To ensure alignment the motor shall be mounted to the bearing assembly via a bolted motor bracket assembly, and a rubber motor mount shall be used to assist in aligning the motor shaft with the pump shaft.
 - .10 Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall be resilient mounted. Motors shall have permanently lubricated ball bearings and must be completely maintenance free. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
 - .11 Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.
 - .12 Each pump shall be factory tested and name-plated before shipment and shall be provided with a (3) year warranty from date of installation.
 - .13 Schedule:
 - .1 Both P-1 and P-2 shall be scheduled as follows:

FLOW RATE	3.0 L/s
HEAD	90 KPa
WATER TEMPERATURE	7.2 °C
MOTOR	0.75 HP
DUTY POINT	0.63 HP
MOTOR SPEED	1800 RPM
EFFICINECY	62.5 %
IMPELLER DIAMETER	146 Mm
ELECTRICAL	208 V
	3 PHASE

3. Execution

3.1. Precision Cooling Unit

- .1 General
 - .1 Units to be installed a level concrete housekeeping pad. Pad shall extend a minimum of 100mm around the unit. Ensure to maintain manufacturer's recommended service clearance around the unit. Ensure to allow for access to field installed valves and components.
 - .2 The user shall install units in accordance with manufacturer's installation instructions.
 - .3 The units shall be installed plumb and level, firmly anchored in locations indicated and shall maintain manufacturer's recommended clearances.

- .4 Anchoring shall be by bolt or concrete anchors or screws directly into the concrete through neoprene or similar pads.
- .5 Provide hydronic piping, controls, and drain connections.
- .6 Pipe condensate to drain.
- .2 Electrical Wiring
 - .1 The user shall install and connect electrical devices furnished by the manufacturer but not specified to be factory-mounted. The manufacturer shall furnish a copy of manufacturer's electrical connection diagram submittal to electrical contractor.
- .3 Piping Connections
 - .1 The manufacturer shall furnish a copy of piping connection diagram submittal(s) to the contractor.
- .4 Supply and Drain Water Piping
 - .1 The user shall startup units in accordance with the manufacturer's startup instructions.
 - .2 The manufacturer shall test controls and demonstrate compliance with requirements.
- .5 Quality Control
 - .1 Start cooling units in accordance with manufacturer's startup instructions. Test controls and demonstrate compliance with requirements.
 - .2 The system shall be designed to maintain temperature conditions in the rooms containing electronic equipment.
 - .3 The manufacturer shall design and furnish all equipment to be fully compatible with heat-dissipation requirements.

3.2. In-Line Pumps

- .1 Install as per manufacturer's recommendations.
- .2 Support pump at flanges from floor.
- .3 Ensure proper motor/impeller rotation.

End of Section