

1. Division 22

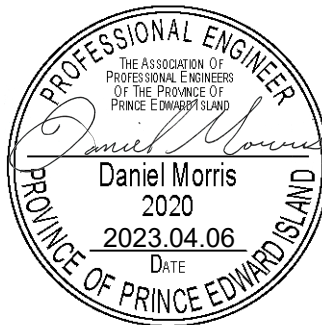
- .1 22 05 00 Common Work Results for Plumbing
- .2 22 07 00 Plumbing Insulation
- .3 22 10 00 Plumbing Piping
- .4 22 30 00 Plumbing Equipment

2. Division 23

- .1 23 05 00 Common Work Results for HVAC
- .2 23 07 00 Insulation for HVAC
- .3 23 30 00 HVAC Air Distribution
- .4 23 80 00 Decentralized HVAC Equipment

3. Division 25

- .1 25 05 00 Common Work Results for Integrated Automation
- .2 25 06 00 Schedules for Integrated Automation
- .3 25 10 00 Integrated Automation Network Equipment
- .4 25 90 00 Sequences of Operation



End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 Section 22 10 00 Plumbing Piping
- .4 Section 22 30 00 Plumbing Equipment
- .5 Division 23
- .6 Division 25

1.2. General Notes

- .1 The requirements of Division 0 and 1 of these specifications apply to all sections of these specifications.
- .2 The term "Trade" refers to all trades that provide work within this section. The term "Contractor" refers to the General or Prime Contractor, however, it is this trade's responsibility to ensure the Contractor knows and understand all the requirements in these specifications.

1.3. Sprinkler System Modifications

- .1 All modifications to the existing sprinkler system are to be performed by a licensed sprinkler contractor.
- .2 Perform work to the following standards:
 - .1 National Building Code 2015
 - .2 National Fire Protection Association Standards
 - .3 Local Fire Department
 - .4 CSA (for life safety), ULC, FM (for listed equipment)
 - .5 Canadian Electrical Code
- .3 Unless indicated otherwise, all modifications to the existing sprinkler system are subject to the requirements of these specifications.

1.4. Scope of Work

- .1 It is the intent of these specifications to describe a complete working plumbing 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.
- .2 These specifications shall be read in conjunction with all other specifications for this project and all drawings sketches. There is a requirement for this Trade to coordinate services with all other trades.

1.5. Inspection of Site

- .1 This Trade 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.

1.6. Cooperation

- .1 The drawings are diagrammatic in nature and cannot show all the details of the installation. This Trade 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 Consultant immediately if any interferences or discrepancies arise due to design parameters. Coordinate with all other trades with respect to any changes required in the contract documents for equipment or material installation.
- .3 Store materials out of the way of other trades and keep all work areas clean daily.

1.7. Shop Drawings

- .1 Refer to Division 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 this Trade before being submitted for review. Shop drawings shall bear the mark of both the Contractor and this Trade.
- .5 All applicable approvals shall be shown, such as CSA, ULC, FM, etc.
- .6 All reviewed shop drawings shall be distributed by the Contractor to all effected trades for coordination. Clearly highlight any discrepancies between specified equipment and equipment provided. Any cost incurred by Trades by deviation from provided equipment specifications shall be at no cost to the Owner.
- .7 Equipment and materials shall not be ordered until the Consultant as returned a shop drawing marked “reviewed” or “reviewed as modified”. The Trade shall assume all responsibility to ensure all modifications are made to shop drawings marked “reviewed as modified” before ordering equipment or materials.

1.8. Alternatives

- .1 Equipment and materials specified in these specifications are for the purposes of design and coordination. This does not limit the Contractor or Trade from providing alternative products. Where products are listed as alternative in the specification, this Trade is still responsible for ensuring the product or materials meets all specifications. Listing of a manufacturer as an approved equal or alternative does not indicate that the manufacturer has an equivalent product. It does indicate that the manufacturer’s level of quality is of a similar level to the specified.
- .2 Where the contractor elects to provide an alternative product to the base bid specification, the contractor is responsible for all costs required to integrate the alternative product where the installation requirements differ from the originally specified product. This includes modifications to existing and new building, mechanical, electrical and structural systems.
- .3 The Owner shall approve, and have the full right to refuse, any equipment or material proposed by the Contractor or Trade as an alternative or equal to the specified if not specifically noted in the contract documents.

1.9. Insurance

- .1 This Trade shall obtain and maintain insurance which will fully protect themselves and the Owner for any and all claims.

1.10. Codes, Fees and Certificates

- .1 This Trade shall procure and pay all fees for all work required by these specifications, unless specifically noted otherwise.
- .2 All work done by this Trade 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 Owner.

1.11. Extras and Credits

- .1 This Trade shall make any claims for extras in writing to the Owner. 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 This Trade 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 Consultant and Owner.
- .3 All quotations for extras shall be accompanied with a detailed breakdown in material and labour. If hourly rates have not already been determined by the Contract, hourly rates shall be determined by the latest addition of MCAA pricing manual.

1.12. Supports

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

1.13. 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.
- .4 Fire-rated separations shall be confirmed with Owner. At a minimum, firestopping shall be provided through the following penetrations:
 - .1 Electrical, mechanical, custodian rooms
 - .2 Corridor doorways
- .5 This trade shall be responsible for all penetrations through the roof. Work to be performed by qualified roofing trades which maintain the roof warranty.

1.14. Demolition

- .1 This trade 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.
- .3 Any demolition of a structural nature shall not be performed by this trade.

1.15. Existing Ceilings

- .1 Extensive work is required above the existing ceilings. As such, the General Contractor is responsible for the removal and replacement of all ceilings throughout the building as required.

1.16. Hazardous Materials

- .1 Report to the Consultant any hazardous or dangerous materials in the existing building.
- .2 The Owner will arrange to have any hazardous or dangerous materials removed, unless specifically noted as part of the Contract scope of work.
- .3 Only qualified trades shall remove such materials.

1.17. 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 Owner. Certificate of substantial performance is not acceptance of the system by the Owner.

1.18. Start-up

- .1 The Trade 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 this Trade before handing over to the Owner.
- .4 Notify the Consultant and Owner before start-up tests are scheduled and allow the Consultant and/or Owner to witness the start-up.
- .5 Where appropriate, the manufacturer's representative shall be present to conduct the start-up.

1.19. Testing and Commissioning

- .1 Notify the Consultant and Owner before commissioning tests are scheduled and allow the Consultant and/or Owner to witness the testing.
- .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.
- .4 The Trade shall return to site for each of the next three seasons to confirm the equipment is operating as intended. Coordinate with the Owner and weather for proper verification of operation.

1.20. Deficiencies

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

1.21. Record Drawings

- .1 This Trade shall keep a clean and neat record of all deviations made from the contract drawings.
- .2 Provide to the Owner a clean set of drawings marked "As Built".

1.22. Operating & Maintenance

- .1 Provide to the Owner, 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 Trade 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
 - .5 Key plan with valve numbers located on the drawings.
 - .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.
- .4 This trade shall provide training to the Owner or Owner's representative for all equipment and systems installed. Where appropriate, the training shall be done by a representative of the manufacturer.

1.23. Guarantees and Warranties

- .1 This trade shall guarantee the Owner a labour and materials warranty for all equipment, material and systems provided as part of this contact for a period of one year from the date of substantial performance unless otherwise specified.

2. Products

2.1. Vibration Isolation

- .1 Vibration equipment shall be a manufactured product from a reputable manufacturer.
- .2 Vibration equipment shall be as recommended by the vibration equipment manufacturer.
- .3 Flexible piping shall be rated for at least twice the maximum design pressure of the system.

2.2. 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 Provide 12mm (1/2") permanent adhesive-coloured dots for identification of serviceable equipment above the ceiling.

3. Execution

3.1. Identification

- .1 Provide snap-around plastic labels for all piping. Provide labels on each side of all pipe penetration and at minimum every 3 m (10') in concealed areas and 6 m (20') where easily visible.
- .2 Provide coloured-numbered dots on ceiling where valves are located above an accessible ceiling.
- .3 Labels required for piping
 - .1 Low-pressure steam humidification
 - .2 Cold soft water piping
 - .3 Condensate piping
- .4 Provide all equipment with nameplates.

3.2. Fire-stopping

- .1 Contractor to identify all fire separation on-site 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 Section 22 05 00 Common Work Results for Plumbing
- .4 Section 22 10 00 Plumbing Piping
- .5 Section 22 30 00 Plumbing Equipment
- .6 Section 22 40 00 Plumbing Fixtures
- .7 Division 23
- .8 Division 25

1.2. Scope of Work

- .1 Provide insulation for all cold water, hot water, sanitary and storm systems and plumbing equipment as more thoroughly described in this section.

1.3. Submittals

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

2. Products

2.1. Pipe insulation

- .1 Provide John Manville, Knauf or Owens Corning.
- .2 Fibreglass insulation shall include an all-service jacket with self-sealing lap closure system, with white kraft bonded to an aluminum foil reinforced fibre glass cover.
- .3 Provide Armacell black closed-cell self-adhesive elastomeric pipe insulation.
- .4 Provide PVC jacketing and molded fitting covers with taped or glued joints with minimum thickness of 0.5 mm (0.020").

2.2. Sealants and Adhesives

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

3. Execution

3.1. General

- .1 Ensure pipes are clean and dry before insulated.
- .2 Notify the Consultant before insulating the piping for review before insulation is installed. This Trade is responsible for removing and repairing insulation if installed without approval from the Consultant.
- .3 All piping shall be pressure tested before being insulated.
- .4 Insulation shall be continuous through penetrations. Protect insulation by means of sleeves or other acceptable means.
- .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.

3.2. Pipe Insulation

- .1 Insulate piping as follows:
 - .1 Cold Water:
 - .1 12 mm (0.5") for 50 mm (2") and under
 - .2 25mm (1.0") for over 50 mm (2")
 - .2 Condensate drains: 12 mm (0.5")
 - .3 Steam hose: 25mm (1.0")

3.3. Pipe Covering

- .1 Provide PVC Covering for all exposed piping.

3.4. Existing Work

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

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 Section 22 05 00 Common Work Results for Plumbing
- .4 Section 22 30 00 Plumbing Equipment
- .5 Division 23
- .6 Division 25

1.2. Scope of Work

- .1 Provide all piping, fittings, pumps, valves, fixtures, drains, traps, vents and materials as required to provide a complete and operational plumbing system.
- .2 The scope of work includes all accessory drains from equipment.

1.3. Submittals

- .1 Equipment
- .2 Valves

2. Products

2.1. General

- .1 All materials shall comply with all applicable codes and regulations.

2.2. Gauges

- .1 Provide Winters, Taylor, Terice, Welsler or WIKA gauges
- .2 Provide 9" (230mm) adjustable stem thermometers with unbreakable glass, dual scale and separable socket and well, with contrasting fluid.
- .3 Provide liquid 4" (100mm) filled pressure gauges. Scales to suite the pressure range and dual scale and contrasting colours.
- .4 Provide isolation valve for each gauge.

2.3. Valves

- .1 Provide: Toyo, Kitz, Nibco, Watts, Victaulic, Viega or Zurn valves. Valves shall have a 200 CWP rating. Valves shall all be from one manufacturer, where possible.
- .2 Ball valves shall have stainless steel trim.
- .3 All stems shall be blow-out proof.

2.4. Hangers

- .1 Provide hangers and supports from: Anvil, Crane, Myatt or Unistrut.
- .2 Hangers shall be manufactured items and rated for the service type and size provided.

2.5. Sanitary Piping and fittings

- .1 Piping shall be CPVC
- .2 Provide solvent weld fittings for CPVC piping.

2.6. Water Piping and fittings

- .1 Provide type L hard copper tubing or PEX piping.
- .2 Sweat fittings for copper piping.
- .3 Compression fittings for PEX piping. Fittings shall be recommended by the piping manufacturer.
- .4 Provide unions for connection to equipment up to 63 mm (2-1/2"). Provide flanges for larger connections.

3. Execution

3.1. General

- .1 Install piping straight, parallel to the walls, close to the ceiling or structure. Use standard 45° or 90° fittings where ever possible.
- .2 Group piping together with minimal space provided for installation of insulation and service.
- .3 Install eccentric fitting to aid with drainage and air elimination.
- .4 Where pipe size differs from equipment, provide reducing fittings at the equipment.
- .5 Use dielectric fittings where connecting differing metallic materials.

3.2. 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.

3.3. 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" (50 mm) and under shall be soldered or threaded or Victaulic.

3.4. 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.

3.5. Sanitary Piping and Fittings

- .1 Install with a minimum of 1:100 slope unless otherwise noted on the drawings.
- .2 Plug or cap all pipes during construction to minimize debris from entering the piping.

3.6. Water Piping and Fittings

- .1 Provide drains at all low points to allow for complete draining of the system.
- .2 All water piping shall be pressure tested.

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 Section 22 05 00 Common Work Results for Plumbing
- .4 Section 22 10 00 Plumbing Piping
- .5 Division 23
- .6 Division 25

1.2. Scope of Work

- .1 Provide all plumbing equipment.

1.3. Submittals

- .1 Water Softener
- .2 Humidifier
- .3 Condensate Pump

2. Products

2.1. Water Softener

- .1 Water softeners shall be WaterGroup, Myers or Siemens
- .2 Two tank duplex configuration.
- .3 Reduces hardness to less than 8 mg/L.
- .4 Water usage based regeneration cycle with water meter.
- .5 No electrical required.
- .6 Tanks made of polyethylene and reinforced with fiberglass wrapping.
- .7 Minimum exchange capacity of 30,000 grains/ft³ (68.6 g/L) of CaCO₃ when regenerated with 15.0 lbs/ft³ (0.24 kg/L) of salt.
- .8 Include brine system for combination brine and salt storage, manufactured from corrosion resistant plastic.
- .9 Brine tank shall allow for adjustable salt setting.

2.2. Humidifiers

- .1 Provide resistive element humidifier generating mineral-free, sterile steam for use with potable-soft water. Packaged unit, wall mounted, atmospheric steam generation using resistive heating element.
- .2 Acceptable Products: Dristeem, Nortec, Neptronic
- .3 Unit[s] to be complete with:
 - .1 User interface with digital display
 - .2 Standard building automation communication protocols BACnet IP, BACnet MSTP (Slave) and Modbus.
 - .3 Single or dual channel analog signal acceptance, supporting both demand and transducer control. Ability to control setpoint from humidifier control when using transducer controls.

- .4 Packaged system with resistive element:
 - .1 Resistive heating element for steam production.
 - .2 Modulating output between 4% and 100% of rated capacity.
 - .3 Control accuracy of up to +/- 1% RH using Solid State Relay control and high precision humidistat.
 - .4 Dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level control and reduced maintenance.
 - .5 Self-diagnostics during start-up of system to prevent unsafe operation of the unit[s]:
 - .1 Fill valve check.
 - .2 Float level check.
 - .3 Drain pump check.
 - .6 Durable powder coated steel cabinet with zero side clearance requirement for minimal footprint.
 - .7 Insulating air gap between plumbing and electrical compartment for increased electronic reliability.
 - .8 Drain water tempering to ensure maximum 140°F [60°C] drain water.
 - .9 Integral fill cup with minimum 1-inch [25 mm] air gap to prevent back siphoning.
 - .10 Automatic off-season shut-down [after 3 days of "no call"] will completely drain the boiling tank[s] and automatically restart on call for humidity.
 - .11 Integral design allowing easy installation and access for servicing.
- .5 Included Options:
 - .1 Solid state relay for +/-1% relative humidity control.
 - .2 Scale management to collect scale debris in scale collection tank which eliminate steam cylinder removal during minor maintenance.
 - .3 Short absorption manifolds as scheduled.
 - .4 High limit humidistat.
 - .5 Air proving switch.
- .4 Distributer
 - .1 Provide SAM-e (or mini SAM-e) or equivalent short absorption distance manifold distributor. Maximum absorption distance to be 225mm (9").
 - .2 Distributer shall be insulated and provided maximum 4% condensate based on 2.5 m/s (500 fpm) air velocity and 21°C (70°F) air temperature.
 - .3 304 Stainless steel tubes and headers.
- .5 Steam and Condensate Piping
 - .1 Use manufacturer provided piping as applicable, otherwise:
 - .1 Provide ASTM A53 continuously-welded steel piping for under 50mm (2").
 - .2 Use factory insulated steam pipes where applicable.
 - .6 Humidifier shall be equipped with internal drain cooling. Where internal drain cooling is not provided with unit, external drain cooler is to be provided.
- .7 Warranty:
 - .1 Two years parts and labour.

2.3. Condensate Pump

- .1 Provide condensate pump as scheduled on the drawings.
- .2 Fractional horsepower, fan-cooled, concentric motor.
- .3 Stainless steel motor shaft.
- .4 Automatic operation.
- .5 Thermally protected.
- .6 Pump shall be plug-in with grounded 3-prong plug.

3. Execution

3.1. Water Softener

- .1 Install to manufacturer's recommendations. Refer to piping schematics on the drawings.

3.2. Humidifiers

- .1 Installation:
 - .1 Install humidifiers per manufacturers' instructions.
 - .2 Install with required clearance for service and maintenance.
 - .3 Install distributor plumb. Rework existing angled ductwork as required.
- .2 Accessories:
 - .1 Install accessories in accordance with manufacturer's recommendations.
- .3 Commissioning:
 - .1 Start-up of humidifier to be by factory-trained technician.

3.3. Condensate Pump

- .1 Install as per manufacturer's instructions.
- .2 Install on a flat, level surface.

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 23 07 00 Insulation for HVAC
- .4 23 30 00 HVAC Air Distribution
- .5 23 80 00 Decentralized HVAC Equipment

1.2. General Notes

- .1 The term "Trade" refers to all trades that provide work within this section. The term "Contractor" refers to the General or Prime Contractor, however, it is this trade's responsibility to ensure the Contractor knows and understand all the requirements in these specifications.

1.3. Scope of Work

- .1 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.
- .2 These specifications shall be read in conjunction with all other specifications for this project and all drawings sketches. There is a requirement for this Trade to coordinate services with all other trades.

1.4. Inspection of Site

- .1 This Trade 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.

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- .4 Fire-rated separations shall be confirmed with Owner. At a minimum, firestopping shall be provided through the following penetrations:
 - .1 All floors
 - .2 Electrical, mechanical, custodian rooms
 - .3 Stairwells
 - .4 Corridor doorways
- .5 This trade shall be responsible for all penetrations through the roof. Work to be performed by qualified roofing trades which maintain the roof warranty.

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- .1 This trade 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.
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- .3 Make record of any deficiencies in the operation and take measures to immediately correct deficiencies.
- .4 The Trade shall return to site for each of the next three seasons to confirm the equipment is operating as intended. Coordinate with the Owner and weather for proper verification of operation.

1.17. 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 The TAB trade shall provide all equipment and labour required to completely balance the entire system. Where reasonably inferred, the TAB trade shall made adjustment to systems and equipment serving the scope of the project but not necessarily supplied in the project.

- .3 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.
- .4 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
 - Ductwork Pressure Test report

1.18. Duct Pressure Testing

- .1 The TAB trade shall pressure test all supply and return ductwork.
- .2 Test pressure shall be 500 Pa. (2" w.c.) and in accordance with SMACNA standards.
- .3 Ductwork is to be pressure tested where required in accordance with ANSI/SMACNA standards.

1.19. Deficiencies

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

1.20. Record Drawings

- .1 This Trade shall keep a clean and neat record of all deviations made from the contract drawings.
- .2 Provide to the Owner a clean set of drawings marked "As Built".

1.21. Operating & Maintenance

- .1 Provide to the Owner, at the completion of the project, two hard copy complete sets and one electronic (USB thumb drive) of operation and maintenance manuals (O&M).
- .2 Manuals shall include:
 - .1 All shop drawings. Where shop drawings were marked "reviewed as modified", the Trade shall update the shop drawing for the O&M manual.
 - .2 All operating manuals for all equipment.
 - .3 As-built drawing
 - .4 Start-up Reports
 - .5 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.

- .4 This trade shall provide training to the Owner or Owner's representative for all equipment and systems installed. Where appropriate, the training shall be done by a representative of the manufacturer.

1.22. Guarantees and Warranties

- .1 This trade shall guarantee the Owner a labour and materials warranty for all equipment, material and systems provided as part of this contact for a period of one year from the date of substantial performance unless otherwise specified.

2. Products

2.1. Identification

- .1 Provide lamicaid 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 and ductwork. 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 Labels required for ductwork, including existing:
 - .1 Supply air
 - .2 Return air
 - .3 Outdoor air
 - .4 Exhaust air
- .3 Provide all equipment with nameplates.

3.2. Training

- .1 Training may be provided either at substantial completion after commissioning, or later near the end of the 1 year warranty period and the discretion of the Owner. Seasonal training shall be provided at the convenience of the Owner.

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 23 05 00 Common Work Results for HVAC
- .4 23 30 00 HVAC Air Distribution
- .5 23 80 00 Decentralized HVAC Equipment
- .6 Division 25

1.2. Scope of Work

- .1 Provide insulation for all and ductwork as described in Division 23 and as more thoroughly described in this section.

1.3. Submittals

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

2. Products

2.1. Acoustic Ductwork Insulation

- .1 Acoustic duct insulation shall be rigid fiber glass liner board with acrylic surface treatment. Duct liner shall not support bacterial growth.

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 (R-4/inch) at 24°C ambient temperature. Variations of this thermal resistant shall require a revision in the minimum thickness applied.
- .2 Ensure ductwork 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 Finished product shall be neat and clean.

3.2. Acoustic Ductwork Insulation

- .1 Acoustic Insulation
 - .1 Provide 25mm (1") of acoustic insulation where shown on the drawings.

- .2 Where acoustic insulation is shown, no exterior insulation is required unless specifically noted otherwise.
- .3 Ensure lining covers 100% of the surface area, edges are neatly butted together, and the entire lining is completely adhered to the duct. Provide additional mechanical fasteners at intervals not to exceed 400mm (15"). Ensure all exposed edges are sealed with adhesive.

3.3. Existing Work

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

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 23 05 00 Common Work Results for HVAC
- .4 23 07 00 Insulation for HVAC
- .5 23 80 00 Decentralized HVAC Equipment
- .6 Division 25

1.2. Scope of Work

- .1 Air distribution system, including ductwork, dampers, fans, duct accessories, diffusers, grilles, registers etc.

1.3. Submittals

- .1 Dampers/fire dampers
- .2 Grilles, registers, and diffusers

2. Products

2.1. General

- .1 Construct to SMANCA standards.
- .2 Increase the size of the ductwork by the thickness of the acoustical insulation where shown on the drawings. Sizes shown are clear inside dimensions after insulated.
- .3 Ductwork shall be galvanized unless otherwise noted. Ductwork in wetted areas or serving showers and downstream of humidifiers shall be aluminum.

2.2. Low Pressure Ductwork

- .1 Ductwork is to be constructed to a minimum of 750 Pa (3"W.C.).
- .2 Provide as a minimum construction standard, based on the largest duct dimension:
 - .1 300mm (24"): 24 ga galvanized, 22 ga aluminum, drive cleats on side, flat S cleat on top and bottom. Joints on 2400mm (7'-11") centres maximum.
 - .2 1540mm (60"): 22 ga galvanized, 20 ga aluminum, 38mm standing S cleat on sides, top and bottom. Joints on 1200mm (3'-11") centre maximum.

2.3. Stainless Steel Ductwork and Drain Pans

- .1 Stainless steel ductwork and drain pans shall be as follows: 20 ga., 304SS with fully welded seams.
- .2 Stainless steel ductwork shall be provided for ductwork between ERV duct flanges and humidifier drain piping. Stainless steel drain pan in ductwork shall slope to humidifier drain piping.
- .3 Sloped stainless steel ductwork/drain pan shall extend approx. 600mm past either side of drain piping.

2.4. Dampers

- .1 Balancing dampers in ductwork shall be a manufactured item. Shop fabricated dampers may be considered. Samples are required to be submitted and may only be used if approved. Dampers shall be a minimum 16 ga galvanized steel or 12 gauge aluminum. Dampers used for service

isolation must be a manufactured product and provide a maximum leakage of class rating of 1 at 1.0 kPa (4"W.C.).

- .2 Splitter dampers shall not be used.
- .3 Dampers shall be lockable in place.
- .4 Back-draft dampers
 - .1 Provide flange mount back-draft dampers. Dampers shall bear the AMCA seal. Blades shall have edge seals.
 - .2 Maximum pressure drop of 0.3"W.C. at 1000 fpm.
 - .3 Maximum leakage of 40 CFM/sq.ft. at 1"W.C.
 - .4 Dampers shall be counter balanced for any orientation.
 - .5 Dampers shall be Ventex model 1205 or equivalent for large dampers.
 - .6 Dampers shall be CFM model BDD. Spring loaded where applicable.
- .5 Fire dampers
 - .1 Fire dampers shall be dynamic type, ULC listed and labelled for 1½ hour fire rating, and rated for a minimum of 1.0 kPa (4"W.C.).
 - .2 Fire dampers shall be the same material as the connecting ductwork. Provide break away connections at the damper.
 - .3 Provide a fusible linkage rated at 70°C (165°F) unless otherwise noted or required by Code.
 - .4 Fire dampers shall be type B or CR or CO. Other types will only be considered for retrofit projects where it can be shown that other types cannot fit.
 - .5 Fire dampers shall be provided with factory installed sleeves.
 - .6 Where fire dampers are not otherwise accessible, access hatches are to be provided.

2.5. Turning Vanes

- .1 Vanes shall be Duro-Dyne "Duro Vane Rail" or equivalent.

2.6. Duct Access Doors

- .1 Door pressure rating shall match or exceed the duct pressure rating. Doors shall be gasketed.
- .2 Door materials shall match the duct in which it is being installed.
- .3 Where installed in ducts with interior insulation, doors shall be double panel and fully insulated.
- .4 Hinges shall be continuous piano hinges.
- .5 Latches shall be self-tightening and hand operated.
- .6 Doors shall be a minimum size of 200mm x 200mm (8"x8") or smaller where duct dimensions are smaller. Doors shall be of adequate size to maintain accessories inside the duct.

2.7. Flexible Connectors

- .1 Provide flexible duct connectors by Duro-Dyne or equivalent. Connector shall use Durolon fabric.

2.8. Grilles, Registers and Diffusers

- .1 Provide Airvector, Krueger, Titus, Nailor, Price, Hart & Cooley or Metalaire.
- .2 Refer to the schedules for required accessories and options.
- .3 Provide grilles, registers and diffusers with appropriate frames for the type of wall, ceiling, floor installed. Refer to the architectural plans.

2.9. Duct Sealing

- .1 Refer to 23 05 00 for requirements pertaining to pressure testing of supply and return ductwork.
- .2 Seal all supply and return ductwork as follows:
 - .1 SMACNA Seal Class = A
 - .2 SMACNA Leakage Class = 6 (rectangular ductwork); 3 (round ductwork).
- .3 This trade shall co-operate with the TAB trade and shall prepare all supply and return ductwork with sealed blank-off plates and connections for the TAB trade's testing equipment.
- .4 Any corrections required as a result of pressure testing by the TAB trade shall be performed by this Trade.

3. Execution

3.1. General

- .1 Provide all ancillary hardware and accessories needed for a complete installation.
- .2 Coordinate with all trades on-site for routing of ductwork.
- .3 Paint the interior of all ductwork visible through open ends and grilles, registers and diffusers.

3.2. Construction

- .1 Construct all ductwork and fittings to SMANCA standards.
- .2 All changes in direction shall be with throat radius full-width and full radius heel radius. Where full-width throat cannot fit, use $\frac{3}{4}$ -width throat radius. Where neither can fit, use square elbow with turning vanes equal to Rovane duct turning vanes.
- .3 Where transformation exceed 30° on reductions and 45° on increases to equipment, use turning vanes.
- .4 Section shall be assembled with Pittsburgh lock or grooved longitudinal seams, fully closed.
- .5 Provide test holes as required for the controls and TAB trades. Where hole are temporary, provide metal caps and tape shut.
- .6 Where ducts terminate at masonry structure, embed angle irons around the duct opening.

3.3. Supports

- .1 Adequately support all ducts. Ducts shall be installed level, straight and parallel to building walls. Supports shall not exceed 2.4m (8') for duct widths up to 450mm (18"); supports shall not exceed 1.2m (4') for larger ducts.
- .2 Duct hangers shall be constructed from galvanized band iron for duct widths of 600mm (24") or smaller. Ducts in width larger than 600mm and up to 900mm (36") shall use galvanized iron angles wrapped around the duct and screwed to the duct. Larger ducts shall use rod hangers connected to galvanized C channels.
- .3 Hang the ducts from structure only. Do not hang from furrings.
- .4 Manufacture special brackets as required where typical hangers are inadequate due to building construction.

3.4. Sheet Metal Installation

- .1 Ductwork is to be installed generally as shown on the drawings. Modification shall be made in the field to avoid interference and fit within the structure. All changes must be approved by the Engineer. Show all changes on the as-builts.
- .2 Where ducts terminate at masonry, provide angle iron around the perimeter of the opening. Caulk the angle iron to the masonry for an air-tight installation.

- .3 All changes in direction shall be done with full radius elbows. Where full radius elbows cannot physically fit, provide ½ radius elbows. If square elbows are required, turning vanes shall be required. Approval is required by the Engineer for all square elbows.

3.5. Dampers

- .1 Provide round butterfly dampers where shown for balancing in round duct.
- .2 Provide fire dampers to UL approved installation instructions. Dampers must be supported from the structure and not the ductwork. Do not compressor or warp the damper in any way.

3.6. Outlets

- .1 Locations of outlet are generally diagrammatic and should correspond to the reflected ceiling plan. Allow for moving outlet up to 1.2m (4') in any direction at no additional cost.

End of Section

1. General

1.1. Related Sections

- .1 Division 0
- .2 Division 1
- .3 23 05 00 Common Work Results for HVAC
- .4 23 07 00 Insulation for HVAC
- .5 23 30 00 HVAC Air Distribution
- .6 Division 25

1.2. Scope of Work

- .1 Provide all labour, material, equipment, etc. for a complete installation of decentralized heating and cooling equipment.

1.3. Submittals

- .1 Energy Recovery Ventilators
- .2 Electric Heating Coils

2. Products

2.1. Energy Recovery Ventilators

- .1 Energy Recovery Ventilators shall be by Systemair, Renewaire, Daikin, Greenheck, Aaon, Cook, Engineered Air, Nuair, or approved equal.
- .2 Cabinet
 - .1 Cabinet shall be constructed of G90 galvanized, 22-gauge steel sheet with lapped corners. All exposed surfaces shall be coated with baked powder paint. All seams shall be sealed, requiring no caulking at job site.
 - .2 The unit shall be fitted with a full length drain pan for controlled condensate drainage including two drains spouts with ½ inch (12.7 mm) barbed fitting for easy connection.
 - .3 Unit casing shall be insulated with 1 inch (25 mm) fiberglass with FSK facing. The flame spread index of the insulation material shall not be over 25 and its smoke developed index shall not be over 50 when tested in accordance with the Standard for Tests for Surface Burning Characteristics of Building Material, UL723. Insulation shall be secured to unit with waterproof adhesive and permanent mechanical fasteners.
- .3 Energy Recovery Core
 - .1 The energy recovery core shall be manufactured from a flame rated polymer membrane which is designed to transfer sensible and latent energy. The flame spread index of the energy recovery core shall not be over 25 and its smoke developed index shall not be over 50 when tested in accordance with the Standard for Tests for Surface Burning Characteristics of Building Material, UL723.
 - .2 The energy recovery core shall be freeze tolerant and water washable.
 - .3 Energy recovery core shall be AHRI listed for performance.
- .4 Frost Control
 - .1 Unit shall be equipped with recirculation defrost control.

- .2 Where recirculation defrost control is not available, unit shall shut down via BMS when frosting occurs.
- .5 Electrical
 - .1 Electrical box shall be isolated from the airflows and all integral wires and connections protected.
 - .2 All internal electrical components shall be factory wired for single point power connection.
 - .3 All electrical components shall be UL Listed or Recognized and CSA Certified or Accepted where applicable and wired in compliance with the National Electrical Code.
- .6 Options:
 - .1 Included with intake and exhaust dampers. Provide externally if not supplied with unit.

2.2. Electric Heating Coils

- .1 Duct mounted heater shall be manufactured by: Stelpro, Ouellet, Trane, Rittling, or Neptronic
- .2 20-gauge galvanized steel cabinet.
- .3 Manual and automatic thermal protection.
- .4 Built-in temperature limit sensor.
- .5 Nichrome electric element.
- .6 SCR modulation control.
- .7 Operate based on duct temperature set-point. Refer to Division 25.

3. Execution

3.1. Energy Recovery Ventilators

- .1 Serviceability
 - .1 Unit shall have hinged and/or screwed access panels on front and back.
 - .2 Cores, filters and motors shall be serviceable from either side of the unit.
 - .3 Fan assemblies shall be mounted on a removable sliding base. Energy recovery cores and filters shall be mounted in slide-out rails for ease of inspection, removal, and cleaning.
 - .4 Accessibility to the electrical box shall be maintained for any unit installation.
- .2 Installation
 - .1 Install as per manufacturer's instructions.
 - .2 Unit shall be roof-mounted.
 - .3 Flanged connection shall be provided for suitable ductwork connection.
 - .4 Unit shall be adaptable for easy service of electrical components.
- .3 Warranty
 - .1 Unit shall have a warranty that is limited to 3 years on all parts from the date of purchase, including parts replaced during this time period.

3.2. Electric Heating Coils

- .1 Install in accordance with manufacturer's instructions.
- .2 Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- .3 Protect coils to prevent damage to fins and flanges. Comb out bent fins.

End of Section

1. General

1.1. General Notes

- .1 The requirements of Division 0 and 1 of these specifications apply to all section of these specifications.
- .2 The term "Trade" refers to all trades that provide work within this section. The term "Contractor" refers to the General or Prime Contractor, however, it is this trade's responsibility to ensure the Contractor knows and understand all the requirements in these specifications.

1.2. Scope of Work

- .1 It is the intent of these specifications to describe a complete working building automation 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.
- .2 These specifications shall be read in conjunction with all other specifications for this project and all drawings sketches. There is a requirement for this Trade to coordinate services with all other trades.

1.3. Cooperation

- .1 The drawings are diagrammatic in nature and cannot show all the details of the installation. This Trade 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 Consultant immediately if any interferences or discrepancies arise due to design parameters. Coordinate with all other trades with respect to any changes required in the contract documents for equipment or material installation.
- .3 Store materials out of the way of other trades and keep all work areas clean daily.

1.4. Shop Drawings

- .1 Refer to Division 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 this Trade before being submitted for review. Shop drawings shall bear the mark of both the Contractor and this Trade.
- .5 All applicable approvals shall be shown, such as CSA, ULC, FM, etc.
- .6 All reviewed shop drawings shall be distributed by the Contractor to all effected trades for coordination. Clearly highlight any discrepancies between specified equipment and equipment provided. Any cost incurred by Trades by deviation from provided equipment specifications shall be at no cost to the Owner.
- .7 Equipment and materials shall not be ordered until the Consultant as returned a shop drawing marked "reviewed" or "reviewed as modified". The Trade shall assume all responsibility to ensure all modifications are made to shop drawings marked "reviewed as modified" before ordering equipment or materials.

1.5. Alternatives

- .1 Equipment and materials specified in these specifications are for the purposes of design and coordination. This does not limit the Contractor or Trade from providing alternative products. Where products are listed as alternative in the specification, this Trade is still responsible for ensuring the product or materials meets all specifications. Listing of a manufacturer as an approved equal or alternative does not indicate that the manufacturer has an equivalent product. It does indicate that the manufacturer's level of quality is of a similar level to the specified.
- .2 The Owner shall approved, and have the full right to refuse, any equipment or material proposed by the Contractor or Trade as an alternative or equal to the specified if not specifically noted in the contract documents.

1.6. Insurance

- .1 This Trade shall obtain and maintain insurance which will fully protect themselves and the Owner for any and all claims.

1.7. Codes, Fees and Certificates

- .1 This Trade shall procure and pay all fees for all work required by these specifications, unless specifically noted otherwise.
- .2 All work done by this Trade 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 Owner.

1.8. Extras and Credits

- .1 This Trade shall make any claims for extras in writing to the Owner. 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 This Trade 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 Consultant and Owner.
- .3 All quotations for extras shall be accompanied with a detailed breakdown in material and labour. If hourly rates have not already been determined by the Contract, hourly rates shall be determined by the latest addition of MCAA pricing manual.

1.9. Supports

- .1 Provide steel or concrete supports as required for all equipment and materials. This trade 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.
- .4 Fire-rated separations shall be confirmed with Owner. At a minimum, firestopping shall be provided through the following penetrations:

.1 All floors

.2 Electrical, mechanical, custodian rooms

.3 Stairwells

.4 Corridor doorways

- .5 This trade shall be responsible for all penetrations through the roof. Work to be performed by qualified roofing trades which maintain the roof warranty.

1.11. Existing Ceilings

- .1 Extensive work is required above the existing ceilings. As such, the General Contractor is responsible for the removal and replacement of all ceilings throughout the building as required. Refer to drawings for further information.

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 Owner. Certificate of substantial performance is not acceptance of the system by the Owner.

1.13. Start-up

- .1 The Trade 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 this Trade before handing over to the Owner.
- .4 Notify the Consultant and Owner before start-up tests are scheduled and allow the Consultant and/or Owner to witness the start-up.
- .5 Where appropriate, the manufacturer's representative shall be present to conduct the start-up.

1.14. Electrical Wiring

- .1 This Trade shall thoroughly review the electrical drawings to determine allowance for electrical wiring for this Trade. This Trade is responsible for all low-voltage wiring and all other higher voltage wiring not explicitly noted on the electrical drawings but required for a properly functioning system.
- .2 All wiring shall comply with Division 26 specifications.

1.15. Testing and Commissioning

- .1 Notify the Consultant and Owner before commissioning tests are scheduled and allow the Consultant and/or Owner to witness the testing.
- .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.
- .4 The Trade shall return to site for each of the next three seasons to confirm the equipment is operating as intended. Coordinate with the Owner and weather for proper verification of operation.

1.16. Testing, Adjusting and Balancing

- .1 This trade shall cooperate with the TAB trade to aid in all testing and balancing activities as required by Division 23.
- .2 Provide pre-commissioning forms to the TAB trade prior to balancing.
- .3 This trade shall aid in determining the lowest static pressure set-point required for variable flow air and hydronic systems.

1.17. Deficiencies

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

1.18. Record Drawings

- .1 This Trade shall keep a clean and neat record of all deviations made from the contract drawings.
- .2 Provide to the Owner a clean set of drawings marked "As Built".

1.19. Operating & Maintenance

- .1 Provide to the Owner, at the completion of the project, two hard copy complete sets and one electronic (USB thumb drive) of operation and maintenance manuals (O&M).
- .2 Manuals shall include:
 - .1 All shop drawings. Where shop drawings were marked "reviewed as modified", the Trade shall update the shop drawing for the O&M manual.
 - .2 All operating manuals for all equipment.
 - .3 As-built drawing
 - .4 Start-up Reports
 - .5 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.
- .4 This trade shall provide training to the Owner or Owner's representative for all equipment and systems installed. Where appropriate, the training shall be done by a representative of the manufacturer.

1.20. Guarantees and Warranties

- .1 This trade shall guarantee the Owner a labour and materials warranty for all equipment, material and systems provided as part of this contact for a period of one year from the date of substantial performance unless otherwise specified.

2. Products

2.1. Access Doors

- .1 Access doors shall be by Acudor or equivalent. Doors shall be prime-coated where there is a paint finish and aluminum for tiled or similar unpainted areas. Doors shall be a minimum 8"x8" (200mm x 200m) size or larger as required for the application.
- .2 Access doors in fire rated assemblies shall be ULC listed as a fire rated access door.

2.2. Identification

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

3. Execution

3.1. Access Doors

- .1 Provide access doors for all location where serviceable equipment are concealed in an inaccessible location.

3.2. Identification

- .1 Provide all equipment with nameplates.

3.3. Testing, Adjusting and Balancing

- .1 The TAB trade shall make arrangements with the Controls Trade to simulate system operations in order to balance the system under various conditions.

End of Section

1. General

1.1. Scope of Work

- .1 This section generally describes the control points required for a complete system operation as more generally described in the other sections of Division 25.
- .2 It is not the intention of this section to limit control points to only these listed.
- .3 Where points are listed here, they shall be display on the graphically user interface.

1.2. Abbreviations

- AI: Analog Input
- AO: Analog Input
- DI: Binary digital input
- DO: Binary digital output
- VFD: Variable speed drive
- VP: Virtual point – software only

1.3. Ventilation System (ERV-1, ERV-2)

Description	Type	Device	Units	Remarks
ERV enable	DO	Relay	On/off	
ERV status	DI	Current sensor	Amps	
ERV exhaust air humidity	AI	RH sensor	%RH	
ERV supply air temperature	AI	Thermistor	°C	
Heating coil enable	DO	Dry contact	On/off	One per heating coil (qty 4)
ERV supply air humidity	AI	RH sensor	%RH	
Humidifier alarm	DI	Dry contact	Ok/alarm	
Outdoor Air Temperature	AI	Outdoor Thermistor	°C	

1.4. Existing Heating System

Description	Type	Device	Units	Remarks
Boiler status	AI	Dry contact	On/off	

End of Section

1. General

1.1. Scope of Work

- .1 The Building Automation System shall be as indicated as described in these specifications. System must be fully integrated and coordinated with mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory as specified in those sections. The intent of the BAS is to integrate all mechanical equipment into one system for global monitoring, control, and alarming associated with the building. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BAS operators have the capability of managing the building mechanical system to ensure occupant comfort while maintaining energy efficiency.
- .2 The BAS shall meet BACnet communication standards. BAS controllers shall be listed by BACnet Testing Laboratories (BTL) with appropriate classification. System controller shall be BTL listed BACnet Building Controller (B-BC) Equipment Controllers shall be BTL listed BACnet Application Specific Controller (B-ASC) or BACnet Advanced Application Controller (B-AAC), as appropriate for the purpose of the controller.
- .3 Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems and terminal devices on this project.
- .4 Communication between DDC controllers and all workstation(s) shall be over the existing network or a new network between new controllers shall be installed. The operator shall not have to know the controller identifier or location to view or control a point (object). Application Specific Controllers shall be constantly scanned by the Building Controllers to update point information and alarm information globally.
- .5 The BAS manufacturer shall provide all hardware and software necessary to implement the functions and sequence of operations specified.
- .6 The BAS manufacturers shall provide all devices required for the system to function properly. The Owner shall provide a workstation, meeting the BAS minimum requirements, in order to access the GUI.

1.2. Submittals

- .1 Automation Network equipment
 - .1 Building controllers
 - .2 Application controllers
 - .3 System architecture
 - .4 Points list

1.3. Project Record Documents

- .1 Upon completion of installation, submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:
 - .1 Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .dwg and .pdf drawing files shall be provided.
 - .2 Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.
 - .3 Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:

- .1 Names, address and 24-hour/7-day per week telephone numbers of Contractor personnel managing and installing equipment, along with service personnel responsible for supporting the ongoing warranty and services of the control system.
 - .2 Procedures for operating the BAS including logging on/off, alarm management, generation of reports, trends, overrides of computer control, modification of setpoints, and other interactive system requirements.
 - .3 Description of the programming language including syntax, statement descriptions, algorithms, calculations, point database creation and modification, program creation and modification, and operator use of the editor.
 - .4 Explanation of how to design and install new points, new DDC controllers, and other BAS hardware.
 - .5 Preventative Maintenance and calibration procedures; hardware troubleshooting; and hardware repair and/or replacement procedures.
 - .6 Documentation of all software program logic created for Custom Programmable Controllers including the overall point database. Provide one set of magnetic media containing files of the software and point database.
 - .7 One set of electronic media containing files of all operator color graphic screens for the project.
 - .8 A list of recommended spare parts including pricing, manufacturer, supplier, and part numbers.
 - .9 Documentation, installation, and maintenance information for all third party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
 - .10 Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
 - .11 Licenses, Guarantee, and Warranty documents for all equipment and systems.
 - .12 Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) and task descriptions.
- .4 Training Manuals: The BAS manufacturer shall provide a course outline and copies of training manuals at least two weeks prior to the start of any corporate training class to be attended by the Owner.

1.4. Warranty

- .1 Warrant all work as follows:
 - .1 BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BAS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).
 - .2 At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BAS is operational, and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
 - .3 Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates.

- .4 The BAS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips, upgrades, and training schedules for a one year period of time correlating with the warranty period.
- .2 System Maintenance
 - .1 Perform Building Automation System preventative maintenance and support for a period of 1 year (beginning the date of substantial completion).
 - .1 Make a minimum of 2 complete Building Automation System inspections, in addition to normal warranty requirements. Inspections to include:
 - .1 System Review – Review the BAS to correct programming errors, failed points, points in alarm, and points that have been overridden manually.
 - .2 Seasonal Control Loop Tuning – Control loops are reviewed to reflect changing seasonal conditions and / or facility heating and cooling loads.
 - .3 Sequence of operation verification – Systems all verified to be operating as designed and in automatic operation. Scheduling and setpoints are reviewed and modified.
 - .4 Database back-up
 - .5 Operator coaching
 - .2 Technician shall review critical alarm log and advise owner of additional services that may be required.
 - .3 Technician shall provide a written report to owner after each inspection.
 - .2 Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of owner.

1.5. System Performance

- .1 Performance Standards. The BAS system shall conform to the following:
 - .1 Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 10 seconds of the operator's request.
 - .2 Graphic Refresh. The system shall update all dynamic points with current data within 10 seconds.
 - .3 Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 5 seconds. Analog objects shall start to adjust within 5 seconds.
 - .4 Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current within the prior 10 seconds.
 - .5 Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 10 seconds.
 - .6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
 - .7 Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 - .8 Multiple Alarm Annunciations. All workstations on the network shall receive alarms within 5 seconds of each other.

1.6. Ownership of Material

- .1 Project specific software and documentation shall become the owner's property upon project completion. This includes the following:
 - .1 Operator Graphic files
 - .2 As-built hardware design drawings
 - .3 Operating & Maintenance Manuals
 - .4 BAS System software database
 - .5 Controller application programming databases
 - .6 Application Specific Controller configuration files

2. Product

2.1. Web Server

- .1 The successful controls contractor shall ensure either integration into an existing web server at the Public School Board head office or provide a new web server at the Public School Board head office.
- .2 The system shall be a Web-based system with all graphics and programming software included.
- .3 The system shall include unlimited users with unlimited points.
- .4 The cost of the software shall be included bid price and there shall be no recurring fees for on-going usage.

2.2. Communication

- .1 This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be as defined below.

2.3. Operator Interface

- .1 The Owner shall be providing a computer for dedicated access to the BMS. The contractor shall review the specifications of the proposed computer and comment on any required changes required. Note that this does not limit access of the BMS to this dedicated computer as noted below.
- .2 Building operator web interface
- .3 The building operator web interface shall be accessible via a web browser without requiring any "plug-ins" (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
- .4 System Security
 - .1 Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
 - .2 User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
 - .3 Each operator shall be allowed to change their user password.
 - .4 The System Administrator shall be able to manage the security for all other users.
 - .5 The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.
 - .6 User logon/logoff attempts shall be recorded.

- .7 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
- .8 All system security data shall be stored in an encrypted format.
- .5 On-Line Help and Training
 - .1 Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
 - .2 On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.
- .6 System Diagnostics
 - .1 The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
 - .2 The failure of any device shall be annunciated to the operators.
- .7 Equipment & Application Pages
 - .1 The building operator web interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application.
 - .2 Engineering Units
 - .1 Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
 - .2 Unit selection shall be able to be customized by locality to select the desired units for each measurement.
 - .3 Scheduling. A user shall be able to perform the following tasks utilizing the building operator web interface:
 - .1 Create a new schedule, defining the default values, events and membership.
 - .2 Create exceptions to a schedule for any given day.
 - .3 Apply an exception that spans a single day or multiple days.
 - .4 View a schedule by day, week and month.
 - .5 Exception schedules and holidays shall be shown clearly on the calendar.
 - .6 Modify the schedule events, members and exceptions.
 - .7 Alarm/Event Notification
 - .8 An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
 - .9 Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any building operator web interface.
 - .1 The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - .2 Alarm/event messages shall use full language, easily recognized descriptors.
 - .3 An operator with the proper security level may acknowledge and clear alarms/events.
 - .4 All alarms/events that have not been cleared by the operator shall be stored by the building controller.
 - .5 The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.

2.4. Controller Software

- .1 Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the building operator interface.
- .2 Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:
 - .1 Weekly Schedule. Provide separate schedules for each day of the week.
 - .2 Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
 - .3 Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
 - .4 Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.
- .3 Alarm/Event Log
 - .1 Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.
 - .2 Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
 - .3 An alarm/event shall be capable of triggering any of the following actions:
 - .4 Route the alarm/event to one or more alarm log
 - .1 The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.
 - .1 Route an e-mail message to an operator(s)
 - .2 Log a data point(s) for a period of time
 - .3 Run a custom control program
 - .4 Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.
 - .5 Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, building operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the building operator interface.
 - .6 Anti-Short Cycling. All binary output points shall be protected from short cycling

2.5. Building Controller

- .1 There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies described in Application and Control Software section.
- .2 The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
- .3 The controller shall provide a communications port for connection to a PC.
- .4 The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
- .5 All System Controllers shall have a real time clock.
- .6 Data shall be shared between networked System Controllers.
- .7 The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - .1 Assume a predetermined failure mode.
 - .2 Generate an alarm notification.
 - .3 Create a retrievable file of the state of all applicable memory locations at the time of the failure.
 - .4 Automatically reset the System Controller to return to a normal operating mode.
- .8 Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40° C to 50° C [-40° F to 122° F].
- .9 Clock Synchronization.
 - .1 All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
 - .2 All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
 - .3 All System Controllers shall automatically adjust for daylight savings time if applicable.
- .10 Serviceability
 - .1 Provide diagnostic LEDs for power, communications, and processor.
 - .2 The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
 - .3 All wiring connections shall be made to field removable, modular terminal connectors.
 - .4 The System controller shall utilize standard DIN mounting methods for installation and replacement.
 - .1 Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller.
 - .2 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage.
 - .3 BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs with a minimum BACnet Protocol Revision of 14.

2.6. Application Controller

- .1 Application Controllers shall be microprocessor-based DDC controllers which, through hardware or firmware design, control specified equipment.

- .1 Software
 - .1 To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.
 - .2 Stand-Alone Operation: Each piece of equipment specified in section "A" shall be controlled by a single controller and provide stand-alone control in the event of communication failure. In case of communications failure stand-alone operation shall use default values or last values for remote sensors read over the network such as outdoor air temperature.
 - .3 For controlling ancillary devices and for flexibility to change the sequence of operation in the future, the controller shall be capable running custom programs written in a graphical programming language.
- .2 Environment: Controller hardware shall be suitable for the anticipated ambient conditions.
 - .1 Storage: -55° to 203° F (-48° to 95° C) and 5 to 95% Rh, non-condensing.
 - .2 Operating: -40° to 158° F (-40 to 70° C) and 5 to 95% Rh, non-condensing.
 - .3 Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum.
 - .4 Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40° to 158° F [-40° to 70° C].
- .3 Input/Output:
 - .1 For flexibility in selection and replacement of valves, the controllers shall be capable of supporting all of the following valve control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC floating point, 24VAC - 2 position (Normally Open or Normally Closed).
 - .2 For flexibility in selection and replacement of sensors, the controllers shall be capable of reading sensor input ranges of 0 to 10V, 0 to 20mA, pulse counts, and 200 to 20Kohm.
 - .3 For flexibility in selection and replacement of binary devices, the controller shall support dry and wetted (24VAC) binary inputs.
 - .4 For flexibility in selection and replacement devices, the controller's shall have binary output which are able to drive at least 12VA each.
 - .5 or flexibility in selection and replacement of motors, the controller shall be capable of outputting 24VAC (binary output), DC voltage (0 to 10VDC minimum range) and PWM (in the 80 to 100 Hz range).
 - .6 For future needs, any I/O that is unused by functionality of equipment control shall be available to be used by custom program on the controller and by another controller on the network.
- .4 Software Retention: All Zone Controller operating parameters, setpoints, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.
- .5 Transformer for the controller must be rated at minimum of 115% of ASC power consumption, and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads, for a maximum of 12 VA for each binary output.
- .6 Agency Approval: The controller shall have meet the Agency Compliance:
 - .1 UL916 PAZX, Open Energy Management Equipment
 - .2 UL94-5V, Flammability

FCC Part 15, Subpart B, Class B Limit

2.7. Power Supplies

- .1 Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish overcurrent protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- .1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in overvoltage and overcurrent protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - .1 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 - .2 Line voltage units shall be UL recognized and CSA approved.

2.8. Control Devices

- .1 Wired Temperature Sensors
 - .1 Temperature sensors shall be RTD or thermistor.
 - .2 Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross section.
 - .3 Provide matched temperature sensors for differential temperature measurement.
- .2 Transformers and Power Supplies
 - .1 Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.
 - .2 Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
 - .3 Unit shall operate between 0 C and 50 C.
 - .4 Unit shall be UL recognized.
- .3 Local Control Panels
 - .1 All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
 - .2 Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
 - .3 Provide on/off power switch with over-current protection for control power sources to each local panel.
- .4 Humidity sensor
 - .1 Outdoor humidity sensors shall be provided in outdoor weather enclosure. Wiring to the outside shall be sealed water-tight
 - .2 Accuracy of +/-1%RH within temperatures of 5°C - 30°C
 - .3 Linear output

2.9. Wiring and Raceways

- .1 Provide copper wiring, cable, and raceways.
- .2 Where wiring cannot be installed in existing walls, conduit shall be provided.
- .3 All insulated wire to be copper conductors, UL labeled for 90°C (194°F) minimum service.

3. Execution

3.1. Examination

- .1 The Contract Documents shall be thoroughly examined for coordination of control devices, their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- .2 The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.2. General Workmanship

- .1 Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- .2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- .3 Install all equipment in readily accessible locations as defined by National Electric Code (NEC). Control panels shall be attached to structural walls or properly supported in a free-standing configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- .4 Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.
- .5 All control device installation and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract Documents.

3.3. Wiring

- .1 Provide all new line-voltage wiring as required for the execution of the controls as noted in these specifications.
- .2 All wiring shall comply with the National, Local Electrical Codes.
- .3 All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC requirements.
- .4 Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.
- .5 Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer's recommendation and meet National and Local Codes.
- .6 Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.
- .7 Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.4. Communication Wiring

- .1 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- .2 Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- .3 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer shall not be exceeded during installation.
- .4 Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- .5 All runs of communication wiring shall be unspliced length when the length is commercially available.
- .6 All communication wiring shall be labeled to indicate origin and destination.

3.5. Installation of Sensors

- .1 Mount sensors rigidly and adequately for the environment the sensor will operate.
- .2 Wiring for space sensors shall be concealed in building drywall. EMT conduit is acceptable within mechanical equipment and service rooms.

3.6. Identification of Hardware and Wiring

- .1 All field wiring and cabling, including that within factory mounted, and wired control panels and devices for mechanical equipment, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information for troubleshooting, maintenance, and service purposes. BAS manufacturer to coordinate this labeling requirement with mechanical equipment manufacturer as it relates to controls.
- .2 Permanently label or code each point of field terminal strips to show the instrument or item served and correlate them to the BAS design drawings.
- .3 Identify control panels with minimum 1-cm letters on laminated plastic nameplates.
- .4 Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.7. Control System Checkout and Testing

- .1 Start-up testing. All testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - .1 The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all of the instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer's recommendations.
 - .4 Verify all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starter, etc.) operate properly and normal positions are correct.
 - .5 Verify all analog output devices (I/Ps, actuators, etc) are functional, that start and stop span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.

- .6 Verify the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimal start/stop routines.
- .7 Alarms and Interlocks
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction,
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.8. Cleaning

- .1 Provide The BAS manufacturer's installing contractor(s) shall clean up all debris resulting from their installation activities on a daily basis. The installation contractors shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Owner, Construction Manager, General Contractor, and/or Mechanical Contractor.
- .2 At the completion of work in any area, the installation contractor shall clean all of their work, equipment, etc., making it free from dust, dirt and debris.
- .3 At the completion of work, all equipment furnished under this Section shall be checked for paint damage. Any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

End of Section

1. General

1.1. Scope of Work

- .1 The following sequences of operation describe the general principles of operation expected for the control trade to implement. It is the responsibility of the controls trade to interpret the intent of the sequences and provide all automation equipment and labour required to implement the intention.

1.2. Boilers

- .1 Existing boiler sequencing is to be maintained. BMS monitors operation of boilers only.

1.3. Ventilation System (ERV-1, ERV-2)

.1 Overview

- .1 This system is a 100% outdoor air energy recovery system providing ventilation and exhaust to all areas of the building excluding the gymnasium.

.2 Start-up

- .1 ERV is enabled on occupancy schedule via BMS.

.3 Normal operation

- .1 ERV operates continuously.
- .2 The humidifier operates on its own internal controls to maintain humidity based on the exhaust duct relative humidity sensor.
 - .1 The BMS shall monitor the humidifier and supply and exhaust air humidity.
- .3 The electric heating coils modulate via built-in SCR control to maintain user-adjustable duct temperature set-point of 18°C discharge air temperature.
 - .1 BMS to disable heating coils above OAT of 13°C.

.4 Shut-down

- .1 ERV is disabled on occupancy schedule via BMS.

.5 Alarms

- .1 ERV alarm.
- .2 Humidifier alarm.
- .3 Electric heating coil alarm.

.6 Trends

- .1 ERV command alarm.
- .2 ERV status alarm.

End of Section