METROLINX

Capital Projects Group

Basic Mechanical Materials and Methods Specification

Specification 20 05 10

Revision 0
Date: August 2018

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Amendment Record Sheet

Amendment in Clause No.	Date of Amendment	Description of Changes

LIST OF CONTENT

TABLES

1. GENERAL

1.1. SCOPE OF WORK

1.1.1. Provide basic mechanical materials and perform work with methods, as required, scheduled and specified herein.

1.1.2. This Section specifies products, criteria and characteristics, and methods and execution that are common to one or more Sections of Mechanical Divisions. It is intended as a supplement to each Section and is to be read accordingly.

1.2. DESIGN REQUIREMENTS

1.2.1. All equipment, vent, access door, door grille, diffuser, return air grille, and exposed duct locations shall be coordinated with Architect/Prime Consultant.

1.2.2. Isolators and vibration control devices shall be designed and specified as required to ensure that equipment-noise and vibration do not interfere with GO Transit operations, as well as to protect adjacent properties from noise and vibration, where necessary.

1.2.3. Single phase motors smaller than ½ HP are to typically be continuous duty capacitor start type with NEMA 48 or 56 frame size, and 1.15 service factor.

1.2.4. Explosion-proof single-phase motors are to typically be totally enclosed, fan cooled, continuous duty capacitor start type and 1.0 service factor.

1.2.5. Motors ½ HP and larger are to typically be totally enclosed, fan cooled, 3-phase, T-frame, squirrel cage continuous duty induction motors and 1.15 service factor.

1.2.6. Explosion-proof 3-phase motors are typically to be totally enclosed fan cooled motors suitable for use in required hazardous location classifications and with a 1.0 service factor.

1.2.7. Motors for 2-speed cooling towers to typically be 2-speed single winding type.

1.2.8. Motors for 2-speed fans to typically be 2-speed double winding type.

1.2.9. Motors 30 HP and larger are to typically be complete with heat sensing PTC thermistors.

1.2.10. Motors for equipment with variable frequency drives are to typically be inverter duty type for operation from a variable frequency drive.

1.2.11. Coordinate equipment enclosure ratings and sprinkler proof provisions with Electrical Division specifications to ensure proper rating are provided to suit environment of installed products.

1.2.12. Additional design requirements are based on Part 2 specified requirements of products.

1.3. RELATED WORKS

1.3.1. Section 20 05 05 - Mechanical Work General Instructions.

1.3.2. All other Division 20 Sections.

1.4. REFERENCE STANDARDS

1.4.1. Standards and codes to be latest editions adopted by and enforced by local governing authorities.

1.4.2. ASTM D2855 Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.

1.4.3. ASTM A-193 Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

1.4.4. ASTM A-194 Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

1.4.5. CAN/CSA-A23.1 Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete.

1.4.6. CSA B51 Boiler, Pressure Vessel and Pressure Piping Code.

1.4.7. CAN/CGSB-24.3, Identification of Piping Systems.

1.4.8. CAN/CSA B149.1 Natural Gas and Propane Installation Code.

1.4.9. CAN/CSA B149.2 Propane Storage and Handling Code.

1.4.10. CSA C22.2 No. 145 Electric Motors and Generators for Use in Hazardous (Classified) Locations (Tri-national standard, with NMX-J-652-ANCE and UL 674).

1.4.11. CAN/CSA C390 Test Methods, Marking Requirements, And Energy Efficiency Levels for Three-Phase Induction Motors.

1.4.12. CAN/CSA C747 Energy Efficiency Test Methods for Small Motors.

1.4.13. CSA W48 Filler Metals and Allied Materials for Metal Arc Welding.

1.4.14. CAN/CSA W117.2, Safety in Welding, Cutting and Allied Processes.

1.4.15. CAN/CSA Z166.2 Powder Actuated Tools - Use and Handling.

1.4.16. IEEE 112B IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.

1.4.17. Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58.

1.4.18. NEMA Standard MG1 Motors and Generators.

1.4.19. NFPA No. 13 Standard for the Installation of Sprinkler Systems.

1.4.20. NFPA No. 14 Standard for the Installation of Standpipe and Hose Systems.

1.4.21. NFPA No. 2001 Standard on Clean Agent Fire Extinguishing Systems.

1.4.22. Occupational Safety and Health Administration (OSHA) Standards.

1.5. SPARE PARTS

1.5.1. Provide spare part list including component parts availability, names and addresses of spare part suppliers, and list of specialized tools necessary for maintenance.

1.5.2. Supply spare parts in accordance with Specification Sections. In addition, provide following:

a) 1 set of packing for each pump;

b) 1 set of belts for each piece of belt operated equipment (tagged and identified);

c) 1 filter cartridge or set of filter media for each filter, including all HVAC equipment;

d) 1 strainer basket for each strainer;

e) Spare parts as identified in Sections.

1.5.3. Submit product manufacturer's recommended spare parts lists for all mechanical equipment for purposes of ordering selected spare parts.

1.6. TRAINING

1.6.1. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

1.6.2. For pressure piping include for 3 training sessions of maximum 7 hours duration per session for 6 Metrolinx people per session.

1.6.3. For each of motor control centres, motor starters and electric motors, include for 6 training sessions of maximum 7 hours duration per session for 6 Metrolinx people per session.

1.6.4. Refer to Section 20 05 05 for additional general requirements.

1.7. WARRANTY

1.7.1. Products to be guaranteed by manufacturer, for a minimum of 2 years after acceptance by Metrolinx.

1.7.2. Refer to requirements within Section to any extended warranties.

1.8. DELIVERY, STORAGE AND HANDLING

1.8.1. Handle and store products in accordance with manufacturer's instructions, in locations approved by Metrolinx. Include one copy of these instructions with product at time of shipment.

1.9. SUBMITTALS

1.9.1. Refer to submittal requirements in Section 20 05 05.

1.9.2. Submit samples as noted within Specifications including sample of each proposed access door.

1.9.3. Product Data

a) Submit manufacturer's Product data indicating:

1) technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;

2) performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol;

3) product transportation, storage, handling, and installation requirements;

4) product identification in accordance with Metrolinx requirements.

1.9.4. Shop Drawings

a) Submit shop drawings/product data sheets for following:

1) pressure gauges and thermometers;

2) electric motors (submit with equipment with which they are associated).

b) Submit weight loads for selected equipment (upon request).

c) Submit copy of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations.

d) Submit samples of materials and any other items as specified in Sections of Mechanical Divisions.

e) Submit a list of equipment identification nameplates indicating proposed wording and sizes.

f) Submit a list of pipe and duct identification colour coding and wording.

g) Submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording.

h) Submit drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.

i) Submit list identifying backflow prevention valves and cross selection survey.

j) As specified in Part 2 of this Section, submit a spare belt set, tagged and identified, for each belt driven piece of equipment.

k) Submit any other submittals specified in this Section or other Sections of Mechanical Divisions.

1.9.5. Commissioning Package

a) Submit the following in accordance with Sections 20 05 05 and 20 05 40:

1) Commissioning Plan;

2) Commissioning Procedures;

3) Certificate of Readiness;

4) complete test sheets specified in Section 20 05 40 and attach to the Certificate of Readiness;

5) Source Quality Control inspection and test results and attach to the Certificate of Readiness.

1.9.6. Commissioning Closeout Package:

a) Submit the following in accordance with Section 20 05 05:

1) Deficiency Report;

2) Commissioning Closeout Report;

3) Submit the following for each Product for incorporation into the Operation and Maintenance Manuals in accordance with Section 20 05 05:

i) identification: Manufacturer's name, type, year, serial number, number of units, capacity, and identification to related systems;

ii) functional description detailing operation and control of components;

iii) performance criteria and maintenance data;

iv) safety precautions;

v) operating instructions and precautions;

vi) component parts availability, including names and addresses of spare part suppliers;

vii) maintenance and troubleshooting guidelines/protocol;

viii) product storage, preparation, handling, and installation requirements;

ix) Commissioning Report.

1.10. QUALITY ASSURANCE

1.10.1. Manufacturers Qualifications

a) Manufacturer shall be ISO 9000, 9001 or 9002 certified. Manufacturer of product shall have produced similar product for a minimum period of five years. When requested by Consultant, an acceptable list of installations with similar product shall be provided demonstrating compliance with this requirement.

b) Where manufacturers provide after installation onsite inspection of product installations, include for manufacturer's authorized representative to perform onsite inspection and certificate of approvals.

1.10.2. Installers Qualifications

a) Installers for work to be performed by or work under licensed Mechanical Contractor.

b) Installers of equipment, systems and associated work are to be fully qualified and experienced installers of respective products and work in which they are installing.

c) Where manufacturers provide training sessions to installers and certificates upon successful completion, installers to have obtained such certificates and submit copies with shop drawings.

1.10.3. Regulatory Requirements

a) Products and work to comply with applicable local governing authority regulations, bylaws and directives.

b) Include for required inspections and certificate of approvals of installation work from local governing authorities.

2. PRODUCTS

2.1. PIPE SLEEVES

2.1.1. Galvanized Sheet Steel - Minimum #16 gauge galvanized steel with an integral flange at one end to secure sleeve to formwork construction.

2.1.2. Polyethylene - Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.

2.1.3. Waterproof Galvanized Steel Pipe - Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at sleeve midpoint.

2.1.4. Galvanized Steel or Cast Iron Pipe - Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2. FIRESTOPPING AND SMOKE SEAL MATERIALS

2.2.1. Firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are typically coordinated with and specified in other Specification Sections.

2.2.2. When firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are included as part of Mechanical Division responsibility, refer to Section entitled Firestopping and Smoke Seal Systems.

2.3. WATERPROOFING SEAL MATERIALS

2.3.1. Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.

2.3.2. Standard of quality assurance manufacturers are:

a) Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;

b) The Metraflex Co. "MetraSeal" type ES;

c) or approved equivalent.

2.4. PIPE ESCUTCHEON PLATES

2.4.1. One-piece chrome plated brass or #4 finish type 302 stainless steel plates with matching screws for attachment to building surface, each plate sized to completely cover pipe sleeve or building surface opening, and to fit tightly around pipe or pipe insulation.

2.5. PIPING HANGERS AND SUPPORTS

2.5.1. Pipe hanger and support materials, including accessories, are to be, unless otherwise specified, in accordance with Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58, Pipe hangers and Supports-Materials, Design and Manufacture, and where possible, MSS designations are indicated with each product specified below. Conform to following requirements:

a) unless otherwise specified, ferrous hanger and support products are to be electro-galvanized;

b) hangers and supports for insulated piping are to be sized to fit around insulation and insulation jacket.

2.5.2. Hangers and supports for horizontal suspended piping as follows:

a) adjustable steel clevis hanger - MSS Type 1;

b) adjustable swivel ring band hanger - MSS Type 10.

2.5.3. Supports for horizontal pipe on vertical surfaces as follows:

a) steel offset pipe clamp - Anvil Fig. 103 or Myatt Fig. 170;

b) heavy-duty steel pipe clip - MSS Type 26;

c) single steel pipe hook - Myatt Fig. 156;

d) epoxy coated steel pipe stays are not permitted.

2.5.4. Floor supports for vertical risers as follows:

a) copper tubing riser clamp - MSS Type 8;

b) heavy-duty steel riser clamp - MSS Type 8.

2.5.5. Supports for vertical piping on vertical surfaces as follows:

a) steel offset pipe clamp - Anvil Fig. 103 or Myatt Fig. 170;

b) heavy-duty steel pipe bracket or soil pipe bracket - MSS Type 26;

c) extension split pipe clamp - MSS Type 12;

d) epoxy coated steel pipe stays are not permitted.

2.5.6. Base support for vertical risers in excess of 6 m (20') high extending out from base mounted equipment is to consist of a base elbow support with flange.

2.5.7. For horizontal pipe on racks, Unistrut or equal galvanized steel pipe racks with pipe securing hardware as follows:

a) standard galvanized steel U-bolts/clamps supplied by rack manufacturer;

b) Special hangers and supports for various applications as follows:

1) vibration isolated riser supports - black steel riser clamps as specified above, complete with neoprene-steel-neoprene sandwich type vibration isolation pads between clamp and floor;

2) for groups of pipes having same slope - MSS Type 32 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place;

3) for sections of piping connected to vibration isolated equipment - hangers and supports as specified above but complete with MSS Type 48 spring cushions;

4) for piping on existing roof - Portable Pipe Hangers (Canada) Inc. "PP" Series or approved equivalent, prefabricated portable pipe support system components to suit pipe, complete with required accessories including bases, galvanized structural steel frames, and galvanized steel pipe hangers and supports conforming to MSS SP-58;

5) for piping on new roofs - Lexcor "Flash-Tite" or Thaler Roofing Specialties Products Inc. "MERS" Series or approved equivalent, insulated aluminum support risers with diameter, height, securement method and flashing to suit the application, channel type aluminum cross members, and galvanized steel pipe hangers and supports conforming to MSS SP 58, complete with all required accessories;

6) for glass drain and vent piping - special padded hangers supplied by pipe supplier;

7) for plastic piping - generally as specified above but in accordance with pipe manufacturer's recommendations;

8) for fire protection piping - generally as above but ULC listed and/or FM approved, and in accordance with Chapter requirements of NFPA Standard applicable to piping system;

9) for bare horizontal copper piping - generally as above but factory vinyl coated to prevent direct copper/steel contact;

10) for bare copper vertical piping - corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate pipe from clamp;

11) insulation protection shields to and including 40 mm (1-½") dia. - MSS Type 40 galvanized steel shields with ribs to keep shield centered on hanger.

2.5.8. Hanger rods are to be electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit loading in accordance with Table 3 in MSS SP-58, but in any case, minimum 9.5 mm (3/8") diameter.

2.5.9. Standard of quality assurance manufacturers are:

a) E. Myatt & Co. Inc.;

b) Anvil International Inc.;

c) Empire Industries Inc.;

d) Hunt Manufacturing Ltd.;

e) Unistrut Canada Ltd.;

f) Nibco Inc. "Tolco";

g) Taylor Pipe Supports

h) or approved equivalent.

2.6. ACCESS DOORS

2.6.1. Coordinate consistency of look and finish of access doors on project with each Division of Work. Coordinate exact requirements with General Trades Contractor.

2.6.2. Access doors to be rust resistant steel door panels, with concealed hinges and positive locking and self-opening screwdriver operated lock. Wall type frame to be suitable for wall installation and have integral keys for plaster walls. Doors in tile wall to be stainless steel and in ceilings to be suitable for plaster covering with only frame joint showing. Other doors to be prime painted steel.

2.6.3. Size access doors to suit the concealed work for which they are supplied, and wherever possible they are to be of standard size for all applications, but in any case, they are to be minimum 300 mm x 300 mm (12" x 12") for hand entry and 600 mm x 600 mm (24" x 24") for body entry.

2.6.4. Lay-in type tiles, properly marked, may serve as access panels. Coordinate marking of ceiling tiles with Consultant. Panels in glazed tile walls to be 12 gauge, 304 alloy stainless steel, No. 4 finish, with recessed frame secured with stainless steel counter-sunk flush head screws.

2.6.5. Panels in plaster surfaces to have dish-shaped door and welded metal lath, ready to take plaster. Provide a plastic grommet for door key access.

2.6.6. Other access doors to be welded 12 gauge steel, flush type with concealed hinges, lock and anchor straps, complete with factory prime coat. Submit to Consultant for review, details of non-standard door construction details.

2.6.7. Access doors in fire rated ceilings, walls, partitions, structures, etc., to be ULC listed and labelled and of a rating to maintain fire separation integrity.

2.6.8. Where access doors are located in surfaces where special finishes are required, they are to be of a recessed door type capable of accepting finish in which they are to be installed so as to maintain final building surface appearance throughout.

2.6.9. Standard of quality assurance manufacturers include Le Hage, SMS, Pedlar, Acudor or approved equivalent.

2.7. PRESSURE GAUGES AND THERMOMETERS

2.7.1. Pressure gauges as follows:

a) adjustable, glycerine filled, 100 mm or 115 mm (4" or 4-½") diameter and each accurate to within 1% of scale range;

b) type 304 stainless steel case with relief valve and polished stainless steel bayonet;

c) stainless steel rotary movement with stainless steel bushings and socket;

d) clear acrylic window;

e) dual scale white dial with a scale range such that working pressure of system is at approximate mid-point of scale;

f) black pointer.

2.7.2. Pressure gauge accessories and additional requirements as follows:

a) bronze ball type shut-off valve is to be provided in the piping to each pressure gauge;

b) each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber;

c) each pressure gauge for steam piping or steam equipment is to be equipped with a steel coil syphon;

d) pressure gauges in fire protection piping must be ULC listed and labelled.

2.7.3. Thermometers as follows:

a) round, 125 mm (5") diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale;

b) hermetically sealed stainless steel case with stainless steel ring;

c) dampened bimetal coil;

d) calibration adjustment screw;

e) white aluminum dual scale dial with black and blue markings and a range such that working temperature of system is approximate mid-point of the scale;

f) black aluminum pointer;

g) double strength glass window;

h) 12 mm (½") NPT connection with 6.4 mm (¼") diameter stainless steel stem;

i) suitable thermowell.

2.7.4. Standard of quality assurance manufacturers are:

a) H.O. Trerice Co.;

b) Weiss Instruments;

c) Ashcroft;

d) or approved equivalent.

2.8. EQUIPMENT BELT DRIVES

2.8.1. ANSI/RMA Standard V-belt type rated at minimum 1.5 times motor nameplate rating, and in accordance with following requirements:

a) belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;

b) sheaves are to be cast iron or steel, secured to shafts with removable keys unless otherwise specified, standard adjustable pitch (± 10% range) for motors under 10 HP, fixed pitch type with split tapered bushing and keyway for motors 10 HP and larger, and, if required, replaced as part of mechanical work to suit system air/water quantity testing and balancing work;

c) motor slide rail adjustment plates are to allow for centre line adjustment.

2.9. EQUIPMENT DRIVE GUARDS AND ACCESSORIES

2.9.1. For V-belt drives - removable, 4-sided, fully enclosed, galvanized sheet steel guards to OHSA standards, cleaned, factory primed and painted with yellow equipment enamel, complete with a two piece full length hinged front panel to permit belt maintenance or replacement without removing guard, and 40 mm (1-½") diameter tachometer openings at each shaft location.

2.9.2. For flexible couplings - removable "U" shaped galvanized steel guards to OHSA Standards with a 2.3 mm (3/32") thick frame and expanded mesh face.

2.9.3. For unprotected fan inlets and outlets - unless otherwise specified, removable 20 mm (¾") galvanized steel wire mesh with galvanized steel frames, all to OHSA Standards.

2.10. ELECTRIC MOTORS

2.10.1. Unless otherwise specified, motors are to conform to NEMA Standard MG1, applicable IEEE Standards, and applicable CSA C22.2 Standards, and are to meet NEMA standards for maximum sound level ratings under full load. Confirm motor voltages prior to ordering.

2.10.2. Vertically mounted and submersible motors are to be purposely designed for mounting in this attitude.

2.10.3. Efficiency of 1-phase motors to 1 HP is to be in accordance with CAN/CSA C747. Efficiency of 3-phase motors 1 HP and larger is to be in accordance with CAN/CSA C390 or IEEE 112B.

2.10.4. Unless otherwise specified, 1-phase motors smaller than ½ HP are to be 115 volt, continuous duty capacitor start type with an NEMA 48 or 56 frame size, solid base, heavy-gauge steel shell with solid die-cast end shields, dynamically balanced die-cast rotor, integral automatic reset thermal overload protection, Class "B" insulation, and a 1.15 service factor at 40°C (105°F) ambient temperature.

2.10.5. Explosion-proof 1-phase motors are to be totally enclosed, fan cooled, 115 volt continuous duty capacitor start type in accordance with CSA C22.2 No. 145, as specified for standard 1-phase motors but suitable for use in Class 1 Group D hazardous locations and complete with a rolled steel shell and a 1.0 service factor at 40°C (105°F) ambient temperature.

2.10.6. Unless otherwise specified, motors ½ HP and larger are to be totally enclosed, fan cooled, 3-phase, T-frame, squirrel cage continuous duty induction motors suitable for voltages indicated on Drawings, NEMA Design "B" for normal starting torque or Design "C" for high starting torque as required by the application, each complete with Class "B" insulation, a 1.15 service factor at 40°C ambient temperature, grease lubricated open ball bearings with grease fittings to permit re-lubrication without dismantling motor, a cast iron frame with cast iron feet where required, cast iron end bracket and precision machined bearing fit, and balanced carbon steel shaft assembly with die-cast aluminum rotor windings.

2.10.7. Explosion-proof 3-phase motors are to be totally enclosed fan cooled motors in accordance with CSA C22.2 No. 145, generally as specified above for standard 3-phase motors but suitable for use in Class 1 Group D hazardous locations and with a 1.0 service factor at 40°C (105°F) ambient temperature.

2.10.8. Motor(s) for two-speed cooling tower(s) are to be as specified above but two-speed single winding type.

2.10.9. Motor(s) for two-speed fan(s) are to be as above but two-speed double winding type.

2.10.10. Unless otherwise indicated, motors 30 HP and larger are to be complete with a heat sensing PTC thermistor in the end turn of stator winding for each phase and connected in series inside motor with two marked leads brought out to motor conduit box.

2.10.11. Motors for equipment with variable frequency drives are to be generally as specified above but inverter duty type to NEMA Standard MG-1 Part 31, quantified by CSA for operation from a variable frequency drive of type specified, and complete with Class "H" insulation. Motors are to be equipped with AEGIS, or approved equal, shaft grounding ring system to protect bearings from damage by diverting harmful shaft voltages and bearing currents to ground.

2.10.12. Motors for equipment which is scheduled or specified with a corrosion resistant coating or constructed from corrosion resistant materials are to be factory coated with a primer and epoxy paint finish.

2.10.13. Standard of quality assurance manufacturers are:

a) TECO-Westinghouse Motors (Canada) Inc.;

b) Canadian General Electric;

c) Baldor Electric Co.;

d) U.S. Electrical Motors;

e) WEG Electric Corp.;

f) Marathon Electric;

g) Toshiba Corp.;

h) Leeson Canada;

i) or approved equivalent.

2.11. MOTOR STARTERS AND ACCESSORIES

2.11.1. Motor starters must be capable of starting associated motors under the imposed loads. Confirm starter voltage matches motor prior to ordering.

2.11.2. Unless otherwise specified, starters for 1-phase motors are to be 115 volt, thermal overload protected manual starting switches with a neon pilot light, a surface or recessed enclosure to suit the application, and, where automatic operation is required, a separate H-O-A switch in an enclosure to match starter enclosure.

2.11.3. Unless otherwise specified, starters for 3-phase motors less than 50 HP are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with and overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

2.11.4. Unless otherwise specified, starters for 3-phase motors 50 HP to 150 HP are to be reduced voltage, non-reversing, auto-transformer type starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

2.11.5. Unless otherwise specified, starters for 3-phase motors 150 HP and larger are to be reduced voltage, non-reversing, closed transition "wye-delta" starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.

2.11.6. Starters for 2-speed double winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.

2.11.7. Starters for 2-speed single winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.

2.11.8. Starters for reversible motors for cooling towers are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to allow fan(s) to coast down to a stop before being operated in reverse rotation.

2.11.9. Unless otherwise specified, motor starter enclosures are to be in accordance with following NEMA ratings:

a) enclosures located in sprinklered areas - Type 2;

b) enclosures exposed to the elements - Type 3R, constructed of stainless steel;

c) enclosures inside the building in wet areas - Type 3R, constructed of stainless steel;

d) enclosures in explosion rated area - Type 7 with exact requirements to suit the area and application;

e) enclosures except as noted above - Type 1;

f) enclosures located in finished areas - as above but recess type with brushed stainless steel faceplate.

2.11.10. Motor control centres are to be multi-unit, 2.28 m (9') high, NEMA Class 1, type "B", factory assembled, dead front, floor mounted, free-standing motor control centre with tin plated copper bus and an NEMA Type 1 or Type 2 enclosure as for loose starters specified above. Each motor control centre is to be complete with starters as specified above, load and control wiring terminal boards, and required facilities for line and load side power wiring connections.

2.11.11. Disconnect switches for motor control centres are to be heavy-duty, CSA certified, front operated switches as per motor starter schedule, each complete with a handle suitable for padlocking in "off" position and arranged so that door cannot be opened with handle in "on" position and an NEMA enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.

2.11.12. Fuses are to be, unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.

2.11.13. Standard of quality assurance manufacturers are:

a) Rockwell Automation Inc. - Allen-Bradley;

b) Eaton Corp.;

c) Siemens Canada;

d) Schneider Electric;

e) or approved equivalent.

2.12. SPRINKLER PROTECTION

2.12.1. Provide drip shields for protection of surface mounted equipment enclosures from water spray and dripping of liquids. Features of shields include:

a) factory constructed by respective equipment manufacturers;

b) constructed from non-combustible materials (sheet steel);

c) enamel painted to match equipment;

d) surfaces and edges filled/sanded smooth prior to painting;

e) supported from equipment with structural steel rods/metal framing or other method reviewed with Consultant;

f) structural support finish painted to match shield.

2.12.2. Include with equipment shop drawings, detailed dimensions of drip shields and methods of supporting.

2.12.3. Equipment with top cable/conduit entries to include additional sealing of entries with gasketting and/or waterproof sealant to prevent water from entering enclosure.

2.12.4. Design ventilation louvers such that live components are not exposed to water spray and dripping liquids.

2.12.5. Above requirements are additional minimum sprinkler provisions or "sprinkler proof" standards for equipment specified as NEMA 1, 2 or 12.

2.12.6. Obtain CSA approval where required by local governing authorities.

2.13. MECHANICAL WORK IDENTIFICATION MATERIALS

2.13.1. Equipment, piping, and systems shall be clearly identified according to industry standards. Equipment shall include manufacturer's nameplate, CSA, and/or CUL registration plates where applicable. Piping and ducting systems shall be identified using a standard identification system, ASHRAE, CGSB or similar. All labels, tags, nameplates, etc., shall be stainless steel, brass, or thick laminated plastic, as appropriate to suit application.

2.13.2. Equipment nameplates are to be minimum 1.6 mm (1/16") thick 2-ply laminated coloured plastic plates, minimum 12 mm x 50 mm (½" x 2") for smaller items such as damper motors and control valves, minimum 25 mm x 65 mm (1" x 2-½") for equipment, and minimum 50 mm x 100 mm (2" x 4") for control panels and similar items. Additional requirements are as follows:

a) unless otherwise specified or required, each nameplate is to be white, complete with bevelled edges and black engraved wording to completely identify equipment and its use with no abbreviations;

b) wording is generally to be as per drawings, i.e. Fan EF-1, and is to include equipment service and building area/zone served, but must be reviewed prior to engraving;

c) supply stainless steel screws for securing nameplates in place;

d) nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.

2.13.3. Valve tags are to be coloured, 40 mm (1-½") square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match piping identification colour, each complete with a 3.2 mm (1/8") diameter by 100 mm (4") long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:

VALVE V12
200 mm (8")
CHILL. WATER
NORMALLY OPEN

2.13.4. Standard pipe identification is to be equal to Smillie McAdams Summerlin Ltd., Brady or Primark Manufacturing Inc. vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:

a) for pipe less than or equal to 150 mm (6") diameter, coiled type snap-on markers of a length to wrap completely around pipe or pipe insulation;

b) for pipe larger than 150 mm (6") diameter, saddle type strap-on markers with two opposite identification locations and complete with nylon cable ties.

2.13.5. Identification wording and colours for pipe identification materials are to be as follows:

Table 2-1: Pipe Identification Materials

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	green	DOM. COLD WATER
domestic hot water supply	green	DOM. HW SUPPLY
domestic hot water recirculation	green	DOM. HW RECIRC.
tempered domestic water	green	TEMP. DOM. WATER
chilled drinking water	green	CH. DRINK WTR.
storm drainage	green	STORM
sanitary drainage	green	SAN.

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
plumbing vent	green	SAN. VENT
acid sanitary drainage	yellow	ACID DRAIN
acid drainage vent	yellow	ACID VENT
fire protection standpipe	red	F.P. STANDPIPE
fire protection sprinklers	red	F.P. SPRINKLER
natural gas	to Code	To Code, c/w pressure
natural gas vent	to Code	To code
propane gas	to Code	To Code, c/w pressure
propane gas vent	to Code	To code
fuel oil supply	yellow	FUEL OIL SUPPLY
fuel oil return	yellow	FUEL OIL RETURN
fuel oil vent	yellow	FUEL OIL VENT
heating water supply	yellow	HTG. WTR. SUPPLY
heating water return	yellow	HTG. WTR. RETURN
heating water drain	yellow	HTG. WTR. DRAIN
glycol heating supply	yellow	GLY. HTG. SUPPLY
glycol heating return	yellow	GLY. HTG. RETURN
glycol heating drain	yellow	GLY. HTG. DRAIN
glycol heat reclaim return	yellow	GLY. HTG. RECLAIM R.
glycol heat reclaim supply	yellow	GLY. HTG. RECLAIM S.
heat pump geothermal loop – source side supply	green	GEO. LOOP SOURCE SUPPLY
heat pump geothermal loop – source side return	green	GEO. LOOP SOURCE RETURN
heat pump geothermal loop – load side supply	green	GEO. LOOP LOAD SUPPLY
Heat pump geothermal loop – load side return	green	GEO. LOOP LOAD RETURN
condenser water supply	green	COND. WTR. SUPPLY
condenser water return	green	COND. WTR. RETURN
chilled water supply	green	CH. WTR. SUPPLY
chilled water return	green	CH. WTR. RETURN

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
chilled water drain	green	CH. WTR. DRAIN
low pressure steam	yellow	….kPa STEAM
medium pressure steam	yellow	….kPa STEAM
high pressure steam	yellow	….kPa STEAM
low pressure condensate	yellow	L.P. CONDENSATE
medium pressure condensate	yellow	M.P. CONDENSATE
high pressure condensate	yellow	H.P. CONDENSATE
pumped condensate	yellow	PUMPED CONDENSATE
steam vent	yellow	STEAM VENT
boiler feedwater	yellow	BLR. FEEDWATER
boiler blowdown	yellow	BLR. BLOW-OFF
refrigerant suction	yellow	REFRIG. SUCTION
refrigerant liquid	yellow	REFRIG. LIQUID
refrigerant hot gas	yellow	REFRIG. HOT GAS
diesel engine exhaust	yellow	ENGINE EXHAUST
gasoline	yellow	GASOLINE
distilled water	green	DISTILL. WATER
demineralized water	green	DEMIN. WATER
compressed air (< 700 kPa)	green	….kPa COMP. AIR
compressed air (>700 kPa)	yellow	….kPa COMP. AIR
control air	green	CONTROL AIR

2.13.6. Colours for pipe identification legends and directional arrows are to be as follows:

Table 2-2: Pipe Identification Legends and Directional Arrows

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
yellow	black
green	white
red	white

2.13.7. Duct identification is to be custom made Mylar stencils with 50 mm (2") high lettering to accurately describe duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with lettering background.

2.14. FLEXIBLE CONNECTORS

2.14.1. Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application.

2.14.2. Standard of quality assurance manufacturers are:

a) Hyspan Precision Products Inc.;

b) Senior Flexonics Ltd.;

c) The Metraflex Co;

d) or approved equivalent.

3. EXECUTION

3.1. GENERAL PIPING AND DUCTWORK INSTALLATION REQUIREMENTS

3.1.1. Unless otherwise specified, locate and arrange horizontal pipes and ducts above or at ceiling on floors, arranged so that under consideration of all other work in area, maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, with Consultant's approval.

3.1.2. Unless otherwise specified, install work concealed in finished spaces, and concealed to degree possible in partially finished and unfinished spaces. Refer to and examine Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Walls which are painted are considered finished.

3.1.3. Install pipes and ducts parallel to building lines and to each other.

3.1.4. Neatly group and arrange exposed work.

3.1.5. Locate work to permit easy access for service or maintenance as required and/or applicable. Locate valves, dampers and any other equipment which will or may need maintenance or repairs and which are to be installed in accessible construction so as to be easily accessible from access doors. Where valves, dampers and similar piping or ductwork accessories occur in vertical services in shafts, pipe spaces or partitions, locate accessories at floor level.

3.1.6. Make connections between pipes of different materials using adapters suitable for application. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.

3.1.7. Comply with equipment and material manufacturer's installation instructions unless otherwise specified herein or on drawings, and unless such instructions contradict governing codes and regulations.

3.1.8. Carefully clean ducts, pipe and fittings prior to installation. Temporarily cap or plug ends of pipe, ducts and equipment which are open and exposed during construction.

3.1.9. Install piping and ductwork which are to be insulated so that they have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around pipe or duct, except for ductwork at fire barriers, in which case insulation will be terminated at each side of the duct fire damper.

3.1.10. Inspect surfaces and structure prepared by other trades before performing work. Verify surfaces or structure to receive work has no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of work will constitute acceptance of such surfaces as being satisfactory.

3.1.11. Any ferrous piping that exhibits in excess of 5% surface rust, either inside or outside or both, is to be wire brush cleaned to bare metal and coated with suitable primer. Steel pipe, fittings and accessories are to be free of corrosion and dirt when work is complete or prior to being concealed from view. Where dirt is evident, clean piping prior to being concealed.

3.1.12. Provide continuous galvanized sheet metal drip pan under drain, water and water solution piping extending through rooms with electrical equipment such as electrical, elevator equipment and transformer rooms, and other spaces provided primarily for the installation of electrical equipment. Drip pans are to be complete with a drain pipe connection and drain piping is to be extended to closest drain.

3.1.13. For factory applied finishes, repaint or refinish surfaces damaged during shipment and installation. Quality of repair work is to match original finish. This requirement also applies to galvanized finishes.

3.1.14. Where mechanical work is located in high humidity areas where ferrous metal products will be subject to corrosion and protection for such products is not specified, provide finishes on products to protect against corrosion or provide products which will not corrode in the environment, i.e. aluminium ductwork, copper or stainless steel pipe, etc.

3.1.15. Provide screwed unions or flanges in piping connections to equipment and in regular intervals in long (in excess of 12 m [40']) piping runs to permit removal of sections of piping.

3.1.16. Unless otherwise specified and except where space limitations do not permit, piping elbows are to be long radius. Eccentric reducers are to be installed with straight side at top of piping.

3.2. HIGH PRESSURE PIPING SYSTEM REQUIREMENTS

3.2.1. Provide high pressure piping for areas such as but not limited following:

a) for high pressure wash areas for trains;

b) for high pressure wash areas for and buses.

3.2.2. Following requirements apply to piping designated above as high pressure piping, regardless of what may be specified to contrary elsewhere in Specification:

a) Class 250 screwed fittings for steel pipe;

b) grooved end fittings and couplings for grooved end steel pipe are to be pressure rated for the application;

c) 95% tin, 5% antimony solder for copper piping joints;

d) 300 lb. Class companion flange unions;

e) ASTM A-193 Grade B7 bolts and ASTM A-194 CL-2H nuts for flanged joints;

f) other piping system accessories are to be suitable in all respects for system operating pressure;

g) meet requirements of governing authorities.

3.3. PIPE JOINT REQUIREMENTS

3.3.1. Do not make pipe joints in walls or slabs.

3.3.2. Ream piping ends prior to making joints.

3.3.3. Properly cut threads in screwed steel piping and coat male threads only with Teflon tape or paste, or an equivalent thread lubricant. After pipe has been screwed into fitting, valve, union, or piping accessory, not more than two pipe threads are to remain exposed.

3.3.4. Site bevel steel pipe to be welded or supply mill bevelled pipe. Remove scale and oxide from bevels and leave smooth and clean. Use factory made welding tees or welding outlet fittings for piping branches off mains. Do not use shop or site fabricated fittings unless written approval has been obtained.

3.3.5. Welded joints are to be made by CWB certified licensed journeyman welders qualified in accordance with CSA B51, Boiler Pressure Vessel and Pressure Piping Code, and who are in possession of a proper certificate of qualification for each procedure to be performed. Each weld is to be identified with the welder's identification symbol, and welds are not to be concealed until they have been inspected and approved. Electrodes are to be in accordance with CSA W48 Series, Electrodes, and requirements of CAN/CSA W117.2, Safety in Welding, Cutting and Allied Processes are to be followed.

3.3.6. Include (and pay for) magnetic particle testing of 10% of the welds in piping systems indicated below. Testing is to be done by a specialist qualified in accordance with CSA W178.1 and CSA W178.2 and approved by Consultant. Testing is to be done to ANSI/ASME Boiler and Pressure Vessels Code, Section V, CSA B51, and requirements of governing authorities. Systems to be tested include but are not limited to following:

a) natural gas piping;

b) hydronic heating piping;

c) process fluid piping.

3.3.7. Unless otherwise specified, make flanged joints with Garlock 5500 or approved equivalent gasket materials to suit the application, and bolts and nuts. Bolts are not to be longer than length necessary to screw nut up flush to the end of bolt. Bolts used for flanged connections in piping with a working pressure of 690 kPa (100 psi) and greater are to be ASTM A-193 Grade B-7, with heavy hexagon nuts to ASTM A-194 CL-2H. Provide suitable washers between each bolt head and flange and between each nut and flange.

3.3.8. A random check of bolted flanged connections will be made to verify flanged connections are properly mated with no shear force acting on bolts. Supply labour to disconnect and reconnect selected flanged joints. If improperly mated joints are found, remove and reinstall affected piping so flanges mate properly. If improperly mated joints are found, additional joints will be checked, and you will be responsible for the repair of any other improper joints discovered.

3.3.9. Unless otherwise specified make soldered joints in copper piping using flux suitable for and compatible with type of solder being used. Clean the outside of pipe end and inside of fitting, valve, or similar accessory prior to soldering.

3.3.10. Install mechanical joint fittings and couplings in accordance with manufacturer's instructions.

3.3.11. Grooves are to be rolled. Make arrangements with coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding the grooved piping system.

3.3.12. If pressure crimped couplings and fittings are used, ensure gaskets are fully compatible with piping fluid, and valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of the piping system.

3.3.13. Solvent weld PVC piping in two parts, primer stage and cementing stage, in accordance with manufacturer's recommendations, ASTM D2855, and CSA requirements.

3.3.14. Install PVC piping with gasketed joints in accordance with manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.4. INSTALLATION OF PIPE SLEEVES

3.4.1. Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:

a) in poured concrete slabs - unless otherwise specified, minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;

b) in concrete or masonry walls - Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.

3.4.2. Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a waterstop plate in accordance with drawing detail. Provide waterproof sleeves in following locations:

a) in mechanical room floor slabs, except where on grade;

b) in slabs over mechanical, fan, electrical and telephone equipment rooms or closets;

c) in floors equipped with waterproof membranes;

d) in roof slab;

e) in waterproof walls.

3.4.3. Size sleeves, unless otherwise specified, to leave 12 mm (½") clearance around pipes, or where pipe is insulated, a 12 mm (½") clearance around pipe insulation.

3.4.4. Pack and seal void between pipe sleeves and pipe or pipe insulation in non-fire rated construction for the length of sleeves as follows:

a) pack sleeves in interior construction with mineral wool and seal both ends of sleeves with non-hardening silicone base caulking compound;

b) pack sleeves in exterior walls above grade with mineral wool and seal both ends of sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;

c) seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified.

3.4.5. Where sleeves are required in masonry work, accurately locate and mark sleeve location, and hand sleeves to mason for installation.

3.4.6. Terminate piping for sleeves that will be exposed so sleeve is flush at both ends with building surface concerned so sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above finished floor.

3.4.7. "Gang" type sleeving will not be permitted.

3.4.8. Where sleeves are provided in non-fire rated construction for future piping, or where piping has been removed from existing sleeves, cap and seal both ends of sleeved opening.

3.5. INSTALLATION OF WATERPROOF MECHANICAL SEALS

3.5.1. Provide watertight link type mechanical seals in exterior wall openings.

3.5.2. Assemble and install each mechanical seal in accordance with manufacturer's instructions.

3.5.3. After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until seal is completely watertight.

3.6. DUCT OPENINGS

3.6.1. Duct openings, air inlet and outlet openings, fire damper and similar openings will be provided in new poured concrete work, masonry, drywall and other building surfaces by trade responsible for particular construction in which opening is required.

3.6.2. Size openings for fire dampers to 600 mm (24") high to suit damper arrangement with folding blade out of air stream.

3.6.3. For duct openings except where fire dampers are required, pack and seal space between duct or duct insulation and duct opening as specified above for pipe openings in non-fire rated construction.

3.7. SLEEVE AND FORMED OPENING LOCATION DRAWINGS

3.7.1. Prepare and submit for review, drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.

3.7.2. Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.

3.7.3. Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

3.8. INSTALLATION OF PIPE ESCUTCHEON PLATES

3.8.1. Provide escutcheon plates suitably secured over exposed piping passing through finished building surfaces. A finished building surface is any surface with a factory finish or that receives a site applied finish.

3.8.2. Install plates so they are tight against building surface concerned, completely covering pipe sleeves and/or openings, except where waterproof sleeves extend above floors, in which case fit plate tightly around sleeve.

3.9. INSTALLATION OF FASTENING AND SECURING HARDWARE

3.9.1. Provide fastening and securing hardware required for mechanical work to maintain installations attached to structure or to finished floors, walls and ceilings in a secure and rigid manner capable of withstanding dead loads, live loads, superimposed dead loads, and any vibration of installed products.

3.9.2. Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.

3.9.3. Where floor, wall or ceiling construction is not suitable to support loads, provide additional framing or special fasteners to ensure proper securement to structure that is to support the products. Provide reinforcing or connecting supports where required to distribute loading to structural components.

3.9.4. Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CAN/CSA Z166.2.

3.9.5. Do not attach fasteners to steel deck without written consent from Metrolinx and review with Consultant.

3.10. INSTALLATION OF PIPE HANGERS AND SUPPORTS

3.10.1. Provide required pipe hangers and supports.

3.10.2. Provide any additional structural steel channels, angles, inserts, beam champs and similar accessories required for hanging or supporting pipe. Unless otherwise shown or specified, hang or support pipes from structure only.

3.10.3. For insulated pipe, size hanger or support to suit diameter of insulated pipe and install hanger or support on outside of insulation and insulation finish.

3.10.4. Support requirements for underground piping are as follows:

a) support underground pipe located in accordance with drawing detail;

b) support underground pipe, unless otherwise specified, on a well compacted bed of dry, natural, undisturbed earth free from rocks or protrusions of any kind, or on compacted material as specified;

c) support underground service piping penetrating building exterior walls or foundations to prevent pipe damage if minor building settlement occurs, all as per drawing detail;

d) ensure bedding and supports for underground pipes are flat and true and allowances are made for pipe hubs, couplings, or other protrusions so no voids are left between pipe and bedding.

3.10.5. Unless otherwise shown or specified, hang and/or support horizontal pipe above ground by means of hangers and/or supports specified in Part 2 of this Section. Unless otherwise shown or specified, hangers for suspended pipe less than or equal to 25 mm (1") dia. are to be clevis type or adjustable ring type, and hangers for suspended pipe greater than or equal to 40 mm (1-½") dia. are to be adjustable clevis type.

3.10.6. Space hangers and supports in accordance with following:

a) cast iron pipe - hang or support at every joint with maximum 2.4 m (8') spacing;

b) plastic pipe - conform to pipe manufacturer's recommended support spacing;

c) glass pipe - conform to pipe manufacturer's recommended support spacing and support requirements;

d) copper and steel pipe - hang or support at spacing in accordance with following schedule:

Table 3-1: Copper and Steel Pipe - Hang or Support at Spacing

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 25 mm (1")	2.4 m (8')	1.8 m (6')
40 mm (1-½")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2-½")	3.6 m (12')	3.0 m (10')

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
75 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3-½")	3.6 m (12′)	3.6 m (12')
100 mm (4")	4.2 m (14')	3.6 m (12')
250 mm (10")	6.0 m (20')	
300 mm (12")	6.7 m (22')	

e) flexible grooved pipe/coupling joint piping - as above but with not less than one hanger or support between joints.

3.10.7. Where pipes change direction, either horizontally or vertically, provide a hanger or support on horizontal pipe not more than 300 mm (12") from elbow, and where pipes drop from tee branches, support tees in both directions not more than 50 mm (2") on each side of tee.

3.10.8. When pipes with same slope are grouped and a common hanger or support is used, space hanger or support to suit spacing requirement of smallest pipe in group and secure pipes in place on common hanger or support.

3.10.9. Provide roller hangers or supports for heat transfer piping greater than or equal to 150 mm (6") diameter and conveying a material 75°C (170°F) or greater to facilitate pipe movement due to expansion and contraction, and at each hanger or support tack weld a steel protection saddle to pipe to protect piping insulation.

3.10.10. Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with following:

a) support vertical pipes at maximum 3 m (10') intervals or at every floor, whichever is lesser;

b) for sections of vertical piping with a length less than 3 m (10'), support pipe at least once;

c) for vertical cast iron plain end pipe (mechanical joint type), secure riser or pipe clamp around pipe under a flange integral with pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support;

d) for vertical steel pipe risers in excess of 3 m (10'), weld shear lugs to pipe to carry load;

e) for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between riser clamps and floor.

3.10.11. Support piping on roof in accordance with requirements of drawing detail, where applicable.

3.10.12. Where detail is not shown on drawings, support piping on the roof as follows:

a) on existing roof - provide support members as specified in Part 2 of this Section spaced as per schedule above and of a type to suit the application, and, for each support, carefully scrape away roofing gravel, bed support in a heavy covering of roofing mastic, then scrape gravel back up around support and secure pipes to supports;

b) on new roof - supply manufactured roof supports as per Part 2 of this Section to accommodate piping involved and support spacing specified above, and hand supports to roofing trade on roof for installation as part of roofing work, then secure piping in place on supports.

3.10.13. Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between pipe and ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from pipe by means of strips of flexible rubber inserts. Use of painted ferrous hangers and supports, including those painted with copper coloured paint, is not acceptable. Site application of tape or other types of isolation is not acceptable.

3.10.14. For insulated horizontal piping less than or equal to 40 mm (1-½") diameter, provide galvanized steel insulation protection shields between insulation and hanger or support. Install shields immediately after pipe is insulated.

3.10.15. Do not support piping from steel deck without written consent from Metrolinx and review with Consultant.

3.11. SUPPLY OF ACCESS DOORS

3.11.1. Supply access doors to give access to mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on drawings.

3.11.2. Before commencing installation of mechanical work, coordinate with other trades and prepare on a set of reflected ceiling plans and wall elevations, complete layouts of access doors. Submit these layouts for Consultant's review and show exact sizes and locations of such access doors. Locate and arrange mechanical work to suit.

3.11.3. Access doors will be installed by trade responsible for particular type of construction in which doors are required. Supply access doors to trade installing same at proper time.

3.11.4. Wherever possible, access doors to be of a standard size for each application. Review exact dimensions and minimum size restrictions with Consultant prior to ordering.

3.11.5. Group piping and ductwork to ensure minimum number of access doors is required.

3.11.6. Submit a sample of each proposed access door for review prior to ordering.

3.11.7. Coordinate with Electrical Contractor and General Trades Contractor to ensure access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and work involving both mechanical and electrical services should, where possible, be accessible from common access door. Coordinate work to ensure common location access doors are not supplied by both Mechanical Divisions and Electrical Divisions.

3.12. INSTALLATION OF VALVES

3.12.1. Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where valves are specified, however, regardless of locations shown or specified, following requirements apply:

a) provide shut-off valves to isolate systems, at base of vertical risers, in branch take-offs at mains and risers on floors, to isolate equipment, to permit work phasing as required, and wherever else required for proper system operation and maintenance;

b) install shut-off valves with handles upright or horizontal, not inverted, and located for easy access;

c) unless otherwise specified, provide a check valve in discharge piping of each pump;

d) valve sizes are to be same as connecting pipe size;

e) valves are to be permanently identified with size, manufacturer's name, valve model or figure number and pressure rating, and wherever possible, valves are to be product of same manufacturer;

f) for valves in insulated piping, design of valve stem, handle and operating mechanism is to be such that insulation does not have to be cut or altered in any manner to permit valve operation.

3.13. INSTALLATION OF PRESSURE GAUGES AND THERMOMETERS

3.13.1. Provide pressure gauges in locations including but not limited to following:

a) in valved tubing across suction, suction strainer (if applicable), and discharge piping of each circulating pump;

b) in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, heat exchangers, main coils, etc.;

c) in expansion tank(s);

d) in separate domestic hot water storage tank(s);

e) at top most outlet in each standpipe fire protection system riser;

f) in piping at each side of a pressure reducing valve;

g) in potable water service piping downstream of meter;

h) wherever else shown and/or specified.

3.13.2. Provide thermometers in locations including but not limited to following:

a) in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, cooling towers, heat exchangers, main coils, etc., unless temperature indication is supplied with equipment;

b) wherever else shown and/or specified.

3.13.3. Conform to following installation requirements:

a) for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in piping well;

b) for pressure gauges in piping at equipment locations, install pressure gauge between equipment and first pipe fitting;

c) locate, mount and adjust instruments so they are easily readable;

d) where pressure gauges and/or thermometers are located at high level or in an area where they cannot be easily seen, provide remote reading instruments.

3.14. INSTALLATION OF EQUIPMENT DRIVE GUARDS AND ACCESSORIES

3.14.1. Provide OHSA guards for exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on mechanical equipment.

3.14.2. Install belt guards to allow movement of motors for adjusting belt tension.

3.14.3. Provide a means to permit lubrication and use of test instruments with guards in place.

3.14.4. Secure guards to equipment or equipment base but do not bridge sound or vibration isolation.

3.14.5. Where equipment oil level gauges, oil reservoirs, grease cups, or grease gun fittings are integral with equipment but are not easily accessible for service, extend to an accessible location using aluminum or copper tubing.

3.15. MECHANICAL WORK IDENTIFICATION

3.15.1. For identification of mechanical work, comply with requirements of local governing authorities, and to governing codes including but not limited to following:

a) natural gas and propane gas: to CSA/CGA B149.1;

b) sprinklers: to NFPA 13;

c) standpipe and hose systems: to NFPA 14;

d) other piping systems: to: CSA/CGSB -24.3;

e) products not listed: confirm with Metrolinx.

3.15.2. Identify new exposed piping and ductwork as per Part 2 of this Section in locations including but not limited to following:

a) at every end of every piping or duct run;

b) adjacent to each valve, strainer, damper and similar accessory;

c) at each piece of connecting equipment;

d) on both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;

e) at 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length;

f) at least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length.

3.15.3. Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations including but not limited to following:

a) at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;

b) at maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;

c) at each access door location;

d) at each piece of connected equipment, automatic valve, etc.

3.15.4. Provide an identification nameplate for equipment provided as part of this project, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate nameplates in the most conspicuous and readable location.

3.15.5. Paint new natural and/or propane gas piping with primer and 2 coats of yellow paint in accordance with Code requirements and requirements of painting Specifications. Identify piping at intervals as specified above.

3.15.6. Provide an identification nameplate for each motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter provided as part of mechanical work, and on each disconnect switch provided as part of the electrical work for motorized equipment provided as part of mechanical work.

3.15.7. For electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".

3.15.8. Tag valves and prepare a valve tag chart in accordance with following requirements:

a) attach a valve tag to each new valve, except for valves located immediately at equipment they control;

b) prepare a computer printed valve tag chart to list tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed);

c) if an existing valve tag chart is available at site, valve tag numbering is to be an extension of existing numbering and new valve tag chart is to incorporate existing chart;

d) frame and glaze one copy of chart and, unless otherwise directed, affix to a wall in each main Mechanical and/or Equipment Room;

e) include a copy of valve tag chart in each copy of operating and maintenance instruction manuals;

f) hand an identified CD of valve tag chart to Metrolinx at same time O & M Manuals are submitted.

3.15.9. Where shut-off valves, control dampers, sensors, and similar items which will or may need maintenance and/or repair are located above accessible suspended ceilings, provide round coloured ceiling tacks in ceiling panel material, or stickers equal to Brady "Quick Dot" on ceiling grid material to indicate locations of items.

3.16. FINISH PAINTING OF MECHANICAL WORK

3.16.1. Finish paint exposed mechanical work as specified and/or scheduled in accordance with requirements of painting Specifications.

3.16.2. Touch-up paint damaged factory applied finishes on mechanical work products.

3.16.3. Finish painting of exposed mechanical work is typically specified in painting Specifications.

3.16.4. Coordinate work requirements with respective trades.

3.17. PIPE LEAKAGE TESTING

3.17.1. Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.

3.17.2. Tests are to be witnessed by Consultant and/or Metrolinx representative, and, where required, representatives of governing authorities. Give ample notice of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.

3.17.3. When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.

3.17.4. Include for but not be limited to testing of following:

a) Gravity Drainage and Vent Piping (including Storm Water System Piping):

1) Test piping in accordance with local governing building code.

2) After fixtures and fittings are set and pipes are connected to building drain or drains, turn on water into pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Perform a smoke test if required by local governing authorities.

b) Pumped Drainage Piping:

1) Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for a minimum of 2 hours.

c) Domestic Water Piping:

1) Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for a minimum of 2 hours.

d) Sprinkler System Piping:

1) Test system piping in accordance with requirements of NFPA No. 13, "Installation of Sprinkler Systems", and in accordance with any additional requirements of governing authorities.

e) Standpipe System Piping:

1) Test system piping in accordance with requirements of NFPA No. 14, "Standpipe and Hose Systems", and in accordance with any additional requirements of governing authorities.

f) Clean Agent Fire Extinguishing System Piping:

1) Test system piping in accordance with requirements of NFPA No. 2001, "Standard on Clean Agent Extinguishing Systems", and in accordance with any additional requirements of governing authorities.

g) Heat Transfer (HVAC) System Piping:

1) Test piping with cold water at a pressure of 1035 kPa (150 psi) for a minimum of 2 hours.

h) Steam and Condensate Piping:

1) Test piping with cold water for a minimum of 2 hours at following pressures:

i) 0 kPa to 105 kPa (0 psi to 15 psi) low pressure piping - 690 kPa (100 psi);

ii) 110 kPa to 690 kPa (16 psi to 100 psi) medium pressure piping - 1035 kPa (150 psi);

iii) greater than 690 kPa (100 psi) high pressure piping - 1380 kPa (200 psi).

i) Natural Gas Piping:

1) Test piping in accordance with requirements of CAN/CSA B149.1 and any additional requirements of local governing authorities.

2) After completion of the verification test, locate required tag stating results of the verification test at the point of entry of gas main into building, affixed to the pipe in a secure manner.

3) Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.

j) Propane Gas Piping:

1) Test piping in accordance with requirements of CAN/CSA B149.2 and any additional requirements of local governing authorities.

2) After completion of the verification test, locate required tag stating results of the verification test at the point of entry of gas main into building, affixed to the pipe in a secure manner.

3) Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.

k) Compressed Air Piping:

1) Test piping with dry compressed air or nitrogen at 690 kPa (100 psi) for a minimum of 2 hours.

2) Test piping joints with a water-soap solution while piping is under pressure to detect leaks.

l) Fuel Oil Piping:

1) Test piping (not tanks) with dry compressed air or nitrogen for a minimum period of two hours at 1035 kPa (150 psi).

2) Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.

m) Gasoline Piping:

1) Test piping (not tanks) with dry compressed air or nitrogen for a minimum period of 2 hours at 1035 kPa (150 psi) in accordance with TSSA requirements.

2) Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.

n) Refrigerant Piping:

1) Test refrigerant piping for leakage and dehydrate in accordance with requirements of Chapter 18 of ASHRAE Handbook - Fundamentals.

o) Control Air Piping and Tubing:

1) Test control air piping and tubing with dry compressed air or nitrogen before concealing and again before connection of instruments.

2) Rough-in test pressure is to be 345 kPa (50 psi) maintained over 24 hours with a pressure drop not to exceed 35 kPa (5 psi).

3) Test joints for leaks with a soap solution.

4) Finish test is to be 205 kPa (30 psi) with a permissible loss of 7 kPa (1 psi) over a 4 hours period. Prior to connecting instruments, blow systems clean and dry, and test component connections for leaks with a water/soap solution.

p) Pure Water Piping:

1) When piping has been properly flushed and cleaned, test at 690 kPa (100 psi) for 2 hours with only distilled water or filtered dry compressed air. If distilled water is used, drain system when testing is complete.

q) Snow Melting and In Floor Heating System Piping (Glycol):

1) Perform pressure testing of grid piping / tubing in accordance with local applicable governing standards and manufacturer's recommendations.

2) Ensure grid piping / tubing has been successfully pressure tested prior to concealment.

3.17.5. Following requirements apply to all testing:

a) ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;

b) temporarily remove or valve off piping system specialties or equipment which may be damaged by test pressures prior to pressure testing systems, and flush piping to remove foreign matter;

c) when testing is carried out below highest level of the particular system, increase test pressure by the hygrostatic head of 7 kPa (1 psi) for every 600 mm (24") below the high point;

d) include for temporary piping connections required to properly complete tests;

e) piping under test pressure is to have zero pressure drop for length of test period;

f) make tight leaks found during tests while piping is under pressure, and if this is impossible, remove and refit piping and reapply test until satisfactory results are obtained;

g) where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions;

h) tests to be done in reasonably sized sections so as to minimize number of tests required;

i) in addition to leakage tests specified above, demonstrate proper flow throughout systems including mains, connections and equipment, as well as proper venting and drainage, and include for any necessary system adjustments to achieve proper conditions.

3.18. SUPPLY OF MOTOR STARTERS AND ACCESSORIES

3.18.1. Unless otherwise shown or specified, supply a starter for each item of motorized equipment. Refer to Motor Starter Schedule.

3.18.2. Where 3-phase starters are indicated in motor control centres, supply motor control centres with starters and bolt to a concrete housekeeping pad.

3.18.3. Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from a motor control centre, provide a disconnect switch in motor control centre in lieu of a motor starter.

3.18.4. Where 3-phase starters are indicated and/or scheduled to be mounted on a motor starter panel, starters will be mounted and connected, complete with panels and splitter trough, as part of electrical work. Hand starters to electrical trade at site when they are required.

3.18.5. Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from a motor starter panel, a disconnect switch will be provided on motor starter panel as part of electrical work.

3.18.6. Unless otherwise specified or shown on drawings, 1-phase motor starters will be mounted adjacent to equipment they serve and connected complete as part of electrical work. Hand starters to electrical trade at site at the proper time.

3.18.7. Coordinate exact responsibilities with Electrical Division Contractor and ensure required provisions are provided for equipment.

3.19. ELECTRICAL WIRING WORK FOR MECHANICAL WORK

3.19.1. Unless otherwise specified or indicated, following electrical wiring work for mechanical equipment to be typically provided as part of the electrical work:

a) "line" side power wiring to motor starters or disconnect switches in motor control centres and starters or disconnects on motor starter panels, and "load" side wiring from starters or disconnects to equipment;

b) "line" side power wiring to individual wall mounted starters, and "load" side wiring from starters to equipment;

c) "line" side power wiring to pre-wired power and control panels and variable frequency drives (VFD), and "load" side power wiring from the panels and VFD's to equipment;

d) where harmonic filters are provided on input of VFDs, provide required input and output wiring and connections;

e) provision of receptacles for plug-in equipment;

f) provision of disconnect switches for motors in excess of 10 m (30') from starter location, or cannot be seen from starter location, and associated power wiring;

g) motor starter interlocking in excess of 24 volts;

h) wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts;

i) 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;

j) 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units;

k) 120 volt wiring connections to duplex receptacles integral with air handling unit control panels.

3.19.2. Mechanical wiring work not listed above or specified herein or on drawings to be done as part of electrical work is to be installed in conduit and is to be done as part of mechanical work in accordance with wiring requirements specified for electrical work.

3.19.3. Coordinate exact responsibilities with Electrical Division Contractor and ensure required provisions are provided for equipment.

3.20. INTERRUPTION TO AND SHUT-DOWN OF MECHANICAL SERVICES AND SYSTEMS

3.20.1. Co-ordinate shut-down and interruption to existing mechanical systems with Metrolinx. Generally, as confirmed with Metrolinx, shut-downs may be performed only between the hours of 01:00 a.m. until 05:00 a.m.

3.20.2. Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.

3.20.3. Prior to each shut-down or interruption, inform Metrolinx and Consultant in writing minimum 10 business working days in advance of proposed shut-down or interruption and obtain written consent to proceed. Do not shut-down or interrupt any system or service without such written consent. Shutdowns of some essential services may require additional advance notification time.

3.20.4. Perform work associated with shut-downs and interruptions as continuous operations to minimize shut-down time and to reinstate systems as soon as possible, and, prior to any shut-down, ensure materials and labour required to complete the work for which shut-down is required are available at site.

3.20.5. Pipe freezing may be used to connect new piping to existing piping without draining existing piping. Pipe freeze equipment is to be equal to "NORDIC FREEZE" equipment supplied by Mag Tool Inc. or Rigid Tool Co. RIGID "SuperFreeze" or approved equivalent.

3.21. EQUIPMENT BASES AND SUPPORTS

3.21.1. Unless otherwise specified or required, set floor mounted equipment on minimum 100 mm (4") high reinforced concrete housekeeping pads 200 mm (8") clear of equipment on each side and end, or a minimum of 200 mm (8") from centreline of equipment anchor bolts to edge of the base, whichever is larger. Conform to following requirements:

a) supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads;

b) place anchor bolts during concrete pour and be responsible for required levelling, alignment, and grouting of equipment;

c) as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.

3.21.2. For equipment not designed for base mounting, where required, provide welded, cleaned and prime coat painted structural steel stands or supports conforming to following requirements:

a) provide stands and supports, except those for small equipment, designed by a structural engineer registered in jurisdiction of the work, and submit stamped and signed design drawings with calculations as shop drawings for review;

b) flange bolt steel stands to concrete housekeeping pads;

c) seismically restrained stands and supports in accordance with applicable requirements.

3.22. MECHANICAL SERVICE REQUIREMENTS FOR FLOATING FLOOR SLABS

3.22.1. Where mechanical services are required to be installed in or through a vibration isolated floating slab, install such services so as not to transmit any vibration to base slab on which floating floor slab is placed.

3.22.2. Wherever possible, arrange mechanical work to avoid penetrating a floating floor slab.

3.23. CONCRETE WORK FOR MECHANICAL EQUIPMENT BASES/PADS

3.23.1. Concrete work required for mechanical equipment bases/pads will be provided as part of work under concrete work Section of Specification. Coordinate work requirements with respective trades.

3.23.2. Exactly locate bases/pads at site and be present during concrete pour to ensure anchor bolts, inserts, plates and similar hardware are not damaged or dislodged.

3.23.3. Supply dimensions and weight and other data such that General Trades Contractor can arrange for dimensioned shop drawings, prepared and stamped by a professional structural engineer registered in the jurisdiction of the work, for concrete pads or bases for support of large, heavy equipment.

3.24. EXCAVATION AND BACKFILL WORK

3.24.1. Excavation, backfill and related work such as dewatering required for mechanical work will be performed as part of excavation and backfill work Section of Specification, except for final hand grading work which is to be done as part of mechanical work. Mark out location and routing of excavation required for work as well as required depth. Ensure that bedding is graded to provide proper drainage for ducts as reviewed with Consultant.

3.24.2. Inverts and locations of existing site services may have been site surveyed and approximate location may be shown on drawings. Confirm local utilities have performed locates and marking out. Ensure inverts and locations are correct, prior to commencement of work. Where discrepancies are found, immediately inform Consultant, and await a direction.

3.24.3. Accurately mark-out location and routing of excavation required, as well as required depth.

3.24.4. Ensure underground piping subject to freezing and located outside building has a minimum of 1.65 m (65") of cover.

3.24.5. Ensure underground piping subject to freezing and located inside building in unheated areas has a minimum of 1.2 m (48") of cover.

3.24.6. Ensure pipe bedding is proper prior to laying pipes. Hand excavate under pipe hubs, couplings, flanges and similar items to ensure even bearing along the entire barrel of each length of pipe.

3.24.7. Ensure piping is inspected, leakage tested and approved prior to backfilling. Supervise initial backfilling operation to ensure buried work is not disturbed.

3.24.8. Notify and allow for work to be inspected by Consultant and/or Metrolinx before covering and backfilling. Failure to do so prior to backfilling will require re-excavating of work and re backfill at no additional cost to Metrolinx.

3.24.9. Coordinate requirements for final surface toppings (concrete, asphalt, pavers, grass sod, etc.) with General Contractor and Metrolinx.

3.25. CUTTING, PATCHING AND CORE DRILLING

3.25.1. Unless otherwise provided by General Trades, perform cutting, patching, and core drilling of existing building required for installation of mechanical work. Perform cutting in a neat and true fashion, with proper tools and equipment to Consultant's approval. Patching is to exactly match existing finishes and be performed by tradesmen skilled in particular trade or application. Work is subject to approval from Metrolinx and review with Consultant.

3.25.2. Criteria for cutting holes for additional services:

a) cut holes through slabs only; no holes to be cut through beams;

b) cut holes 150 mm (6") diameter or smaller only; obtain approval from Structural Consultant for larger holes;

c) keep at least 100 mm (4") clear from beam faces;

d) space at least three-hole diameters on center;

e) for holes that are required closer than 25% of slab span from supporting beam face, use cover meter above slab to clear slab top bars;

f) for holes that are required within 50% of slab span, use cover meter underside of slab to clear slab bottom bars;

g) submit sleeving drawings indicating holes and their locations for Structural Consultant's review.

3.25.3. Do not cut or drill any existing work without approval from Metrolinx and review with Consultant. Be responsible for damage done to building and services caused by cutting or drilling.

3.25.4. Where pipes pass through existing construction, core drill an opening. Size openings to leave 12 mm (½") clearance around pipes or pipe insulation.

3.25.5. Prior to drilling or cutting an opening, determine, in consultation with Consultant and Metrolinx, and by use of non-destructive radar scan (magnetic scan) of slab or wall, presence of any existing services and reinforcement bars concealed behind building surface to be cut and locate openings to suit. Coring is not permitted through concrete beams or girders.

3.25.6. Where drilling is required in waterproof slabs, size opening to permit snug and tight installation of a pipe sleeve sized to leave 12 mm (½") clearance around pipe or pipe insulation. Provide a pipe sleeve, constructed of Schedule 40 galvanized steel pipe with a flange at one end and of a length to extend 100 mm (4") above slab, in opening. Secure flange to the underside of slab and caulk void between sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.

3.25.7. Firestop and seal openings in fire rated construction in accordance with requirements of Section - Firestopping and Smoke Seal Systems. Do not leave openings open overnight unless approved by Metrolinx and review with Consultant.

3.25.8. Coordinate work requirements with respective trades.

3.26. PACKING AND SEALING CORE DRILLED PIPE OPENINGS

3.26.1. Pack and seal void between pipe opening and pipe or pipe insulation for length of opening as follows:

a) non-fire rated interior construction - pack with mineral wool and seal both ends of opening with non-hardening silicone base caulking compound to produce a water-tight seal;

b) exterior walls above grade - pack with mineral wool and seal both ends of sleeves water-tight with non-hardening silicone base caulking compound unless mechanical type seals have been specified;

c) exterior walls below grade (and any other wall where water leakage may be a problem) - seal with link type mechanical seals as specified.

3.27. CLEANING MECHANICAL WORK

3.27.1. Refer to cleaning requirements specified in Architectural Sections.

3.27.2. Clean mechanical work prior to application for Substantial Performance of the Work.

3.27.3. Include for vacuum cleaning interior of air handling units and ductwork systems.

3.28. CONNECTIONS TO OTHER EQUIPMENT

3.28.1. Carefully examine Contract Documents during bidding period and include for mechanical work piping and/or ductwork connections to equipment requiring such connections.

3.29. FAN NOISE LEVELS

3.29.1. Submit sound power levels with fan shop drawings/product data, with levels measured to AMCA 300 and calculated to AMCA 301.

3.30. EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

3.30.1. When equipment/system installation is complete, but prior to start-up procedures, arrange and pay for equipment/system manufacturer's authorized representative to visit site to examine installation, and after any required corrective measures have been made, to certify in writing to Metrolinx that equipment/system installation is complete and in accordance with equipment/system manufacturer's instructions.

3.31. EQUIPMENT AND SYSTEM START-UP

3.31.1. When installation of equipment/systems is complete but prior to commissioning, perform start-up for equipment/systems as specified in mechanical work Sections in accordance with following requirements:

a) submit a copy of each equipment/system manufacturer's start-up report sheet to Consultant for review, and incorporate any comments made by Consultant;

b) under direct on-site supervision and involvement of equipment/system manufacturer's representative, start-up equipment/systems, make any required adjustments, document procedures, leave equipment/systems in proper operating condition, and submit to Consultant complete set of start-up documentation sheets signed by manufacturer/supplier and Contractor;

c) include for leak test and affixation of leak test tag for refrigerant containing equipment.

END OF SECTION