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**Project Manual
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**NRCAN MAP Laboratory
Renovation**

Hamilton, ON

Project No. R.106310.002

Set No:

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PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- .1 This Section is common to each Section of Division 26, Division 27 and Division 28, and is supplement to each Section and read accordingly.
- .2 Advise vendors and trades of each Section, of requirements of this Section.
- .3 Comply with rules and regulations when working in existing building, of existing building management, as specified in Division 01.

1.2 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM A123/A123M-17, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - .2 ASTM A653/A653M-20, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - .3 ASTM A1011/A1011M-18a, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
- .2 Canadian Standards Association (CSA).
 - .1 CSA C22.1-18, Canadian Electrical Code, Part 1 (24th Edition), Safety Standard for Electrical Installations (CEC).
 - .2 CSA C235-19, Preferred voltage levels for AC systems up to 50 000 V.
 - .3 CAN/CSA-O80 Series-15(R2020), Wood Preservation.
 - .4 CSA O121-17, Douglas Fir Plywood.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS): Safety Data Sheets (SDS).
- .4 Institute of Electrical and Electronics (IEEE)
 - .1 IEEE 100 CD-2013, Standards Dictionary: Glossary of Terms and Definitions.
- .5 National Building Code of Canada (NBC)- 2015.
- .6 Ontario Building Code (OBC) - 2012 with amendments in effect up to January 1, 2020.
- .7 Ontario Electrical Safety Code (OESC), 27th edition - 2018.
- .8 Ontario Regulation 632/05, Occupational Health and Safety Act - Confined Spaces.
- .9 Telecommunications Industries Association (TIA)
 - .1 TIA 569-Revision E, 2019, Telecommunications Pathways and Spaces.

- .10 Underwriters Laboratories of Canada
 - .1 CAN/ULC-S101-14-REV1, Standard Methods of Fire Endurance Tests of Building Construction and Materials.
 - .2 CAN/ULC-S115-2018, Standard Method of Fire Tests of Firestop Systems.
 - .3 CAN/ULC-S1001-2011, Standard for Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.3 DEFINITIONS

- .1 Electrical and electronic terms, unless otherwise defined in Specifications or on Drawings, are those defined by IEEE 100 CD.
- .2 BAS: Building Automation System.
- .3 Concealed: Hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
- .4 Delete or Remove (and tenses of delete or remove): To disconnect, make safe, and remove obsolete materials in planned deconstruction and disassembly of electrical items from existing construction including removal of conduit, junction boxes, cabling and wiring from electrical component to panel, taking care not to damage adjacent assemblies designated to remain. Legally dispose of deleted items off site. Patch and repair/finish surfaces to match adjoining similar construction. Re-program systems to suit deletions. Revise documentation identifications to suit deletions. Retain items indicated as removed and salvaged. Retain items indicated as removed and reinstalled.
- .5 Demolish: Detach items from existing construction and legally dispose of items off site. Retain items indicated as removed and salvaged, or removed and reinstalled.
- .6 Existing to Remain: Existing items of construction that are not removed and that are not otherwise indicated as being removed and salvaged, or removed and reinstalled.
- .7 Exposed: Work normally visible, including work in equipment rooms, service tunnels, and similar spaces.
- .8 Finished: When in description of area or part of area or product which receives finish such as paint, or in case of product may be factory finished.
- .9 Install (and tenses of install): Secure in position, connect complete, test, adjust, verify and certify.
- .10 Professional Engineer: Individuals registered or licensed by Professional Engineers Ontario (PEO) to practice engineering in Province of Ontario.
- .11 Provision or provide (and tenses of provide): Supply and install complete.
- .12 Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.

- .13 Remove and Salvage: Detach items from existing construction and deliver them ready for reuse, to onsite storage areas, as reviewed with Departmental Representative.
- .14 Supply: To procure, arrange for delivery to site, inspect, accept delivery and administer supply of products; to distribute to areas; and to provide manufacturer assistance for required on site testing, initial start-up, programming, basic commissioning and verification work.

1.4 DOCUMENTS

- .1 Drawings and Specifications are portions of Documents and identify labour, products and services necessary for performance of Work and form a basis for determining pricing. They are intended as complementary. Perform Work that is shown, specified, or reasonably implied on drawings but not mentioned in Specification, or vice-versa, as though fully covered by both.
- .2 Sections of Specifications are not intended to delegate functions nor to delegate Work and supply of materials to specific trade, but rather to generally designate a basic unit of work, and Sections are read as whole.
- .3 Drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Do not scale Drawings, and do not use Drawings for prefabrication work or for exact distance takeoffs.
- .4 Drawings are intended to convey scope of electrical work and do not show architectural and structural details. Provide, offsets, fittings, transformations and similar products required as result of obstructions and other architectural or structural details.
- .5 Specification is intended to provide product data and installation requirements. Refer to schedules, Drawings (layouts, riser diagrams, schematics, details) and Specification to provide correct quantities. Singular may be read as plural and vice versa.

1.5 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00.
- .2 Submit electronic copies of submittals. Submit hard copies where specified.
- .3 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and product characteristics, performance criteria, physical size, finish and limitations.
 - .2 Provide copies of WHMIS Safety Data Sheets (SDS) in accordance with Section 01 35 43.
- .4 Submit for review revised single line electrical diagrams for placement under plexiglass and locate as follows, as reviewed with Departmental Representative in main electrical room.

.5 Shop Drawings

- .1 Submit for review, drawings showing in detail design, construction, and performance of equipment and materials as requested in Specification. Submit shop drawings for review prior to ordering and delivery of product to site. Prepare and submit following:
 - .1 Product data listed above.
 - .2 Equipment dimension drawings including required clearances and service access requirements.
 - .3 Mounting arrangements.
 - .4 Equipment loads (self-weight, operating weight).
 - .5 Housekeeping pad details.
 - .6 Inertia pads details.
 - .7 Detailed drawings of bases, supports, and anchor bolts.
 - .8 System block diagrams.
 - .9 Sequence of operation.
 - .10 Connection wiring schematic diagrams.
 - .11 Functionality with integrated systems.
 - .12 Manufacturer certification of current model production.
 - .13 Certification of compliance to applicable codes.
 - .14 Spare parts.
 - .15 Maintenance schedules.
 - .16 Other items as listed in Specifications.
- .2 Identify with products, types of finishes and colours of final finishes.
- .3 Limit shop drawing submissions specifically to product (not family of products), without extraneous materials such as manufacturer brochures and sales materials.
- .4 Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items shown to verify coordinated installation.
- .5 Identify on wiring diagrams circuit terminals and indicate internal wiring for each item of equipment and interconnection between each item of equipment.
- .6 Indicate on drawings, clearances for operation, maintenance, and replacement of equipment devices.
- .7 Supply opening sizes and locations to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.
- .8 Supply submittals of field applied glues, adhesives, solvent cements, paints, caulking, sealants, fire stopping coatings and other similar materials, for Departmental Representative review of VOC limits and chemical component limitations.
- .9 Indicate products having requirements for installation and energizing onsite soon after delivery, in order to maintain manufacturer warranty and service life.

- .10 Submit transmittal letter referred to in Section 01 33 00. Identify Section and paragraph number.
- .11 Submit copies of drawings and product data to authority having jurisdiction and inspection authorities. Obtain submission requirements from authority having jurisdiction and inspection authorities, and provide as required.
- .12 Notify Departmental Representative of proposed changes and review with Departmental Representative before making changes.
- .6 Additional Drawings
 - .1 Interference drawings.
 - .2 Layout drawings of equipment and access doors.
 - .3 Sleeving drawings.
 - .4 Detailed section drawings of ceiling spaces.
 - .5 Backboard drawings.
- .7 Certificates
 - .1 Submit test results and commissioning reports of installed electrical systems and equipment.
 - .2 Permits and fees: Include requirements for inspections by and approvals from local governing authorities having jurisdiction.
 - .3 Submit, upon completion of Work, load balance report as described in Section 26 05 70.
 - .4 Submit to Departmental Representative, certificate of acceptance from authority having jurisdiction upon completion of Work.
- .8 Manufacturer Field Reports: Submit to Departmental Representative, manufacturer written report, verifying compliance of Work with results of electrical system coordination study and testing, as described in Part 3 - Field Quality Control and Section 26 05 70.
- .9 Sample Submittals
 - .1 Nameplates, labels and signage.
 - .2 Firestopping and smoke seal materials.
 - .3 Other items as specified.

1.6 AS-BUILT (RECORD DOCUMENTS)

- .1 Provide as-builts (record documents) and record actual site conditions, in accordance with Section 01 78 00.
- .2 Drawings for this project have been prepared on CAD system using AutoCAD software.
- .3 As work progresses at site, clearly mark in red in neat and legible manner on set of bound white prints of Contract Drawings, changes and deviations from routing of services and locations of equipment shown on Drawings, on daily basis, as required for Work. Use notes marked in red. Maintain white print red line as-built set at site for exclusive use of recording as-built conditions, keep set up-to-date, and available for periodic

review. Mark changes as work progresses and as changes occur.
Include following with as-built set:

- .1 Dimensioned location of inaccessible concealed work.
 - .2 Locations of control devices with identification for each.
 - .3 Location and identification of devices in concealed locations such as accessible ceiling spaces and raised floors.
 - .4 For underground ducts, record dimensions, invert elevations, offsets, fittings, cathodic protection and accessories, as applicable, and locate and identify dimensions from benchmarks.
 - .5 Location of concealed services terminated for future extension and work concealed within building in inaccessible locations.
 - .6 Location of fire alarm devices and addresses of devices. Identify fire alarm zones.
 - .7 Identify routing and location of concealed conduits/ducts of diameter 50 mm and greater.
 - .8 Where applicable, changes to existing electrical systems, control systems and low voltage control wiring.
 - .9 Other items indicated on drawings.
 - .10 Other items noted within Specifications.
- .4 Use final reviewed "as-built" drawing set to provide CAD files of drawings thus forming true "as-built" set of Contract Drawings. Identify set as "Project Record Copy".
 - .5 Identify each drawing in lower right-hand corner in letters at least 12 mm high as follows: "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW ELECTRICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
 - .6 Mark-up Specifications for as-builts in accordance with Section 01 78 00.
 - .7 Submit to Departmental Representative for review and make corrections as recommended by Departmental Representative.
 - .8 Submit to Departmental Representative hard copies and electronic version on USB flash drives of completed reproducible as-built drawings with Operating and Maintenance (O & M) Manuals.

1.7 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Operation and Maintenance (O & M) Manuals
 - .1 Supply project specific, indexed copies of equipment manufacturer O & M instruction data manuals. Consolidate each copy of data in identified hard cover three "D" ring binder. Include electronic PDF version saved on USB type flash drives.
 - .2 Provide O & M manuals for each system and principal item of equipment as specified in technical sections for use by operation and maintenance personnel.

- .3 O & M Data: Submit operation and maintenance data for products for incorporation into manuals.
- .4 Provide following:
 - .1 Front cover clearly labelled: Project name label; wording - "Electrical Systems Operating and Maintenance Manual"; with specific system/equipment name high lighted, and date.
 - .2 Introduction sheet listing Subcontractor and trades names, street addresses, telephone number and e-mail addresses.
 - .3 Equipment manufacturers authorized contact person name, telephone number, e-mail and company website.
 - .4 Table of Contents sheet, and corresponding index tab sheets.
 - .5 Copy of each reviewed shop drawing. Limit shop drawing documentation to specific product requirements as specified in article - Shop Drawings, in this Section.
 - .6 Description of systems and their controls. Include systems architecture and operating data.
 - .7 Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
 - .8 Start up, proper adjustment, operating, lubrication, and shutdown procedures.
 - .9 Safety precautions.
 - .10 Maintenance and operating procedures. Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment. Include schedules of tasks, frequency, tools required, task time and spare parts.
 - .11 Performance data as follows:
 - .1 Equipment manufacturers performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .12 Procedures in event of equipment failure.
 - .13 Inspection certificates issued by regulatory authorities.
 - .14 Panelboard directories typed.
 - .15 Warranties.
 - .16 Other items of instruction as recommended by manufacturer of each system or item of equipment.
 - .17 Other items noted within Specifications.
- .3 Provide operating instructions on signage as specified.
- .4 Unless otherwise specified in Division 01, submit 2 copies of draft O & M manuals to Departmental Representative. Combine material as specified and not as individual submissions.

- .5 Make changes as reviewed by and recommended by Departmental Representative and re-submit.
- .6 Additional Data: Prepare and insert into O & M manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .7 Prepare and submit final reviewed with Departmental Representative O & M manuals. Submit to Departmental Representative minimum 2 sets of hard bound copies and PDF version.

1.8 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 and with manufacturers written instructions.
- .2 Delivery and Acceptance Requirements: Deliver materials to site in original factory packaging, labelled with manufacturers name and address.
- .3 Storage and Handling Requirements
 - .1 Store materials indoors in accordance with manufacturers recommendations in clean, dry, well-ventilated area onsite, as reviewed with Departmental Representative.
 - .2 Store and protect products from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new. Remove rejected material and equipment from the site immediately.
 - .4 Touch up damage to factory finishes. Use finishes to match factory finishes. Do not paint over nameplates or labels.

1.9 QUALITY ASSURANCE

- .1 Comply with requirements of Section 01 45 00.
- .2 Pre-Installation Meeting: Convene pre-installation meeting minimum one week prior to beginning on-site installations in accordance with Departmental Representative directive to:
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building subtrades.
 - .4 Review manufacturers installation instructions and warranty requirements.
- .3 Submit following as reviewed with Departmental Representative:
 - .1 Copy of factory inspection and test report for each equipment, and include copy of each report with O & M Manual project close-out data.
 - .2 Manufacturer/supplier installation certification letters as specified in Part 3 of this Section.
 - .3 Submit copies of onsite post installation test reports.

1.10 WORKMANSHIP

- .1 Comply with requirements of Section 01 45 00.

- .2 Perform work so that items are and remain plumb, square and straight. Provide materials and equipment that are free from warp, twist and other defects.
- .3 Install products in accordance with manufacturer written instructions and recommended usage, and to suit specific installation requirements as specified.
- .4 Perform work in accordance with applicable Federal, Provincial and Municipal codes and standards, related industry standards and requirements of local authorities having jurisdiction and local inspection authorities.
- .5 Run exposed conduit and duct runs including runs in ceiling spaces, parallel to building lines. Mount panels, boxes, covers, and such other products in similar manner.
- .6 Replace bolts and nuts in "stripped" condition. Replace bolts and nuts in "cross threaded" condition.
- .7 Avoid connection between dissimilar metals. Where such applications cannot be avoided, provide compound or other means recommended for such applications to prevent effects of contact between dissimilar materials.
- .8 Avoid use of material that corrodes when exposed to moisture in wet locations or damp locations.
- .9 Conceal rough-in work in areas except where surface installations are specifically indicated. Where this becomes impossible, review with Departmental Representative, as to determine what adjustments to make before proceeding with work.
- .10 Maintain superintendent on-site at times when work is being performed.

1.11 REGULATORY REQUIREMENTS

- .1 Obtain and pay for required permits and inspections and give required notices. Include copies of permits and inspection certificates with operation and maintenance manuals.
- .2 Notify Departmental Representative of proposed changes to documents requested by authorities having jurisdiction, and obtain Departmental Representative prior to making changes.
- .3 Provide notification as requested by local authorities having jurisdiction, for authorities having jurisdiction to perform on-site inspection of work, allowing sufficient lead time to correct deficiencies in manner not impeding schedule of completion of Work. Where defect, deficiency and non-compliance is found in work by inspection, provide for such inspection, including related expenses, making good and return to site, until work is passed by local governing authorities having jurisdiction.
- .4 Obtain and submit to Departmental Representative, approval or inspection certificates issued by local authorities having jurisdiction that verifies Work as installed is in accordance with rules and regulations of local governing authorities and are acceptable by such authorities.

- .5 Comply with applicable regulations of governing Ministry of the Environment, Conservation and Parks governing waste management.
- .6 Comply with governing safety rules and regulations of governing Ministry of Labour and with local governing codes and standards.
- .7 Submit required applications, shop drawings, electrical distribution system protection device coordination studies, and short circuit calculations, and other information requested by local authority having jurisdiction.
- .8 Where code, regulation, bylaw, standard, contract form, manual, printed instruction, and installation and application instruction is quoted it means, latest published edition adopted by and enforced by local governing authorities having jurisdiction. Comply with revisions, bulletins, supplementary standards or amendments issued by local authority having jurisdiction. Comply with both federal and provincial codes and standards as required by local authority having jurisdiction.
- .9 Where regulatory codes, standards and regulations are at variance with Drawings or Specification, more stringent requirement applies. Review with Departmental Representative.
- .10 Provide requirements for barrier free access as specified and as indicated.
- .11 Perform Work in accordance with requirements of codes and standards referenced in respective Sections. Perform electrical work in accordance with CSA C22.1 and OESC.
- .12 Perform Work also in accordance with requirements of NBC and OBC.

1.12 DESIGNATED SUBSTANCES AND HAZARDOUS MATERIALS

- .1 Hazardous substances removal by hazardous abatement specialist is not included as part of scope of this package.
- .2 Hazardous substances are as defined in the Hazardous Products Act.
- .3 Immediately notify Departmental Representative when materials suspected of containing hazardous substances are encountered and perform following:
 - .1 Stop work in area of suspected hazardous substances.
 - .2 Take preventative measures to limit users' and workers' exposure, provide barriers and other safety devices and do not disturb materials.
 - .3 Proceed with work only after written instructions have been received from Departmental Representative.

1.13 WORKPLACE SAFETY

- .1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage and disposal of hazardous materials. Submit WHMIS SDS (Safety Data Sheets) for products where required, and maintain copy at site in visible and accessible location available to personnel.
- .2 Comply with requirements of Occupational Health and Safety Act and other regulations pertaining to health and safety, including

worker's compensation/insurance board and fall protection regulations. When working in confined spaces, comply with requirements of Ontario Regulation 632, and other applicable Ministry of Labour requirements.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- .1 Provide material and equipment (products) in accordance with Section 01 61 00 and as specified.
- .2 Provide material and equipment that is CSA certified or ULC listed and labelled, or other certification marks by certification organizations recognized by local governing authority.
- .3 Provide systems and equipment that are "State of the Art" and most recent and up to date series/version of product available at time of shop drawing review process. Provide software of latest version available and with updates available at time of shop drawing review process. Provide software that is backwards compatible and such that future upgrades do not require hardware replacements or additions to utilize latest software.
- .4 Operating Voltages: To CSA C235.
- .5 Provide control devices and equipment rated for local electrical utility connected line voltage operation, or where required low voltage, and operate at 60 Hz within normal operating limits established by above standard.
- .6 Determine short circuit current ratings at various levels of electrical distribution system and advise mechanical equipment vendors of rating requirements for equipment. Refer to Section 26 05 70.
- .7 Provide equipment to operate in extreme operating conditions established in CSA C235 without damage to equipment.
- .8 Factory assemble control panels and component assemblies.
- .9 Provide products (including associated installation and supporting hardware), located in non-climate controlled environments, with features for corrosion resistance and weather-proofing. Products to withstand various climatic conditions and hot and cold temperatures.
- .10 Products located in public spaces and which are located within hands reach, with tamper-proof features and impact resistant features.
- .11 Supply inserts, anchors, bolts, sleeves, ferrules and other items built into work of other Divisions, complete with necessary templates, instructions and assistance for locating and installing.

2.2 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

- .1 Coordinate responsibilities related to supply, installation, testing and verification of motors, equipment and controls.

- .2 Control Wiring and Conduit: In accordance with Section 26 05 21, except for wiring and connections below 50 V which are related to control systems specified in Division 25.

2.3 WIRING TERMINATIONS

- .1 Provide lugs, terminals, and screws used for termination of wiring that are suitable for type of conductors.

2.4 MANUFACTURER EQUIPMENT NAMEPLATES

- .1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
- .2 Lettering and numbers raised or recessed.
- .3 Information: As appropriate for respective application and type of equipment:
 - .1 Equipment: Manufacturer name, model, size, serial number, capacity.
 - .2 Motor: Voltage, Hz, phase, power factor, duty, frame size.

2.5 IDENTIFICATION - GENERAL

- .1 For non-climate-controlled areas: Nameplates and signage of weather resistant and corrosion resistant materials and UV resistant to prevent fading. Mounting hardware of corrosion resistant stainless-steel construction.
- .2 Exact wording, print type and size, nameplate sizing, and colours as approved by local authority having jurisdiction, and reviewed with Departmental Representative, prior to ordering.
- .3 Provide identification nameplates, labeling, operating instructions and signage. Use one nameplate, or one label or one sign as specified, for each language, for each system, for each piece of equipment.
- .4 Confirm bilingual requirements, with Departmental Representative, and provide as required.

2.6 SIGNAGE

- .1 Warning Signs
 - .1 In accordance with requirements and nomenclature of authority having jurisdiction, and reviewed with Departmental Representative.
 - .2 Porcelain enamel signs, minimum size 175 mm x 250 mm, and larger as required.
- .2 General Information Signage and Operating Instruction Signage
 - .1 Semi-rigid vinyl panels with drilled holes in each corner.
 - .2 Stainless steel mounting screws.
 - .3 Pressure sensitive mounting pads on back.
 - .4 Required printed wording: Wording of red on white background with black trim, but review with Departmental Representative prior to ordering.
 - .5 Minimum 3.2 mm thickness.

2.7 EQUIPMENT IDENTIFICATION

- .1 Identify equipment with nameplates as specified, bevelled edges and engraved lettering.
- .2 Nameplates: Lamicoid, minimum 3 mm thick, 2-ply, laminated coloured plastic plates.
 - .1 Normal power equipment: Lamicoid 3 mm thick plastic engraving sheet, white face, black core, mechanically attached with self tapping screws.
 - .2 Emergency power equipment: Lamicoid 3 mm thick plastic engraving sheet, white face, red core, mechanically attached with self tapping screws.
- .3 Nameplate sizes as follows:

NAMEPLATE SIZES			
Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	6 mm high letters

- .4 Labels:
 - .1 Embossed plastic labels with 6 mm high letters, unless specified otherwise. Labels adhesives are to be heavy duty strength and water-resistant, to maintain adhesion to surfaces. Apply clear coat of lacquer over installed labels.
 - .2 Apply labels for: temporary equipment, wiring devices and other equipment confirmed with Departmental Representative.
- .5 Identification in English. Review nomenclature on nameplates and signs with Departmental Representative, prior to manufacture. Review with Departmental Representative, requirements for special sized nameplates other than size listed above.
- .6 Use maximum 25 letters per nameplate. Provide one nameplate for each piece of equipment.
- .7 Typical colours for nameplates:
 - .1 Hazardous: Red letters, white background.
 - .2 Elsewhere: Black letters, white background (except where required otherwise by applicable local governing codes).
- .8 Identify equipment with typically with Size 3 unless otherwise specified, nameplates with numbering and nomenclature, as reviewed with Departmental Representative. Increase nameplate size as required to accommodate required nomenclature.
- .9 Nameplates for panelboards, panels, terminal cabinets, pull boxes and junction boxes: Indicate system and voltage characteristics.

- .10 Nameplates for disconnects, starters and contactors: Indicate equipment being controlled and voltage.
- .11 Nameplates for transformers: Indicate capacity, primary and secondary voltages.
- .12 Nameplates to completely identify equipment and its use with no abbreviations.
- .13 Wording is generally in accordance with drawings and includes equipment service and building area/zone served.
- .14 Supply stainless steel screws for securing nameplates in place.
- .15 For nameplates for equipment suspended above floor level, or generally not within easy viewing from floor level, increase in size making it easier to read from floor level.

2.8 WIRING IDENTIFICATION

- .1 Identify wiring with permanent indelible identifying markings, coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- .2 Maintain phase sequence and colour coding throughout.
- .3 Colour Coding: To CSA C22.1.
- .4 Use colour coded wires in communication cables, matched throughout system.
- .5 Adhesives: Heavy duty strength and water-resistant.

2.9 CONDUIT AND CABLE IDENTIFICATION

- .1 Colour code conduits, boxes and cables. For boxes, identify cover and inside each box.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 10 m (or less) intervals. Where tape is used, apply a minimum of 2 wraps.
- .3 Colours: 25 mm wide prime colour and 20 mm wide auxiliary colour.
- .4 Colour Coding: as described below:

	Prime	Auxiliary
up to 250 V Normal Power	Yellow	Blue
up to 600 V Normal Power	Yellow	Green
up to 250 V Emergency Power	Yellow	Blue and Red
up to 600 V Emergency Power	Yellow	Green and Red
Telephone	Green	
Information Technology	Green	Green
Trunking Radio	Red	Yellow Yellow (2 bands)
Multi Media	Blue	Blue
Other Communication Systems	Green	Blue

	Prime	Auxiliary
Fire Alarm	Red	
Emergency Voice	Red	Blue
Security Systems	Red	Yellow

2.10 HANGERS AND SUPPORTS

- .1 Climate Controlled Areas
 - .1 To ASTM A653/A653M SS GR 33.
 - .2 Pre-galvanized steel, U shape, sized to suit application but no smaller than 41 x 41 mm, and greater where indicated on drawings, not less than 2.5 mm thick.
 - .3 Of type set in poured concrete walls and ceilings or suspended or surface mounted to suit specific applications.
- .2 Non-Climate Controlled Areas
 - .1 To ASTM A1011/A1011M SS GR 33. Finish conforms to ASTM A123/A123M.
 - .2 Hot dipped galvanized steel, U shape, sized to suit application but no smaller than 41 x 41 mm, and greater where indicated on drawings, not less than 2.5 mm thick.
 - .3 Of type set in poured concrete walls and ceilings or suspended or surface mounted to suit specific applications.
- .3 Selected channel type to support loading for specific applications in accordance with manufacturer limitations.

2.11 FINISHES

- .1 Factory finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel, with colour finish. Review finishes with Departmental Representative during shop drawing submission and before manufacturing.
- .2 Paint outdoor electrical equipment "equipment green" finish.
- .3 Paint indoor switchgear and distribution enclosures light gray.

2.12 SPRINKLER PROTECTION

- .1 Provide drip shields for protection of surface mounted equipment enclosures from water spray and dripping of liquids. Features of shields:
 - .1 Factory constructed by respective equipment manufacturers.
 - .2 Constructed from non-combustible materials (sheet steel).
 - .3 Enamel painted to match equipment.
 - .4 Surfaces and edges filed or sanded smooth prior to painting.
 - .5 Mechanically supported from equipment with structural steel rods or metal framing or other similar means by equipment manufacturer.
 - .6 Structural support finish painted to match shield.

- .2 Include with equipment shop drawings, detailed dimensions of drip shields and methods of supporting.
- .3 Provide equipment with top cable or conduit entries, additional sealing of entries with gasketing or waterproof sealant to prevent water from entering enclosure.
- .4 Ventilation louvers provide live components from exposure to water spray and dripping liquids.
- .5 Above requirements are additional minimum "sprinkler protection" standards for equipment specified as NEMA 1, 2 or 12.
- .6 Obtain CSA approval where required by local governing authorities.

2.13 SLEEVES

- .1 For poured concrete construction:
 - .1 Galvanized sheet steel: Minimum 1.6 mm thick galvanized steel with integral flange at one end to secure sleeve to formwork construction.
 - .2 Polyethylene: Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses. Use where permitted by local governing authorities and local codes.
- .2 For waterproof sleeves in new poured concrete construction: Schedule 40 waterproof mild galvanized steel pipe with welded-on square steel anchor and water stop plate at sleeve midpoint.
- .3 For masonry and drywall construction:
 - .1 Schedule 40 mild galvanized steel pipe.
 - .2 Class 4000 cast iron pipe.

2.14 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Asbestos-free, elastomeric materials and intumescent materials, tested, listed and labelled by ULC in accordance with CAN/ULC-S115, and CAN/ULC-S101 for installation in ULC designated firestopping, and smoke seal systems to provide a positive fire, water and smoke seal and a fire resistance rating (flame, hose stream and temperature) no less than fire rating for surrounding construction.
- .2 Firestopping and smoke seal material system to be specifically ULC certified with designated reference number for its specific installation. As part of shop drawing submission, submit copies of firestopping drawings with ULC certificate and system number for each specific installation.
- .3 Smoke and fire seal materials and manufacturers must be specifically approved for each application of penetrated surfaces, and as confirmed with Departmental Representative as approved by FM Global and listed in FM Global Approval Guide. As part of shop drawing submission, submit copies of firestopping drawings with FM Global Approval Guide.
- .4 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports, and anchoring devices in accordance with

firestopping manufacturer's recommendations and ULC tested assembly. Coordinate material requirements with trades supplying abutting areas of materials.

- .5 Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- .6 Supply products of a single manufacturer for use on work of this Division.
- .7 Installer to be manufacturer trained and certified on specific product. Submit copy of certificate with shop drawings.
- .8 Include for manufacturer's authorized representative to inspect and verify each installation and application. Submit test report signed and verified by system installer authorized representative and manufacturer's representative.
- .9 Acceptable certification to also include certification by Underwriters Laboratories of Northbrook IL, using tests conforming to CAN/ULC-S115 and given cUL listing published by UL in their "Products Certified for Canada (cUL) Directory".
- .10 Refer to additional requirements of Section 07 84 00.

2.15 ACCESS DOORS

- .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 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. All other doors to be prime painted steel.
- .3 Size access door 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 for hand entry and 600 mm x 600 mm for body entry.
- .4 Lay-in type tiles, properly marked, may serve as access panels. Coordinate marking of ceiling tiles with Departmental Representative. Panels in glazed tile walls to be 2.6 mm thick, 304 alloy stainless steel, No. 4 finish, with recessed frame secured with stainless steel counter-sunk flush head screws.
- .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.
- .6 Other access doors to be welded 2.6 mm thick steel, flush type with concealed hinges, lock and anchor straps, complete with factory prime coat. Submit to Departmental Representative for review, details of non-standard door construction details.

- .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.
- .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.

2.16 EQUIPMENT BACKBOARDS

- .1 FSC (Forest Stewardship Council), G1S (good one side) construction grade fir plywood, containing no added urea formaldehyde, flame retardant prime coat painted on exposed surfaces, minimum 20 mm thick, as sized on drawings and with flame spread rating in accordance with local governing building code requirements.
- .2 Fire retardant treated plywood: Douglas Fir to CSA O121, G1A, fire retardant treated to CAN/CSA-O80, maximum flame spread 25, maximum smoke developed 25. Backboard: 19 mm thick, sanded to Table E-1.

2.17 ESCUTCHEON PLATES

- .1 One-piece or split #4 finish type 302 stainless steel plates with matching screws for attachment to building surface, each plate sized to completely cover sleeve or building surface opening, and to fit tightly around conduits.

2.18 EQUIPMENT SUPPORTS

- .1 Design, construct and install metal supports, stands, platforms and other metal structures required for and associated with equipment. Design equipment supports to properly distribute loads and impact loads onto building structure.
- .2 Where equipment is indicated or specified to be floor mounted on stands or legs, fabricate these from structural steel section or steel pipe with adequate bracing and steel plate flanges for bolting to concrete housekeeping pad.
- .3 Where ceiling or wall mounting is indicated on drawings or specified, provide suspended platform, bracket or shelf, whichever is most suitable for equipment and its location. Fabricate from standard structural steel sections and plate or steel pipe. Securely fasten structures to building structure.
- .4 Provide supports large enough to support equipment along entire length and width. Install isolators when necessary, either below support or between support and equipment.

2.19 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

- .1 Perform electrical equipment installation in accordance with local governing authority seismic requirements, and NBC and OBC seismic requirements, applicable for building designation.
- .2 Provide labour, materials, and equipment required and necessary to seismically restrain electrical equipment and equipment bases including concrete pads, and guarantee function of materials and

equipment supplied. Provide seismic requirements for suspended electrical raceways and luminaires.

- .3 Make electrical connections to vibration-isolated equipment with flexible conduit or other flexible means acceptable to Departmental Representative and local governing authority so as not to restrict maximum anticipated movement of equipment under seismic excitation movement.
- .4 Isolation product manufacturer seismic restraint engineer to verify that seismic restraints and combination isolator/restraints intended for use on project are fit for intended purpose and are in accordance with applicable local building code requirements for Place of Work.
- .5 Test and adjust installation in accordance with product manufacturer instructions.
- .6 Certify installation is in accordance with local governing authority requirements. Obtain required certificates of approvals.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions
 - .1 Verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for respective product installation in accordance with manufacturers written instructions.
 - .2 Verify that conditions are acceptable for product installation in accordance with manufacturers written instructions and for work of respective Sections.
 - .3 Field verify building and site dimensions prior to fabrication and installation of equipment or materials.
- .2 Visually inspect in presence of Departmental Representative.
- .3 Report to Departmental Representative, conditions that hinder or obstruct installation work beyond intent of issued Documents.
- .4 Proceed with installation only after these conditions have been remedied, and reviewed with Departmental Representative.

3.2 LAYOUT AND COORDINATION OF WORK

- .1 Cooperate and coordinate with other Divisions as required for completion of the Work and to avoid interference with work by other Sections. Coordinate locations of conduits, raceways, junction and pull boxes, with other Divisions as well as other pertinent trades.
- .2 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings. Lay out work for proper execution of work.

- .3 Examine drawings to verify work can be performed without changes to building as shown on plans.
- .4 Plan, coordinate, and establish exact locations and routing of services with affected trades prior to installation such that services clear each other as well as other obstructions.
- .5 Prepare plan and interference drawings of work for coordination with each trade. Prepare detailed section drawings of ceiling spaces, areas of shafts, rooms and ceilings which are highly congested and for which site workers could not solve construction coordination issues. Section drawings to indicate lateral and elevation dimensions of major services within spaces. These drawings propose solutions for trades affected.
- .6 Prepare and submit drawings showing sleeving, recessed and formed holes required in concrete for electrical work. Prepare drawings in conjunction with other trades. Prepare drawings to a scale sufficient to show necessary details. Submit for review using same procedures as specified for shop drawings.
- .7 Dimension sleeves, recesses and openings with respect to building elevations and established grid lines.
- .8 Instruct and supervise those Divisions doing related work.
- .9 Supply measurements of equipment to other Divisions to allow for necessary openings in their work.
- .10 Locate equipment to maximize usable space. Install raceways, fittings, pull boxes, junction boxes, concealed wiring and cables, close to building structure in order that furring is as small as possible.
- .11 Prior to commencing work, review relevant shop drawings and product data of other Divisions where they affect work of this Section.
- .12 Refer to mechanical drawings when coordinating locations of starters, variable frequency drives, motors, panels, and connected equipment.
- .13 Review and coordinate equipment deliveries with manufacturers and suppliers, and Departmental Representative so equipment is delivered to site when it is required, or so it can be stored and protected from elements within building, subject to available space.
- .14 Coordinate various low voltage systems. Perform following:
 - .1 Coordinate with trades of various systems which are interfaced with, monitored by, integrated to.
 - .2 Prepare systems coordination drawings detailing related system coordination and integration points.
 - .3 Coordinate security system requirements with successful door hardware supplier and prepare detailed coordination drawings of component installations, sequence of operations, wiring and conduit layouts and division of responsibility between various trades.

- .4 Review systems requirements for power supplies, communication interface protocols, component back boxes and conduits.
- .5 Be present at testing and commissioning functions of each system and provide technical assistance.
- .6 Document coordination and integration requirements and maintain records for submission as part of shop drawings.

3.3 GENERAL INSTALLATION REQUIREMENTS

- .1 Provide complete and fully tested operational equipment and systems in accordance with specified requirements, CSA C22.1, OESC, and product manufacturer instructions, except where specified otherwise.
- .2 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.
- .3 Refer to drawings, details and schedules for additional requirements.
- .4 Install equipment with access and service clearances around equipment, and with space for future equipment removal and replacement. Provide access and service space provisions around equipment in accordance with requirements of local governing authority codes and standards.
- .5 Provide adequate clear space for equipment designated as supplied by others and provide connections for such equipment. Provide detailed layouts for review with Departmental Representative, prior to commencing work.
- .6 Leave clear, spaces reserved for equipment noted as future on drawings, allowing for future connections.
- .7 Secure floor mounted equipment in place on minimum 100 mm high concrete housekeeping pads, minimum 100 mm wider and longer than equipment base dimensions. Provide vibration isolation and seismic controls as specified.
- .8 Departmental Representative reserves right to relocate electrical components such as receptacles, switches, communication system, outlets, hard wired outlet boxes and luminaries from original designed location, but prior to surfaces installations and component installations, without additional cost, and relocation per component does not exceed 3 m from original location.

3.4 SERVICE AND MAINTENANCE ACCOMMODATION

- .1 Install equipment with access and service clearances around equipment, and with space for future equipment removal and replacement. Provide access and service space provisions around equipment in accordance with requirements of local governing authority codes and standards.
- .2 Install equipment and controls, in manner to facilitate proper maintenance and ease of repair or replacement.

- .3 Provide maintenance platforms, safety rails, ladders, and other products, to facilitate maintenance of equipment which is not readily and safely accessible by ladder or from floor.

3.5 INSTALLATION OF NAMEPLATES AND SIGNAGE

- .1 Provide nameplates and signage as specified.
- .2 Provide warning signage as specified, in accordance with requirements of local governing codes and requirements of authorities having jurisdiction.
- .3 Verify manufacturer nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.
- .4 For identification nameplates and signage, review nomenclature, sizing, colours and print type with Departmental Representative. Obtain local authority having jurisdiction approval, where required.
- .5 Secure nameplates and signage with mechanical stainless-steel screws.

3.6 CONDUIT AND CABLE INSTALLATION

- .1 Install conduit and sleeves prior to pouring of concrete.
- .2 Size sleeves for free passage of conduit, and protruding 50 mm.
- .3 Do not use plastic sleeves in fire rated walls or floors.
- .4 Install cables, conduits and fittings embedded or plastered over, close to building structure so furring can be kept to minimum.

3.7 LOCATION OF OUTLETS

- .1 Locate outlets in accordance with Section 26 05 32.
- .2 Do not install outlets back-to-back in wall. Allow minimum 150 mm horizontal clearance between boxes.
- .3 Change location of outlets at no extra cost or credit, providing distance does not exceed 3000 mm, and information is given before installation.
- .4 Locate light switches on latch side of doors.
- .5 Locate disconnect devices in mechanical and elevator machine rooms on latch side of doors.

3.8 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to centreline of equipment or indicated otherwise.
- .2 Where mounting height of equipment is not specified or indicated, review with Departmental Representative before proceeding with installation.
- .3 Install electrical equipment at following heights or otherwise required to comply with accessibility requirements of governing building code.
 - .1 Local Switches: 1400 mm (or to comply with accessibility requirements of local governing building code).

- .2 Wall Receptacles:
 - .1 General: 300 mm.
 - .2 Above top of continuous baseboard heater: 200 mm.
 - .3 Above top of counters or counter splash backs: 175 mm.
 - .4 In mechanical rooms: 1400 mm.
- .3 Panelboards: As required by local governing code or as indicated.
- .4 Telephone and interphone outlets: 300 mm.
- .5 Wall mounted telephone and interphone outlets: 1500 mm.
- .6 Fire Alarm Stations: 1500 mm (or to comply with accessibility requirements of governing building code).
- .7 Fire Alarm Bells: 2100 mm.
- .8 Television Outlets: 300 mm.
- .9 Wall Mounted Speakers: 2100 mm.
- .10 Clocks: 2100 mm.
- .11 Door Bell Pushbuttons: 1500 mm or to comply with accessibility requirements of governing building code).
- .4 For barrier free access installation, install control devices at following heights. Mounting height of equipment is from finished floor to top of equipment. Refer to drawings for barrier free areas.
 - .1 Local Switches: 1050 mm.
 - .2 Wall Receptacles: 400 mm.
- .5 Review mounting heights with Departmental Representative, prior to start of Work.

3.9 INSTALLATION OF SLEEVES

- .1 Where conduits, round ducts and conductors pass through structural poured concrete or masonry surfaces, provide sleeves as specified, of type suitable for application, and approved by local governing codes.
- .2 Install sleeves of type and as sized as specified or on drawings.
- .3 Submit to concrete reinforcement detailer at proper time, drawings indicating required sleeves, recesses and formed openings in poured concrete work or masonry work. Dimension such drawings and relate sleeves, recesses and formed openings to suitable grid lines and elevation datum.
- .4 Size sleeves to leave 13 mm clearance around conduit, duct, conductor, and other material passing through openings. Pack and seal void between sleeves and conduit, duct, conductors and other material passing through opening, for length of sleeves with materials as specified in this Section and Section 07 84 00 and in Section 07 92 00.
- .5 Provide firestopping and smoke seal materials in fire rated construction.
- .6 Provide acoustic seals for openings in partitions.

- .7 Provide water-tight seals for exterior walls, or walls in contact with moisture.
- .8 Supply sleeves of water protecting type in following locations:
 - .1 Mechanical and Fan Room floor slabs, except where on grade.
 - .2 Slabs over Mechanical, Fan, Electrical and Telephone Equipment Rooms or closets.
 - .3 Floors equipped with waterproof membranes.
 - .4 Roof slabs.
 - .5 Waterproof walls.
- .9 Do not provide "Gang" type sleeving.
- .10 Terminate sleeves for work which is exposed, so that sleeve is flush at both ends with wall, partition, or slab surface such that sleeve may be covered completely by escutcheon plates.
- .11 Where sleeves are provided in non-fire rated construction for future conduits and ducts, cap and seal both ends of sleeved opening.
- .12 Where conduits or duct is removed from existing sleeves, cap and seal both ends of sleeved opening.
- .13 Coordinate below grade penetrations with waterproofing systems, and with damp proofing systems.

3.10 INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Where work penetrates or punctures fire rated construction, provide ULC certified, listed and labelled firestopping and smoke sealing packing material systems to seal openings and voids around and within raceway and to provide continuity and integrity of fire separation is maintained.
- .2 Install firestopping and smoke seal materials for each installation in strict accordance with specific ULC certification number and manufacturer's instructions. Comply with local governing building code requirements and obtain approvals from local building inspection department. Ensure that openings through fire separations do not exceed maximum size wall opening, and maximum and minimum dimensions in accordance with respective ULC listings.
- .3 Ensure that continuity and integrity of fire separation is maintained and conform to respective ULC listings.
- .4 Where work requires removal of existing firestopping materials and replacement of firestopping materials after cabling changes have been made, ensure that replacement material is same material and manufacturer of existing if any remains in place, or ensure that all existing material is removed before installation of replacement material.
- .5 Refer to Section 07 84 00 for additional installation requirements.

3.11 SUPPLY OF ACCESS DOORS

- .1 Supply access doors to give access to junction boxes, pull boxes, conductor joints and other similar electrical work which may need maintenance or repair, but which is concealed in inaccessible construction.
- .2 Before commencing installation of 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 Departmental Representative's review and show exact sizes and locations of such access doors. Locate and arrange electrical work to suit.
- .3 Access doors to 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.
- .4 Wherever possible, access doors to be of a standard size for each application. Confirm exact dimensions and minimum size restrictions with Departmental Representative prior to ordering.
- .5 Coordinate with Mechanical Contractor and General Trades Contractor to ensure that access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and that work involving both mechanical and electrical services should where possible be accessible from common access door. Coordinate work to ensure that common location access doors are not supplied by both Mechanical Divisions and Electrical Divisions.

3.12 INSTALLATION OF BACKBOARDS

- .1 Provide backboards for systems and equipment.
- .2 Securely wall mount each backboard with proper fasteners to suit wall construction.
- .3 Size backboards to sufficiently provide adequate terminal space for each system, plus 20% space for future additions. Provide back boards of dimensions where identified.

3.13 INSTALLATION OF ESCUTCHEON PLATES

- .1 Provide escutcheon plates suitably secured over exposed conduits passing through finished building surfaces. Finished building surface is surface with factory finish or that receives site applied finish.
- .2 Install plates so they are tight against building surface concerned, completely covering sleeves and openings, except where waterproof sleeves extend above floors, in which case fit plate tightly around sleeve.

3.14 INSTALLATION OF HANGERS AND SUPPORTS

- .1 Secure equipment to surfaces with nylon shields or lead anchors to suit types of surfaces and applications.
- .2 Secure equipment to poured concrete with expandable inserts.

- .3 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .4 Secure surface mounted equipment with twist clip fasteners to inverted T bar ceilings. Support T bars to carry weight of equipment specified.
- .5 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories, to basic channel members.
- .6 Fasten exposed conduit or cables to building construction or support system using straps, by means as follows:
- .7 One-hole steel straps to secure surface conduits and cables 50 mm and smaller.
- .8 Two-hole steel straps for conduits and cables larger than 50 mm.
- .9 Beam clamps to secure conduit to exposed steel work.
- .10 Suspended support systems:
- .11 Support individual cable or conduit runs with not smaller than 6 mm diameter threaded rods and spring clips.
- .12 Support 2 or more cables or conduits on channels supported by not smaller than 6 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- .13 For surface mounting of two or more conduits, provide steel C-channels secured to surfaces with manufacturer recommended hardware, to suit application.
- .14 Install C-channel supports in accordance with manufacturer instructions and recommendations, maintaining span and loading limits.
- .15 Provide metal brackets, frames, hangers, clamps and related types of support structures, to support conduit and cable runs.
- .16 Provide support for raceways and cables dropped vertically to equipment where there is no wall support.
- .17 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .18 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade, review with Departmental Representative and obtaining recommendations.
- .19 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer installation recommendations.

3.15 CO-ORDINATION OF PROTECTIVE DEVICES

- .1 Provide and set circuit protective devices such as overcurrent trips, relays and fuses to required values and settings. Refer to requirements of Section 26 05 70.

3.16 ELECTRICAL CONNECTIONS

- .1 Provide electrical connections to equipment. Review shop drawings and coordinate with each equipment vendor, requirements for power feeds, control and communication interconnections, and provide these requirements to complete installations work.
- .2 Provide electrical connections including power and control wiring for equipment supplied by other Divisions. Provide wired and empty conduit systems with fish cord, junction boxes, pull boxes, outlet boxes, faceplates and sleeves. Provide interconnect wiring between remote operator devices, controllers, and equipment being controlled by operator devices. Where equipment is of split unit design and line voltage is required to both units, provide feeders to each unit as coordinated with equipment manufacturer.
- .3 Provide following work:
 - .1 Mounting loose starters and providing "line" and "load" power connections.
 - .2 Providing motor starter panels - conduit work at motor starter panels installed horizontally and vertically plumb; plan installation to avoid crossovers.
 - .3 Making "line" side power connections to motor control centres (MCC) and "load" side connections to motors or other apparatus supplied power from motor control centres.
 - .4 Making "line" side power connections to starters on "packaged" equipment.
 - .5 Providing additional disconnect switches (complete with identification) detailed on drawings, or required by local governing codes, or for apparatus which cannot be seen from its starter or is more than 9 m from its starter.
 - .6 Connections to thermistors and provision of additional relays as required for connections to starters.
 - .7 Performing required motor starter interlocking in accordance with requirements specified and as outlined on MCC and starter schedules. Coordinate interlocking requirements with work of Division 23.
 - .8 In coordination with work of Division 23, providing 120 VAC power feeds to receptacles and luminaires integral with mechanical equipment including air handling units.
 - .9 Verify that identification nameplate is provided on each MCC, VFD, motor starter or disconnect.
 - .10 Connect VFDs and harmonic filters with power, control and monitoring conductors in accordance with manufacturer instructions and local governing electrical code. Provide manufacturer recommended conductors and connectors to suit respective connected equipment. Maintain separation of power and control conductors in accordance to manufacturer requirements to minimize effects of electromagnetic interference. Ground and bond equipment.
 - .11 Other items as indicated on drawings and as noted in Specification.

3.17 PROVISIONS FOR BUILDING AUTOMATION SYSTEM

- .1 Display points and functions of electrical distribution system equipment and other systems on BAS as specified and as scheduled. Provide digital type and analogue communications points, as required.
- .2 Provide wiring, conduit and connections from respective equipment and extend to load side of terminal cabinet. Provide line side wiring, conduit and connections of terminal cabinet and extend to BAS connection points and panels, as coordinated with BAS vendor.
- .3 For potential indications, provide fused disconnect and potential transformer, rated 600/120 V, connected to centre phase.
- .4 Terminal Cabinet
 - .1 NEMA 1, CSA approved.
 - .2 Surface mounted with hinged door and drip shield.
 - .3 Screw type indexed terminals.
 - .4 Of suitable size and labelled with lamaroid nameplate, identifying use, equipment designated number and electrical characteristics.
 - .5 Factory finished painted.
 - .6 Review nameplate nomenclature and finishes with Departmental Representative.
- .5 For each analogue indication, provide two minimum #12 AWG conductor and #12 AWG ground conductor in 13 mm conduit for each function to respective terminal cabinet.
- .6 For each digital function, provide communications and control wiring of type reviewed with respective connected equipment vendors and run in 13 mm conduit for each function to respective terminal cabinet.
- .7 Install terminal cabinets with tops not to exceed 1800 mm above finished floor. Determine exact quantity of cabinets based on BAS circuits in common areas located in same cabinet.
- .8 Provide power feeds (wiring in conduit, breaker circuits) as required to power BAS devices.
- .9 Coordinate requirements with BAS vendor.

3.18 PATHWAYS FOR VARIOUS SYSTEMS

- .1 Provide systems of conduits, raceways, electrical boxes and pull wires, for systems.
- .2 Provide following basic electrical components to accommodate installation of various miscellaneous systems:
 - .1 Conduit: Diameters as sized on drawings with non-metallic fish wires or pull cords and suitable bushings for conduit terminations, and as specified in Section 26 05 34, and respective system trade Section. Provide labelling at each end to clearly identify each conduit run with respect to system and path.
 - .2 Outlet Boxes: Standard galvanized steel, each complete with blank type faceplate and other required types, as specified

- in Section 26 05 32, as specified in respective system trade Section.
- .3 Pull Boxes, junction boxes and back boxes: Types with covers, as specified in Section 26 05 32, and as specified in respective system trade Section.
 - .4 Sleeves: Types as specified in this Section and as specified in respective system trade Sections.
 - .3 Miscellaneous systems are indicated on drawings. Provide dedicated conduit runs for each system. Coordinate sizes of boxes with respective system vendors, to provide proper sizing to accommodate components and sufficient wiring bending radii. Review conduit and box requirements with system vendors.
 - .4 Provide pull boxes in conduit runs longer than 30 m or having more than two 90° bends. Size pull boxes at least 8 times entering conduit in length. Size pull box in accordance with respective system standards.
 - .5 Leave conduits free and clear of obstructions and terminate as required. Equip terminations with bushings, and clearly identify each run. Provide fish wires in empty conduits. Run telecommunications conduits with separation from sources of electromagnetic radiation in accordance to TIA 569. Site bend telecommunications conduit elbows in accordance with system conduit bending radii requirements.
 - .6 Prior to roughing-in, review exact requirements and locations of equipment with Departmental Representative and respective system installers.
 - .7 Refer to system riser diagrams on drawings.
 - .8 Determine quantities for outlets in accordance with floor plan drawings and not riser diagrams.

3.19 PROVISIONS FOR DOOR HARDWARE

- .1 Coordinate supply and installation of door alarm contacts, door holders, electric strikes, electromagnetic locks, door operator controls, power supplies, door controllers, central electromagnetic lock release controller and other door hardware, with respective trades.
- .2 Review product voltage and wiring requirements, back box requirements and wiring installation requirements with door hardware trades and with equipment vendors. Provide wiring in conduit from each device to respective controllers, between each device, and to central control panel and for power connection to such controls and devices. Provide line level voltage power feeds to equipment, as required.
- .3 For controls and interconnections between devices, supply and run interconnecting wiring in conduit to devices and allow spare length of 1.8 m coiled wiring at each end for final termination to devices.
- .4 For applications of electro-magnetically held closed doors, engage fire alarm system vendor to provide fire alarm type pull station with auxiliary contacts for interconnection of electro-

magnetic door hardware and fire alarm system, for release of doors. Provide wiring in conduit and connections. Review pull station requirements with fire alarm system vendor.

- .5 Review type of door alarm contacts with door construction and finishes. Provide recessed mounted contacts and install wiring in concealed conduits. Review requirements with door hardware and security vendor
- .6 Where controls are located remotely from door locations, such as in closets, provide wiring in conduit and extend from secured side above door, junction boxes and devices, with homeruns back to closet location of equipment and leave slack wiring for terminations. Review requirements with door hardware and security vendor and review with Departmental Representative.
- .7 Submit as part of shop drawing submission, detailed responsibility matrix identifying work and responsibilities of each trade and required interconnections.
- .8 Refer to respective trades Sections for additional requirements.

3.20 CLEANING

- .1 Progress Cleaning
 - .1 Clean in accordance with Section 01 74 11.
 - .2 Leave Work area clean at end of each day.
- .2 Final Cleaning
 - .1 For work performed in electrical equipment rooms, electrical closets and communication closets, perform following:
 - .1 HEPA vacuum top of panels, cabinets, raceways and conduits in room, followed by thorough HEPA vacuuming of floors.
 - .2 Clean luminaire reflectors, lenses, and other luminary surfaces that have been exposed to construction dust and dirt, including top surface, whether it is exposed or in ceiling space.
 - .3 Clean switches, receptacles, communications outlets, cover plates, and exposed surfaces.
 - .4 Clean other electrical equipment and devices.

3.21 PROTECTION

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.
- .2 Protect personnel on job site from injury due to live equipment and circuits.
- .3 Arrange for installation of temporary doors for rooms containing electrical distribution equipment. Keep these doors locked except when under direct supervision of electrician.
- .4 Protect concrete floors and finished flooring from damage. Provide additional measures when moving heavy loads or equipment.
- .5 Keep floors free from oils, grease or other materials likely to discolour them or affect bond of applied surfaces.

- .6 Attach and fasten fixtures and fittings in place in safe, sturdy, secure manner so that they cannot work loose, fall or shift out of position during normal use of building.
- .7 Protect finished and unfinished work from damage due to carrying out of this work.
- .8 Make good damages caused directly or indirectly by work to walls, floors, ceilings, woodwork, brickwork, finishes, structures and existing installations.

3.22 INTERRUPTIONS TO AND SHUT-DOWNS OF SERVICES AND SYSTEMS

- .1 Shutdowns and interruptions to existing systems and services are to be coordinated fully with and performed at times acceptable to Departmental Representative. Include for costs of premium time to perform work during nights, weekends or other times outside of normal working hours, which may be necessary to comply with stipulations specified herein this Article. Services for operation of existing non-renovated areas of building are to be maintained.
- .2 Upon award of contract, submit to Departmental Representative for review and approval, a list of anticipated shut-down times and their maximum duration.
- .3 Prior to each shut-down or interruption, inform Departmental Representative in writing minimum 7 working days unless otherwise specified in Division 01, 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 written consent. Note that shutdowns of some essential services may require additional advance notification time.
- .4 Work associated with shut-downs and interruptions are to be carried out as continuous operations to minimize shut-down time and to reinstate systems as soon as possible. Prior to any shut-down, ensure that materials and labour required to complete work for which shut-down is required are available at site.
- .5 Confirm any methods of procedures with Departmental Representative prior to start of work.

3.23 EXISTING BUILDING RELATED WORK

- .1 Visit site to examine and familiarise with existing systems and installations and other conditions affecting the Work.
- .2 Provide electricians licensed in place of Work to perform electrical disconnections. As required, disconnect electrical system circuits and feeders at power source.
- .3 Maintain in operation, existing installations retained in and around areas being renovated, maintaining conditions as follows:
 - .1 Without restrictions on hours of work and access to areas.
 - .2 There are no disruptions to operations in adjoining and other areas. Provide required temporary bypass installations being removed after permanent installations/ changes are complete.

- .3 When respective work is deleted, such deletions are to in no way affect operation of existing interconnected mechanical or electrical components that remain. When existing circuits are being disconnected, maintain supervision of area such that circuits do not affect essential existing circuits being retained.
- .4 Where existing services pass through or are in area to serve items which are to remain, or pass through areas being deleted, maintain services, but re-route as required. Rerouting existing services concealed behind existing finishes and which become exposed during renovation work, and conceal behind new or existing finishes. Review with Departmental Representative services being kept in service and operational.
- .4 For site related work:
 - .1 Protecting existing electrical services including power, against damage during entire construction period.
 - .2 Removing from site, existing materials that are removed and designated as obsolete. Review such materials with Departmental Representative. Transport materials being retained, to storage area designated by Departmental Representative.
- .5 Where indicated on drawings or where required to perform Work of this Project, disconnect and remove items of existing obsolete electrical work. Relocate required devices as required to accommodate work of other Divisions. Where luminaires, switches, receptacles, and other devices and equipment is removed, disconnect at point of electrical supply, remove obsolete wiring and conduit up to source. Remove obsolete conduit/raceways in accessible ceiling spaces, exposed locations, and other indicated locations. Where existing obsolete conduit and similar raceway material cannot be removed, such as embedded in concrete, cut back and cap obsolete conduit and raceways. Refer to specific notes on drawings.
- .6 When relocating luminaires, inspect luminaire for circuit identification and identify circuiting on as-builts if circuiting is maintained. Prior to removing luminaries, remove lamps and glass.
- .7 Refer to applicable drawings which define extent of areas being demolished in existing building. Review drawings and site and demolition and renovation of services as required to accommodate alterations detailed.
- .8 Provide revised typed panelboard directories when affected by renovation, disconnection, or removal of work. Use actual room names/numbers.
- .9 Protect existing devices being relocated to prevent damage to devices. Test such devices prior to disconnection and de-energization, to verify that each device is in working condition. Examine and test that motors are in proper rotation direction. Report devices not working or with damage, to Departmental Representative prior to initiating work.

- .10 Provide junction boxes, outlet boxes, wiring, plates and conduits, as necessary for complete relocation of devices. Clean relocated or temporary removed devices and equipment and test to verify that they are in good operating condition before being reinstalled. Where existing luminaires are relocated, clean luminaires and inspect for damage. Report defects or damages to Departmental Representative. Splice conductors only with Departmental Representative's review and recommendation, and with provision of junction boxes and terminal devices for proper extension of circuits. Otherwise, replace circuits with continuous home runs extending from devices to circuit panel.
- .11 Provide blank cover plates on existing obsolete boxes which remain in position, as reviewed with Departmental Representative.
- .12 After installation is complete, test parts of re-used or relocated electrical equipment and correct faults and grounds. Provide for fire alarm verification company to verify relocated devices and downstream affected devices, and test and verify system as required by local fire authority to suit actual relocation work. For other existing systems, engage manufacturers authorized representative or existing system maintenance contractor reviewed with Departmental Representative, to inspect, test and verify relocated devices. Review exact requirements with Departmental Representative. Document testing in test reports, signed by testing technician. Submit copies to Departmental Representative.
- .13 Maintain in operation, interior, exterior or underground electrical services (including auxiliary services, telephone, fire alarm, P.A. and other communications systems) to operating parts of building. Maintain existing risers in service as required to feed other areas of building(s). Do not interrupt services without review with Departmental Representative and prior written recommendations or instructions from Departmental Representative. Submit formal requests to Departmental Representative outlining in detail, requirements of proposal.
- .14 Where references are made on drawings that existing receptacles and other wiring devices be extended and relocated to suit new construction, test devices and when found defective, replace with new devices. Test and verify operation of replacement devices. Replace cracked or broken cover plates with plates finishes reviewed with Departmental Representative.
- .15 Disconnect power supply to branch circuits controlling lighting, receptacles, panels and mechanical equipment, for safe removal of equipment, conduit, wiring and boxes, affected by demolition.
- .16 Close openings in and around boxes, panels, fixtures and devices, that result from their removal. Close openings with patching suitable for application and terminate and insulate cables to restore system to safe operating condition.
- .17 Disconnect and remove electrical equipment, luminaires, communication devices, and other system components, during demolition of ceilings, walls, floors and structures. Temporarily relocate until demolition work is completed, existing equipment not relocated but interferes with demolition. Maintain in

operation services to temporarily relocated equipment. Test and verify operation of equipment and devices temporarily relocated.

- .18 Remove underground cables and cut back conduit systems to depth of 600 mm below finished grade and abandoned in place.
- .19 Check luminaires designated for deletion, for PCB type ballasts. Disconnect and remove such ballasts. Remove and dispose such materials off-site in accordance with Ministry of Environment, Ministry of Transport and other governing authority having jurisdiction regulations.
- .20 Check transformers designated for deletion, for PCBs materials. Decommission, disconnect and remove transformers and PCB wastes off-site in accordance with Ministry of Environment, Ministry of Transport and other governing authority having jurisdiction regulations.
- .21 Decommission, disconnect and remove transformers designated for deletion and not containing PCBs, off site or salvaged and transported to storage sites, as reviewed with Departmental Representative.

3.24 CUTTING AND PATCHING

- .1 Prior to drilling or cutting openings, determine by review with Departmental Representative, and with use of non-destructive radar scan (magnetic scan) of slab or wall, presence of existing services and reinforcement bars concealed behind building surface being cut. Locate openings to suit. Coring is not permitted through concrete beams or girders.
- .2 Provide holes and chases in existing structures as required for electrical work.
- .3 Review with and obtain recommendations from Departmental Representative prior to cutting or drilling structural elements.
- .4 Core drill or saw cut opening of size to leave minimum 13 mm clearance around materials passing through opening.
- .5 Provide packing and sealing void between opening and material passing through opening for length of opening. Refer to requirements of Section 07 84 00 and in Section 07 92 00.
- .6 Coordinate requirements with respective trades.
- .7 Refer to drawing notes.

3.25 PAINTING REPAIRS AND RESTORATION

- .1 Coordinate responsibilities for painting repairs and restoration.
- .2 Perform painting in accordance with Section 09 91 23.
- .3 Prime and touch up marred finished paintwork to match original.
- .4 Restore to new condition, damaged finishes.

3.26 SYSTEM STARTUP

- .1 Instruct operating personnel in operation, care and maintenance of systems, system equipment and components.

- .2 Provide services of manufacturers factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- .3 Provide these services for such period, and for as many onsite visits as necessary to put equipment in operation and train operating personnel on aspects of operation and maintenance.
- .4 Refer to additional requirements of Section 26 05 70.

3.27 FIELD QUALITY CONTROL

- .1 Perform testing and verification work in accordance with requirements of following Sections:
 - .1 Section 01 45 00.
 - .2 Section 26 05 70.
- .2 Test equipment for proper operation and performance, meeting specification requirements and requirements of local governing authority having jurisdiction. Perform tests in presence of Departmental Representative and Commissioning Agent. Commissioning Agent and Departmental Representative to have option to attend and witness testing. Review and coordinate administration.
- .3 Prepare test and verification reports with documented results and comments, signed by testing technician, or where specified signed and sealed by Professional Engineer. Submit hard copy and electronic PDF copy of report to Departmental Representative.
- .4 Manufacturer Technician Field Services
 - .1 Provide manufacturer technician field services for products and systems as specifically requested for in Sections.
 - .2 Obtain written report or certification letter, from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer Field Reports as described in Part 1 - Action and Informational Submittals.
 - .3 Provide manufacturer technician field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer instructions.
- .5 Perform commissioning of electrical work in accordance with Section 01 91 13.

3.28 SEMI-FINAL AND FINAL INSPECTIONS

- .1 Refer to Section 01 77 00.
- .2 Review scheduling requirements with Departmental Representative and obtain recommendations.
- .3 Semi-Final Inspections
 - .1 Prior to semi-final inspection, provide list of items which are either not finished or deficient at time of semi-final inspection.

- .2 Perform following items prior to semi-final inspection. Provide declaration in writing that following items listed are completed:
 - .1 Systems capable of operation with controls functional and automatic controls generally in operation.
 - .2 Necessary tests on equipment made including tests required by local governing authorities and certificates of approval obtained.
 - .3 Equipment set-up and start-up procedures completed in accordance with manufacturer data.
 - .4 Equipment testing and identification completed.
 - .5 Warranty forms completed and registered with manufacturer. Include copies of original warranties with O&M manuals.
 - .6 Sample of O&M manuals submitted. Operating and maintenance instructions, and schedule submitted for Departmental Representative review.
 - .7 Access doors inspected and verified in suitably location and equipment including plumbing cleanouts, are easily accessible.
- .4 Final Inspections
 - .1 Submit to Departmental Representative, written request for final inspection of systems. Include written certification that:
 - .1 Deficiencies noted during job inspections and semi-final inspections have been completed.
 - .2 Field quality control procedures have been completed.
 - .3 Systems have been tested and verified, balanced and adjusted, and are ready for operation.
 - .4 Final calibration of controls completed.
 - .5 Maintenance and operating data have been completed and submitted to, reviewed with Departmental Representative and accepted.
 - .6 Nameplates are in place and equipment identifications have been completed.
 - .7 Clean-up is complete. Equipment cleaned inside, outside and lubricated.
 - .8 Spare parts and replacement parts specified have been provided, as reviewed with Departmental Representative.
 - .9 As-built and record drawings have been completed and submitted to and reviewed with Departmental Representative and accepted.
 - .10 End users have been instructed in operation and maintenance of systems.
 - .11 Commissioning procedures have been completed.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 38-18, Thermoset-insulated Wires and Cables (Trinational Standard with UL 44 and ANCE NMX-J-451).
 - .2 CSA C22.2 No. 123-16, Metal Sheathed Cables.
 - .3 CSA C22.2 No. 127-18, Equipment and Lead Wires.
 - .4 CSA C22.2 No. 214-17, Communications Cables (Bi-National Standard, with UL 444).

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.
- .4 Submit testing and verification reports.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 GENERAL BUILDING WIRES

- .1 CSA approved, ULC labelled and certified. Provide copper conductors suitable for applications as noted in governing local electrical code and as specified.
- .2 RW90 XLPE
 - .1 To CSA C22.2 No. 38.
 - .2 Single copper conductor, 1000 V, maximum 90°C conductor temperature, -40°C minimum installation temperature.
 - .3 X-link polyethylene (XLPE) insulation, colour coded.
- .3 RWU90 XLPE
 - .1 To CSA C22.2 No. 38.
 - .2 Single copper conductor, 1000 V, maximum 90°C conductor temperature, -40°C minimum installation temperature.
 - .3 Extra thickness X-link polyethylene (XLPE) insulation suitable for wet and buried installations, colour coded.

2.2 CONTROL CABLES

- .1 Type LVT 30 V Control Cable
 - .1 CSA approved, FT4 rated.
 - .2 Soft annealed copper conductors, sized as required or as indicated.
 - .3 Insulation: PVC thermoplastic.
 - .4 Sheath: PVC thermoplastic jacket standard, with armour of closely wound aluminum wire where required for additional protection.
 - .5 60°C temperature rating.
 - .6 Where installed in plenums, cable certified to C22.2 No.214 and FT6 rated.
- .2 Type LVT 300 V Control Cable
 - .1 CSA approved, FT4 rated.
 - .2 Solid annealed copper conductors sized as indicated.
 - .3 Insulation: Polyethylene.
 - .4 Overall Covering: PVC jackets.
 - .5 Where installed in plenums, cable certified to C22.2 No. 214 and FT6 rated.
- .3 Type TEW
 - .1 ULC listed and labelled, CSA certified to C22.2 No. 127.
 - .2 Solid bare copper conductor, rated for 600 volts, No. 18 AWG.
 - .3 Thermoplastic insulated with nylon overall jacket.
 - .4 105°C conductor temperature.
 - .5 Complete with required number of copper conductors and colour coding.
- .4 Provide other types of control wiring reviewed with respective equipment manufacturer requirements and in accordance with applicable local electrical code requirements.

2.3 CABLE FOR VARIABLE FREQUENCY DRIVES

- .1 CSA approved to C22.2 No. 123.
- .2 Flame, oil and UV resistant cable with copper conductors, corrugated continuous aluminum sheath and bonding conductors.
- .3 Impact and crush resistant.
- .4 Temperature rating: 90°C to -40°C.
- .5 1000 V 90°C rated cross link polyethylene insulation.
- .6 FT4 PVC jacket.
- .7 As recommended by connected variable frequency drive manufacturer.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 PROJECT CONDITIONS

- .1 Verify that field measurements and conditions are as identified.
- .2 Cable routing on drawings is schematic and approximate and not reflective of elevations. Route cable as required to meet project conditions. Determine exact routing and lengths on site.
- .3 Review local governing building code requirements for fire protection ratings of rooms and pathways construction, to determine fire rating requirements for conductor runs. Include fire rated conductors as required to meet local governing code requirements.

3.3 CO-ORDINATION

- .1 Co-ordinate work with work provided under other electrical work and work of other trades.
- .2 Determine required separation between cable and other work.
- .3 Determine cable routing to avoid interference with other work.
- .4 Submit proposed alternative cable routing to Departmental Representative for review and recommendations, prior to proceeding with work.

3.4 GENERAL CABLE INSTALLATION

- .1 Terminate cables in accordance with Section 26 05 20.
- .2 Cable Colour Coding: To Section 26 05 00.
- .3 Conductor length identical for parallel feeders.
- .4 Lace or clip groups of feeder cables at distribution centres, pull boxes, and termination points.
- .5 Wiring in Walls: Drop or loop vertically from above to better facilitate future renovations. Avoid wiring from below and horizontal wiring in walls.
- .6 Provide branch circuit wiring for surge suppression receptacles and permanently wired computer and electronic equipment as 2-wire circuits only. Common neutrals not permitted.
- .7 Provide numbered wire collars for control wiring. Numbers to correspond to control shop drawing legend. Obtain wiring diagram for control wiring.
- .8 Conductor sizes, where indicated on drawings, are minimum requirements. Increase where required, to suit length of run and voltage drop in accordance with local governing authority electrical code. Size conductors not sized or specified of type, in accordance with requirements of local governing electrical code.

- .9 Splicing of conductors is not permitted except for extension of existing conductors where reviewed with and recommended by Departmental Representative. Splicing of conductors is subject to following conditions:
 - .1 Splicing to extend existing conductors.
 - .2 For low voltage control and signal conductors, splicing made within electrical box with terminal strips.
 - .3 For interior line voltage conductors, splicing made within electrical box with cold shrink splice kits and mechanical compression connectors. Full assembly to suit type and size of conductors and as reviewed with and recommended by Departmental Representative.
 - .4 For exterior line voltage conductors, splicing made with outdoor weatherproof cold shrink splice kits and mechanical compression connectors. Full assembly to suit type and size of conductors and as reviewed with and recommended by Departmental Representative.
 - .5 Splice/splice box properly identified with identification painting or labelling.
 - .6 Splice/splice box clearly identified on "as-built" drawings.
 - .7 Use of "split bolts" is not permitted.

3.5 INSTALLATION OF BUILDING WIRES AND CONTROL WIRING

- .1 Install wiring as follows:
 - .1 In conduit systems in accordance with Section 26 05 34.
 - .2 Underground inside or outside building and for non-climate-controlled areas - RWU90 XLPE.
 - .3 For climate-controlled areas wiring except as noted above or specified elsewhere in Specification or as noted on drawings - RW90 XLPE.
- .2 Install control wiring. Review type of control wiring with manufacturers of equipment/systems being interconnected, and as required by local governing electrical code, and provide to suit. Provide fire alarm cables for fire alarm system applications or security system applications as recommended by respective system manufacturer, complying with requirements of local governing code and local governing authorities. Run control wiring in conduit or raceways. Provide conductors not installed in conduit or raceways, with fire insulated rating in accordance with governing code flame spread ratings, and mechanically protected by means reviewed with and recommended by Departmental Representative. Provide conductors with fire ratings - FT6 rating requirements when run in plenums and similar construction.
- .3 Coordinate responsibility for provision of control wiring for mechanical equipment and equipment of other Divisions, with respective Divisions.

3.6 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 00 and Section 26 05 70.

- .2 Perform tests witnessed by Departmental Representative and local authority having jurisdiction over installation, as required.
- .3 Perform tests before energizing electrical system.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA International)
 - .1 CSA C22.1-18, Canadian Electrical Code, Part 1 (24th Edition), Safety Standard for Electrical Installations.
- .2 Institute of Electrical and Electronics Engineers (IEEE)
 - .1 IEEE 142-2007, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (Green Book).
 - .2 IEEE 837-2014, IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.
- .3 Ontario Electrical Safety Code (OESC), 27th edition - 2018.
- .4 Telecommunications Industries Association (TIA)
 - .1 TIA 607-Revision D, July 29, 2019, Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.
- .4 Submit testing and verification reports. Where specified, submit reports prepared and sealed by Professional Engineer.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 MATERIALS

- .1 Standards:
 - .1 CSA approved or ULC listed and labelled, as required by local governing authorities and codes.
- .2 Conductor sizes:
 - .1 As specified or as indicated on drawings.

- .2 Where not indicated on drawings, in accordance with local governing electrical code.
- .3 Grounding and Bonding Conductors: Bare stranded copper, soft annealed, to ground and bond equipment.
- .4 Insulated Grounding Conductors: Green, copper conductors, to ground and bond equipment.
- .5 Clamps for Grounding of Conductor: Size and type to ground underground water pipe.
- .6 Copper Conductor: Not less than 6 m long for each concrete encased electrode, bare, stranded, tinned, soft annealed.
- .7 Plate Electrodes: Copper, surface area not less than 0.2 m², not less than 1.6 mm thick.
- .8 Grounding Bar: Copper, in accordance with details.
- .9 Ground Bus: Copper, complete with insulated supports, fastenings, connectors and pre-drilled for 2-hole lug connectors. Bus not less than 50 mm x 9 mm x 900 mm. Provide continuous length where specified, or where indicated.
- .10 Grounding System Accessories: Non-corroding, of compatible materials, including:
 - .1 Grounding and bonding bushings.
 - .2 Protective type clamps.
 - .3 Bolted type conductor connectors.
 - .4 Bonding jumpers, straps.
 - .5 Pressure wire connectors.
- .11 Mechanical Grounding Connector:
 - .1 Above ground or within inspection pits.
 - .2 Connecting cable to rod or pipe, or other types suitable for intended applications.
 - .3 High copper alloy.
 - .4 U-Bolts, nuts and lock-washers of bronze construction.
 - .5 Corrosion resistant.
- .12 Miscellaneous ancillary components to complete grounding and bonding work to requirements of local governing electrical authority and codes.

2.2 TELECOMMUNICATIONS

- .1 Include requirements specified in this Section and additional requirements in Division 27.
- .2 Telecommunications Equipment Rack and Cabinet Ground Bars: Solid copper ground bars designed for mounting on framework of open or cabinet-enclosed equipment racks with dimensions not less than 6 mm thick by 20 mm wide.
- .3 At equipment mounting location (backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks. Where bolting to painted surfaces, use paint piercing type washers.

- .4 LAN Room Ground Bus: Not less than 50 mm x 9 mm x 300 mm copper ground bus with eight drilled taped holes, mounted on walls with standoff insulators.
- .5 Ground Conductor for Grounding Grid and Associated Connections: Not less than No. 3/0 AWG bare, 7-strand medium hard-drawn copper.
- .6 Ground Braid: Constructed from flat 98% conductivity tinned copper grounding braid.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION GENERAL

- .1 Provide grounding and bonding work in accordance with CSA C22.1, OESC, IEEE 142, drawings and local governing electrical authority.
- .2 Provide local governing electrical utility' grounding requirements for stations, vaults and electrical rooms, as applicable. Review requirements with local governing electrical utility. Comply with requirements of IEEE 837.
- .3 Install complete permanent, continuous grounding system including, electrodes, conductors, connectors, accessories. Where EMT is used, run separate ground wire in conduit.
- .4 Install bonding conductors and connect as required.
- .5 Install connectors in accordance with manufacturer instructions.
- .6 Protect exposed grounding conductors from mechanical injury.
- .7 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .8 Soldered joints not permitted.
- .9 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Cleat bonding wire to exterior of flexible conduit.
- .10 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.
- .11 Install separate ground conductor to outdoor lighting standards.
- .12 Connect building structural steel and metal siding to ground.
- .13 Make grounding connections in radial configuration only, with connections terminating at single grounding point typically at street side of metallic water pipe. Avoid loop connections.
- .14 Bond single conductor, metallic armoured cables to cabinet at supply end and load end.

- .15 Install grounding connections to equipment including following:
 - .1 Service equipment, transformers, switchgear, motor control centres, starters, control panels, generators, panel boards.
 - .2 Cable trays, duct systems, frames of motors.
 - .3 Outdoor lighting.
 - .4 Building steel work.
- .16 Connect grounding conductors to motors 746 watts and above or circuits 20 A and above, with solderless terminal and bolt tapped to motor frame or equipment housing. Connect to smaller motors or equipment by fastening terminal to connection box. Connect junction boxes to equipment grounding system with grounding clips mounted directly on box or with machine screws. Remove paint, dirt, or other surface coverings at grounding conductor connection points to provide good metal-to-metal contact.
- .17 Ground metal sheathing and exposed metal vertical structural elements of buildings. Ground metal fences enclosing electrical equipment. Bond metal equipment platforms which support electrical equipment to equipment ground. Bond rooftop equipment.
- .18 Ground and bond various telecommunications, audio visual systems, security, life safety and control systems in accordance with respective system manufacturer recommendations and in accordance with local governing electrical code requirements.
- .19 Install system and circuit grounding connections to systems.
- .20 Provide separate insulated ground wire for each isolated ground receptacle.
- .21 Extend isolated grounding conductors of computer receptacles to isolated ground bus of computer panel board serving area. From ground bus, extend ground conductors to building grounding station.
- .22 Size ground conductors that are not sized on drawings in accordance with local governing electrical authority requirements. Size ground conductor no smaller than requirements specified or indicated on drawings.

3.3 GROUNDING BUS

- .1 Install copper grounding bus mounted on insulated supports on wall of electrical room and communication equipment room.
- .2 For secondary electrical rooms provide no smaller than 50 mm x 9 mm x 900 mm electrical grade copper ground bus on perimeter wall of electrical rooms, 300 mm above finished floor level. Secure ground bus on 20 mm standoff insulators. Connect electrical rooms ground grid with ground bus with no smaller than 3/0 copper ground conductor in conduit. Connect each electrical room perimeter ground electrode system back to main electrical room ground electrode with no smaller than No. 3/0 copper conductors. Refer to drawings and increase dimensions of ground bus and conductors to drawing indicated sizes.

- .3 Ground items of electrical equipment in electrical room and IT equipment in communication equipment room to ground bus with individual bare stranded copper connections no smaller than No. 2/0 AWG. Increase size to suit intended applications and local electrical code requirements.

3.4 TELECOMMUNICATIONS GROUNDING

- .1 Comply with TIA 607 grounding and bonding requirements.
- .2 Provide wire and hardware required to properly ground, bond, and connect communications raceway, cable tray, metallic cable shields, and equipment to ground source.
- .3 Provide continuous ground bonding jumpers with no splices. Use shortest length of bonding jumper possible.
- .4 Provide ground paths which are permanent and continuous with resistance of 5 ohms or less from raceway, cable tray, and equipment connections to building grounding electrode. Test that measured resistance across individual bonding connections is of value 10 milliohms or less.
- .5 Provide communications room telecommunications ground busbar hardware at cable tray height.
- .6 Connect busbar to building ground busbar located in same room using two-hole compression lugs and grounding jumper of same size as pigtail extension of main building grounding ring (minimum 3/0 AWG).
- .7 Ground metallic conduits, wireways, and other metallic equipment located away from equipment racks or cabinets to cable tray pan or telecommunications ground busbar, whichever is closer, using insulated minimum No. 6-AWG ground wire bonding jumpers.
- .8 Ground metallic conduit at each end using minimum No. 6-AWG bonding jumpers.
- .9 Perform cable tray grounding and bonding in accordance with manufacturer recommendations. Bond metallic structures of wireway to provide 100% electrical continuity throughout wireway system.
- .10 Refer to additional grounding and bonding requirements in Division 27.

3.5 TESTING AND FIELD QUALITY CONTROL

- .1 Engage independent testing agent to inspect grounding and perform ground resistance test before backfilling.
- .2 Perform ground continuity and ground resistivity tests using method appropriate to site conditions, approved by local authority having jurisdiction over installation, and reviewed with Departmental Representative.
- .3 Perform tests in accordance with Section 26 05 00 and Section 26 05 70.
- .4 Perform tests before energizing electrical system.
- .5 Disconnect ground fault indicators during tests.

- .6 Document testing and submit copies of reports, prepared by Professional Engineer.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.1-18, Canadian Electrical Code, Part 1 (24th Edition), Safety Standard for Electrical Installations. (CEC.
 - .2 CSA C22.2 No. 18-1998(R2003), Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.
 - .3 CSA C22.2 No. 40-2017, Junction and Pull Boxes.
- .2 Ontario Electrical Safety Code (OESC), 27th edition - 2018.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 OUTLET AND CONDUIT BOXES GENERAL

- .1 Boxes in accordance with CSA C22.1, CSA C22.2 No. 18 and OESC.
- .2 102 mm square or larger outlet boxes.
- .3 Gang boxes where wiring devices are grouped.
- .4 Blank cover plates for boxes without wiring devices.
- .5 347 V outlet boxes for 347 V switching devices.
- .6 Combination boxes with barriers, where outlets for more than one system are grouped.
- .7 Increased size boxes as required to accommodate bending radii of installed cabling, in accordance with respective cabling system standards, as confirmed with Departmental Representative.

2.2 GALVANIZED STEEL OUTLET BOXES

- .1 One-piece electro-galvanized construction.

- .2 Single and multi gang as required, flush device boxes for flush installation, minimum size 76 x 50 x 38 mm, or as indicated. 102 mm square outlet boxes when more than one conduit enters one side with extension and plaster rings.
- .3 Utility boxes for outlets connected to surface-mounted EMT conduit, minimum size 102 x 54 x 48 mm.
- .4 102 mm square or octagonal outlet boxes for luminaire outlets.
- .5 Extension and plaster rings for flush mounting devices in finished tile or plaster walls.

2.3 STANDARD JUNCTION BOXES AND PULL BOXES

- .1 To CSA C22.2 No. 40.
- .2 Galvanized or prime coat plated steel, suitable in respects for application and complete with screw-on or hinged covers as required, and connectors suitable for connected conduit.
- .3 CSA certified, "FS" or "FD" Series cast ferroalloy and aluminium boxes.
- .4 CSA certified rigid plastic (PVC) boxes.
- .5 Covers Flush Mounted: 25 mm minimum extension beyond box sides.
- .6 Covers Surface Mounted: Screw-on flat or turned edge covers to suit specific applications.
- .7 Each box suitable in respects for application and complete with suitable securing lugs, connectors suitable for connected conduit, knockouts and, plaster rings, concrete rings, covers, carpet flanges and other accessories to suit surface constructions.
- .8 Boxes exposed exterior of building or in non-climate controlled locations: Weatherproof boxes with gasketed covers or faceplates.
- .9 Physical size of boxes: As required by local governing electrical code to suit number and size of conduits and conductors, and conductor bending radii.

2.4 CONCRETE BOXES

- .1 Electro-galvanized sheet steel concrete type boxes for flush mount in concrete, with matching extension and plaster rings.

2.5 MASONRY BOXES

- .1 Electro-galvanized steel masonry single and multi gang as required, boxes for devices flush mounted in exposed block walls.

2.6 PVC BOXES

- .1 CSA certified rigid plastic (PVC) outlet boxes.

2.7 CAST BOXES

- .1 Cast FS/FD boxes of ferroalloy iron construction.
- .2 Gasketed covers, factory-threaded hubs and mounting feet for surface wiring of devices.

- .3 Internal green ground screw.
- .4 Finish of electrogalvanized and aluminum acrylic paint.

2.8 FITTINGS - GENERAL

- .1 Bushing and connectors with nylon insulated throats.
- .2 Device plates to suit type of devices.
- .3 Knock-out fillers to prevent entry of debris.
- .4 Conduit outlet bodies for conduit up to 35 mm and pull boxes for larger conduits. Conduit outlet bodies NEMA 3R with raintight gasketed cover, for wet locations.
- .5 Double locknuts and insulated bushings on sheet metal boxes.

2.9 SERVICE FITTINGS

- .1 'High tension' receptacle fitting made of 2-piece die-cast aluminum with duplex power receptacles and communications outlets as indicated. Bottom plate with two knockouts for centered or offset installation. Complete with 12 mm x 102 mm extension piece.
- .2 Pedestal type 'low tension' fitting made of 2-piece die cast aluminum to accommodate amphenol or communications type jack connectors.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 GENERAL INSTALLATION

- .1 Provide outlet box or back box for each luminaire, wiring device, telephone outlet, fire alarm system component, communications systems components, and each other such outlet.
- .2 Size boxes to accommodate wiring devices and for bending radii of installed cables. Review requirements with respective system vendors. For telecommunications devices and cabling, refer to telecommunications systems specified in Division 27.
- .3 Outlet boxes flush mounted in interior construction, surface mounted in concealed interior locations, and surface mounted in exposed interior locations where connecting conduit is EMT: Stamped and galvanized steel outlet boxes.
- .4 Outlet boxes for surface mounted exterior lighting, receptacles, and other device outlets, boxes flush mounted in exterior building surfaces, and boxes mounted in interior device locations where connecting conduit is rigid and boxes in perimeter wall where insulation and vapour barrier is present, and boxes in non-climate-controlled areas: Type "FS" or "FD" Series cast boxes.

- .5 Outlet boxes in plastic conduit systems: Rigid PVC plastic outlet boxes.
- .6 Provide barriered outlet box for switches connected to normal and emergency power and share common faceplate.
- .7 Support boxes independently of connecting conduits.
- .8 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .9 For flush installations, mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm of opening.
- .10 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Do not install reducing washers.
- .11 Vacuum clean interior of outlet boxes before installation of wiring devices.
- .12 Identify systems for outlet boxes.
- .13 Provide sealing around boxes in walls where insulation and vapour barrier is present, or for walls of rooms that are sealed. Maintain sealing system of wall.
- .14 Clearly identify system of boxes by painting outside of covers. Review paint colour scheme with Departmental Representative.
- .15 Provide blank coverplates over boxes left empty for future installation of devices. Clearly identify each box as to its intended use, and reviewed with Departmental Representative.

3.3 JUNCTION AND PULL BOXES INSTALLATION

- .1 Provide pull boxes in conduit systems wherever shown on drawings, or wherever necessary to facilitate conductor installations. Equip conduit runs exceeding 30 m in length, or with more than two -90° bends, with pull box installed at convenient and suitable inconspicuous but accessible location.
- .2 Size boxes to accommodate exact supplied system and for bending radii of installed cables. Review requirements with respective system vendors.
- .3 Provide sealing around boxes in walls where insulation and vapour barrier is present or for walls of rooms that are sealed. Maintain sealing system of wall.
- .4 Boxes in rigid conduit and EMT inside building: Stamped galvanized or prime coated steel.
- .5 Boxes in plastic conduit: Rigid PVC plastic boxes complete with PVC couplings.
- .6 Accurately locate and identify concealed pull boxes and junction boxes on "As-built" record drawings.
- .7 Identify system of main pull or junction boxes by painting outside of covers. Review paint colour scheme with Departmental Representative.

- .8 Cover boxes in fire walls with aluminium tape and seal with caulking. Refer to Section 07 84 00 and Section 07 92 00 and install work in accordance with ULC standards.
- .9 Identify on drawings, main junction and main pull boxes. Install additional pull boxes as required by CSA C22.1 and OESC.

3.4 IDENTIFICATION

- .1 Equipment Identification: To Section 26 05 00.
- .2 Identification Labels: Size 2 unless otherwise specified, indicating voltage and phase and system name, or as indicated on drawings.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA A23.1:19/CSA A23.2:19, Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete.
 - .2 CSA C22.2 No. 18.3-12 (R2017), Conduit, Tubing, and Cable Fittings (Tri-national standard, with ANCE NMX-J-017 and UL 514B).
 - .3 CSA C22.2 No. 18.4-15 (R2019), Hardware for the Support of Conduit, Tubing, and Cable (Bi-national standard with UL 2239).
 - .4 CSA C22.2 No. 45.1-2007 (R2017), Electrical Rigid Metal Conduit - Steel (Tri-National standard, with UL 6 and NMX-J-534-ANCE-2007).
 - .5 CSA C22.2 No. 56-17, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
 - .6 CSA C22.2 No. 83.1-07 (R2017), Electrical Metallic Tubing - Steel (Tri-National Standard, with UL 797 and NMX-J-536-ANCE-2007).
 - .7 CSA C22.2 No. 211.2-06 (R2016), Rigid PVC (Unplasticized) Conduit.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 CONDUITS

- .1 Rigid Metal Conduit (RMC)
 - .1 To CSA C22.2 No. 45.1.

- .2 Exterior zinc and interior enamel coatings, galvanized threads where factory cut and red lead coated threads where site cut.
- .3 Factory made bends where site bending is not possible.
- .4 Factory made and threaded fittings.
- .5 Connectors and terminations with rigid couplings, concrete tight where run in concrete.
- .2 Electrical Metallic Tubing (EMT)
 - .1 To CSA C22.2 No. 83.1.
 - .2 Factory made bends where site bending is not possible and joints.
 - .3 Terminations made with steel couplers and raintight compression type connectors with insulated throats, concrete tight where installed in concrete.
- .3 Flexible Metal Liquidtight Conduit
 - .1 To CSA C22.2 No. 56.
 - .2 Galvanized steel core inside and outside.
 - .3 Outer thermoplastic jacket.
 - .4 Liquid-tight flexible conduit connectors at terminations.
- .4 Rigid PVC Conduit
 - .1 To CSA C22.2 No. 211.2.
 - .2 FT-4 rated, rigid plastic.
 - .3 Site made heat gun bends on conduit to 50 mm diameter.
 - .4 Factory made elbows in conduit larger than 50 mm diameter.
 - .5 Solvent weld joints.
 - .6 Factory made expansion joints.
 - .7 Terminations made with proper and suitable connectors and adaptors.

2.2 CONDUIT FASTENINGS

- .1 Fastenings: To CSA C22.2 No. 18.4, manufactured for use with conduit specified.
- .2 One-hole steel straps to secure surface conduits 50 mm and smaller.
- .3 Two-hole steel straps for conduits larger than 50 mm.
- .4 Beam clamps to secure conduits to exposed steel work.
- .5 Channel type supports for two or more conduits at suitable spacing to support weight of entire assembly.
- .6 Threaded rods, minimum 6 mm diameter or greater, to support suspended channels.

2.3 CONDUIT FITTINGS

- .1 Fittings: To CSA C22.2 No. 18.3, manufactured for use with conduit specified. Coating: Same as conduit.
- .2 Factory "ells" for 90 degrees bends of 25 mm and larger conduits.

- .3 Set-screws not acceptable.

2.4 EXPANSION FITTINGS FOR RIGID CONDUIT

- .1 Fittings: To CSA C22.2 No. 18.3, manufactured for use with conduit specified. Coating: Same as conduit.
- .2 Weatherproof expansion fittings with internal bonding assembly suitable for 200 mm linear expansion.
- .3 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 19 mm deflection.
- .4 Weatherproof expansion fittings for linear expansion at entry to panel.

2.5 PULL CORD

- .1 Synthetic polypropylene fibre (plastic) twine cord, at least 6 mm or greater diameter to support pulling of cables.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 GENERAL INSTALLATION REQUIREMENTS

- .1 Refer to and examine architectural drawings and room finish schedules to determine finished, partially finished or unfinished areas of building. Documents do not identify exact routing. Where shown, routing is diagrammatic, identifying general requirements of routing and locations. Include for necessary offsets, fittings, transformations and similar items required as result of obstructions and other architectural or structural details not shown.
- .2 Install conduit concealed in finished areas, and concealed to degree made possible by finishes in partially finished and unfinished areas. Run parallel or perpendicular to building lines. Do not install horizontal runs in masonry walls. Do not install conduits in terrazzo or concrete toppings.
- .3 Surface Conduits
 - .1 Run conduits exposed in unfinished interior areas such as Electrical and Mechanical Rooms, except where indicated on drawings.
 - .2 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass. Run parallel or perpendicular to building lines. Arrange them to avoid interference with other work, and install as high as possible.
 - .3 Locate conduits behind infrared or gas fired heaters with 1.5 m clearance.
 - .4 Run conduits in flanged portion of structural steel.

- .5 Group conduits wherever possible on suspended or surface metal channels.
- .6 Do not pass conduits through structural members except as indicated.
- .7 Do not locate conduits less than 150 mm parallel to steam or hot water lines with minimum of 50 mm at crossovers.
- .8 Do not run conduits within 900 mm of equipment access opening covers.
- .9 Independently run conduit, supported from wall or ceiling structure, not from ceiling hangers, ductwork, piping, cable trays, formed steel decking, and other elements secured to wall or ceiling.
- .4 Where conduit is proposed for embedding within structural concrete, review with and obtain recommendation from Departmental Representative. Install such conduit in accordance with requirements of CSA A23.1/CSA A23.2.
- .5 Provide conduit as sized on drawings. Size conduit that is not sized on drawings, in accordance with local governing electrical code with consideration that sizes of branch circuit conductors indicated are minimum sizes, and increased to suit length of run and voltage drop in accordance with local governing electrical code voltage drop requirements. Where conductor sizes are increased to suit voltage drop requirements, increase scheduled or specified conduit size to suit.
- .6 Provide conduit of size for power or lighting circuits, no smaller than 19 mm diameter.

3.3 INSTALLATION OF CONDUIT

- .1 Provide conduit for conductors except armoured cable and copper sheathed mineral insulated conductors, and except where duct or similar raceway materials are provided.
- .2 Provide conduit as follows:
 - .1 For interior building surface mounted conductors greater than 600 V: Rigid galvanized steel.
 - .2 For conductors exceeding 600 V for main distribution wiring in Electrical rooms, and for concealed conduit in exterior walls: Rigid galvanized steel.
 - .3 For exposed conduit mounted at a height of less than 1200 mm in electrical, mechanical or other service areas: Rigid galvanized steel.
 - .4 For short branch circuit connectors to motorized equipment and distribution transformers (minimum length 450 mm, maximum length 600 mm with 180° loop where possible): Galvanized steel flexible liquid-tight conduit.
 - .5 At points, where conductors cross building expansion joints: Galvanized steel flexible conduit with no less than 600 mm of extra curve.
 - .6 For branch circuit conductors in poured concrete slab: Rigid PVC.

- .7 For interior conduit above 50 mm diameter containing distribution conductors or communication systems conductors (fire alarm, telephone, security, telecom) (except as noted above): EMT with separate insulated ground conductor.
- .8 For conductors except as noted above or elsewhere in Specification: EMT.
- .3 Run rigid conductors in rigid type conduits suitable for application. Do not use flexible conduit.
- .4 Provide manufactured expansion joints in rigid PVC plastic conduit at spacing as recommended by conduit manufacturer.
- .5 Provide separate ground conductor in plastic conduits.
- .6 Support and secure surface mounted and suspended single or double runs of metal conduit at support spacing in accordance with local governing electrical code requirements by means of galvanized pipe straps, conduit clips, ringbolt type hangers, or by other suitable manufactured devices.
- .7 Support multiple mixed size metal conduit runs with conduit racks spaced to suit spacing requirements of smallest conduit in group.
- .8 Provide conduit fittings constructed of same materials as conduit and which are suitable in respects for application.
- .9 Provide adaptors for joining conduits of different materials.
- .10 Use explosion proof flexible connection for connection to explosion proof motors.
- .11 Install conduit sealing fittings in hazardous areas. Fill with compound to seal openings.
- .12 Cut square and properly ream site cut conduit ends such that field threads on rigid conduit are of sufficient length to draw conduits up tight.
- .13 Site made bends for conduit to maintain full conduit diameter with no kinking, and conduit finishes to not flake or crack when conduit is bent. Bend conduit cold. Replace conduit kinked or flattened more than 1/10th of its original diameter. Mechanically bend steel conduit over 19 mm diameter.
- .14 Plug ends of roughed-in conduits which are exposed during construction with suitable plugs.
- .15 Clean, clear, cap and properly identify at each termination point, conduit systems left empty for future wiring. Provide end bushing and suitable fish wires in such conduits.
- .16 Run 2- 25 mm spare conduits up to ceiling space and 2-25 mm spare conduits down to ceiling space from each flush panelboard. Terminate these conduits in 152 x 152 x 102 mm junction boxes in ceiling space or in case of exposed concrete slab, terminate each conduit in flush or surface concrete type box.
- .17 Remove and replace blocked conduit sections. Do not use liquids to clean out conduits.
- .18 Dry conduits out before installing wire.

3.4 CONDUITS IN CAST-IN-PLACE CONCRETE

- .1 Secure conduit located in poured concrete work in place in manner such that conduit does not float or move when concrete is poured. Protect such conduit from damage prior to and during concrete pour, and from concrete and water penetration. Install rigid PVC type conduit.
- .2 Review with Departmental Representative prior to Start of Work, maximum allowable size of conduit for installation in poured concrete.
- .3 Placement of reinforcing steel in structural concrete work takes precedence over placement of conduit.
- .4 Space multiple runs of conduit in poured concrete work at least three diameters or width on center, as reviewed with and recommended by Departmental Representative.
- .5 Do not run conduits in slabs where slab thickness is not at least 4 times conduit diameter.
- .6 Locate to suit reinforcing steel.
- .7 Install in centre one third of slab.
- .8 Protect conduits from damage where they stub out of concrete.
- .9 Install sleeves where conduits pass through slab or wall.
- .10 Provide oversized sleeve for conduits passing through waterproof membrane, before membrane is installed.
- .11 Use cold mastic between sleeve and conduit.
- .12 Encase conduits completely in concrete with minimum 25 mm concrete cover.
- .13 Organize conduits in slab to minimize cross-overs.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)
 - .1 ANSI Z535.4-2011(R2017) Product Safety Signs and Labels.
- .2 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings (SI Edition).
- .3 Canadian Standards Association (CSA)
 - .1 CSA Z462-2018, Workplace Electrical Safety.
- .4 Institute of Electrical and Electronics Engineers (IEEE)
 - .1 IEEE 1584-2018, IEEE Guide for Performing Arc-Flash Hazard Calculations.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Submit reports and drawings stamped and signed by Professional Engineer.
- .3 Submit after installation and testing, copies of:
 - .1 Completed testing reports with completed test results sheets.
 - .2 Certificate of approvals from local governing inspection authorities, manufacturers of systems and equipment and testing companies.
- .4 Review form of submittals (submission procedures, number of hard copies and requirements for electronic copies) with Departmental Representative, at project start-up.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Perform inspection, testing and verification work including for:
 - .1 Determining short-circuit current ratings to check that electrical distribution equipment can safely withstand level of fault current.
 - .2 Preparing, determining and submitting arc flash study with calculations qualifying required electric shock and arc flash protection provisions.

- .3 Coordination with product manufacturers, providing manufacturer standard procedures for systems and equipment inspection, testing, start-up, adjustments and verification.
- .4 Providing additional testing and verification of systems and equipment as specified.
- .5 Presence onsite of electricians/trades people to:
 - .1 Handle equipment, make temporary connections, operate equipment and make repairs and adjustments.
 - .2 Assist testing and verification personnel during on-site inspection, testing, calibration, start-up, verification work and supplementary commissioning.
- .6 Coordination of work.
- .7 Preparing testing reports and documentation (hard and electronic copies) for submission to Departmental Representative. Include date and time of testing, testing technician's name and signature.
- .8 Performing work under presence of Departmental Representative and Commissioning Agent, at times reviewed with Departmental Representative.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins and datasheets, with regards to testing, start-up and verification of products.

3.2 DISTRIBUTION SYSTEM COORDINATION STUDY AND SHORT CIRCUIT CALCULATIONS

- .1 Prepare coordination study and short circuit calculations (available fault currents) of system work and related equipment. Perform work to standards of applicable local governing authorities, local electrical inspection authority and CSA Standards.
- .2 As applicable, review and survey existing systems and obtain where available, coordination study of existing systems to use in ensuring proper protective device coordination and suitable withstand rating for entire existing, additional and revised distribution equipment/systems. Where existing studies are not available, survey existing systems and prepare additional studies as required to provide full and proper coordination and suitable withstand rating of entire existing, revised and additional distribution equipment/systems.
- .3 Incorporate results and Departmental Representative reviewed comments of final coordination study and short circuit calculations reports, into electrical distribution equipment shop drawings to update and to reflect final supplied equipment. Check for selective coordination of devices and verify short circuit current withstand ratings of equipment meet results from reports. Prepare studies to provide full and proper coordination and

suitable withstand rating of entire distribution equipment/systems.

- .4 Select protective system devices such that protection is adequate and good coordination is possible, however, differences do exist between manufacturers. Make changes in trip ratings or relay settings, as required. Obtain local electrical utility information on their protective devices and include requirements.
- .5 Prepare reports and drawings stamped and signed by Professional Engineer. Report to include test results with properly plotted coordination curves, identified trouble areas of coordination, extensive comments regarding test results and recommendations on best course of remedial action. Submit copies of report to Departmental Representative.

3.3 SHOCK AND ARC FLASH ANALYSIS

- .1 Provide analysis for electric shock and arc flash protection as specified and as required by local governing codes and local governing authorities.
- .2 Prepare study to determine severity of potential exposure and selecting personal protective equipment (PPE) under general guidelines of CSA Z462.
- .3 Determine arc flash hazard distance and incident energy that workers may be exposed to, from electrical equipment under guidelines of IEEE 1584.
- .4 Design safety signs and labels for applications to equipment under guidelines of CSA Z462 and ANSI Z535.4. Provide minimum 90 mm x 127 mm thermal transfer type label of high adhesion polyester for each work location analysed.
- .5 Prepare reports and drawings stamped and signed by Professional Engineer. Document in report, method of calculating and data to support information for labels. Incorporate documentation with short circuit calculations and coordination study report submitted to Departmental Representative.

3.4 SYSTEMS INSPECTION, TESTING, START-UP AND VERIFICATION

- .1 When each system and each major piece of equipment installation is complete and ready for acceptance, include for system and equipment manufacturer authorized representative to visit site to provide system inspection, testing, start-up, and verification.
 - .1 Check component connections and overall installation.
 - .2 Adjust sound systems for high quality, distortion free performance, free from noise, cross-talk, hum or other interference.
 - .3 Test and adjust system and ascertain that components are as specified and verify that products operate as designed.
 - .4 Provide start-up procedures for systems and equipment.
 - .5 Verify and certify system component operations.
 - .6 Prepare, document and evaluate test results.

- .7 Authenticate test results with signature of authorized testing technician.
- .8 Check and verify nameplates.
- .9 Provide maintenance and operating instructions to designated end users.
- .2 Perform work properly documented, and in accordance with manufacturer instructions and recommendations.
- .3 For integration testing of equipment and systems, include for integrated equipment and systems manufacturer authorized technicians being onsite during integration testing, and to provide technical assistance on respective equipment and systems. Coordinate with each manufacturer.
- .4 Rectify deficient work, and work that failed testing and re-test and re-verify, until successful testing.
- .5 Document testing and results in report stamped and signed by Professional Engineer. Submit copies to Departmental Representative.

3.5 ELECTRICAL DISTRIBUTION SYSTEM TESTING AND VERIFICATION

- .1 Include for 3rd party testing company to perform specified electrical distribution system inspection, testing and verification work, for additional work/products or revised work/products, unless otherwise noted. Testing company is independent of equipment manufacturers and employs Professional Engineer to sign and seal testing and verification reports.
- .2 Conduct electrical distribution system inspection, testing and verification work, prior to system and equipment being energized, and provide further testing when energized. Include following items, as applicable to product requirements:
 - .1 Testing, cleaning when necessary, and calibrating/setting relays and circuit breaker trip devices (calibration/setting of protective devices to results of prepared coordination curves.
 - .2 Function test of associated control devices.
 - .3 Replacement of fuses destroyed during testing.
 - .4 Acceptance test in presence of Departmental Representative.
 - .5 Presence, for length of time required, of equipment manufacturer service technician during start-up.
 - .6 Carry out insulation resistance testing of outgoing feeders with respect to ground. Megger circuits, feeders and equipment up to 350 V with 500 V instrument. Megger 350-600 V circuits, feeders and equipment with 1000 V instrument. Check resistance to ground before energizing.
 - .7 Inspection and Testing
 - .1 Generation and electrical distribution system including phasing, voltage, grounding and load balancing.
 - .2 Cables, bus duct, power panels, lighting panels, transformers, power receptacles and switches.

- .3 Electrical system auxiliary systems and devices.
- .4 Electrical devices and communication system components installed in service consoles, furniture systems, and mill work.
- .5 Motor control centres, starters and variable frequency drives.
- .6 Motors, heaters and associated control equipment including sequenced operation of systems.
- .7 Lighting and lighting control systems including central control systems, low voltage relays, sensors and dimming controls. Verification that devices perform in accordance with ASHRAE 90.1 requirements.
- .8 Verification and certification work of equipment and systems.
- .3 Perform general electrical tests as follows:
 - .1 After luminaires, switches, receptacles, motors, signals, and other equipment, are installed, test work to verify that there are no grounds or crosses.
 - .2 Establish and verify proper motor rotation. Measure full load running currents and check overload elements. Report to Departmental Representative, discrepancies which are found. Check existing motors which have been worked on (disconnected and reconnected), with rotation meter to verify proper rotation.
 - .3 Test circuits originating from branch distribution panels and verify with documented test results that branch circuit voltage drop is within specified limits.
 - .4 Load Balance
 - .1 Measure phase current to panelboards with normal loads (lighting) operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
 - .2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
 - .3 Provide upon completion of work, load balance report as directed in Part 1 - Action and Informational Submittals, phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load, as well as hour and date on which each load was measured, and voltage at time of test.
 - .5 Verify that devices are commissioned and operable.
- .4 Perform services procedures documented and in accordance with manufacturer instructions and recommendations. Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .5 Where relays, breakers, and other overcurrent protective devices, do not perform to coordination study curves, revise devices as part of work.

- .6 Adjust and calibrate existing equipment trip units, relays, breakers and other overcurrent protective devices, which do not perform to coordination curves. Where defective or incorrectly applied devices are found in existing distribution system, identify problem areas clearly on curves of test report and provide recommended course of remedial action. Identify on coordination curves in report and provide recommended remedial course of action.
- .7 Provide visual and mechanical inspection of ground system and verify compliance with issued documents and local governing electrical code requirements.
- .8 Perform testing of lighting control systems and devices to verify conformance with ASHRAE 90.1 requirements.
- .9 Comply with surge protection device (SPD) manufacturer instructions to disconnect SPDs during hi-pot testing.
- .10 Coordinate testing of equipment and systems with respective product vendors as required to verify alliance with product vendor standards.
- .11 Rectify deficient work, and work that failed testing and re-test and re-verify, until successful testing.
- .12 Document results into distribution system testing report stamped and signed by Professional Engineer. Report to state that testing was successful and Work complies with project documents, applicable CSA standards, and other applicable governing codes and requirements. Submit copies of reports to Departmental Representative.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Institute of Electrical and Electronics Engineers IEEE)
 - .1 IEEE C62.41.1-2002(R2008), IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
 - .2 IEEE C62.41.2-2002, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
- .2 Underwriters' Laboratories
 - .1 UL 924-Edition 10-2016, Standard for Emergency Lighting and Power Equipment.
 - .2 UL 1472-Edition 2-2015, Solid-State Dimming Controls.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section, and on Schedule of Luminaires.
- .4 Submit LED/drivers and controls manufacturers documentation verifying compatibility.
- .5 Submit testing and verification reports.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 and with manufacturer written instructions.

1.5 PRODUCT COMPATIBILITY

- .1 Provide lighting controls 100% compatible with luminaires, when integrated together for control purposes.
- .2 Coordinate with driver and LED manufacturers and dimmer/light sensor/occupancy control manufacturers to verify that components are compatible with each other and that interconnections do not adversely affect performance, life or warranties.
- .3 Submit manufacturer documentation verifying compatibility.

1.6 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROL SYSTEM - GENERAL

- .1 Central lighting control system provides central low voltage digital addressable control of lighting in designated areas. System components are CSA approved, and/or ULC listed and labelled, microprocessor controllable to provide but not be limited to following functions:
 - .1 ON/OFF control of luminaires.
 - .2 Dimming of luminaires.
 - .3 Low voltage control through low voltage relay panels.
 - .4 Group/zoned switching/control/dimming of luminaires.
 - .5 User programmable timed sequence of operations.
 - .6 Logging of system operations and generation of reports.
 - .7 Self-monitoring.
- .2 System to be 100% compatible with controlled luminaires. Coordinate between product manufacturers to ensure compatibility.
- .3 Include following:
 - .1 System software and required licenses for use of system by end users.
 - .2 Custom programming of system to sequence of operations approved by Departmental Representative.
 - .3 Equipment, conduit, boxes, wiring, connectors, hardware, supports and accessories.
 - .4 Ancillary components as necessary for complete operating system meeting Specification.
- .4 System designed for minimum 10 year operational life while operating continually at any temperature in ambient temperature range of 0 °C to 40 °C and 90 percent non-condensing relative humidity.
- .5 Surge Protection:
 - .1 To IEEE C62.41.1.
 - .2 Panels: Designed and tested to withstand surges of 6,000 V, 3,000 amps according to IEEE C62.41.2 without impairment to performance.
 - .3 Other Power Handling Devices: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
- .6 Power Failure Recovery: When power is interrupted and subsequently restored, within 3 seconds lights to automatically

return to same levels (dimmed setting, full on, or full off) as prior to power interruption.

- .7 Refer to system diagram drawings for additional product requirements.

2.2 LIGHTING MANAGEMENT SYSTEM SOFTWARE

- .1 Performs system programming and configuration changes.
- .2 Windows-based, capable of running on either central server or a remote client over TCP/IP Ethernet connection.
- .3 Capture system design:
 - .1 Geographical layout.
 - .2 Load schedule zoning.
 - .3 Equipment schedule.
 - .4 Equipment assignment to lighting management hubs.
 - .5 Daylighting design.
- .4 Defines configuration for following in each area:
 - .1 Lighting scenes.
 - .2 Control station devices.
 - .3 Interface and integration equipment.
 - .4 Occupancy/after hours.
 - .5 Partitioning.
 - .6 Daylighting.
 - .7 Emergency lighting.
 - .8 Night lights.
- .5 Startup:
 - .1 Addressing.
 - .2 Daylighting.
 - .3 Provide customized conditional programming.
- .6 System navigation and status reporting is performed using customized CAD based drawings of building. Pan and zoom feature allows for easy navigation.
- .7 Control of Lights:
 - .1 Area lights can be monitored for on/off status.
 - .2 Lights in an area can be turned on/off or sent to specific level.
 - .3 For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
 - .4 Area lighting scenes can be modified in real-time, changing levels that zones go to when a scene is activated.
 - .5 High and low end of area lighting can be tuned/trimmed.
 - .6 Control and monitor area partition status.
- .8 Occupancy (Capability when sensors are provided):
 - .1 Area occupancy can be monitored.

- .2 Area occupancy can be disabled to override occupancy control or in case of occupancy sensor problems.
- .3 Area occupancy settings including level that lights turn on to when area is occupied, and level that lights turn off to when area is unoccupied can be changed in real-time.
- .9 Daylighting (Capability when sensors are provided):
 - .1 Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
 - .2 Daylight target levels can be changed for each daylit area.
 - .3 Daylight status can be monitored.
- .10 Load Shedding: Allows end user to monitor whole building lighting power usage and apply a customized load shed reduction to selected areas, thereby reducing a building's power usage.
- .11 Scheduling: Schedule time of day and astronomic time clock events to automate functions.
- .12 Reporting: Provide reporting capability that allows building manager to gather real-time and historical information about system as follows:
 - .1 Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas or meter groups.
 - .2 Power Reports: Show power usage trend over a period of time for one or more areas or meter groups.
 - .3 Activity Report: Show what activity has taken place over a period of time for one or more areas.
 - .4 Lamp Failure Report: Shows which areas are currently reporting lamp failures.
 - .5 Alert Activity Report: Capable of generating historical reports of all alert activity within system.
 - .6 Diagnostics: Allows building manager to check on status of equipment in system.
- .13 Alerts and Alarms:
 - .1 Monitors system for designated events/triggers and automatically generates alerts according to configured response criteria.
 - .2 Monitors wireless sensors and devices for low battery levels and alerts when battery of specific device requires replacement.
- .14 Administration:
 - .1 New user accounts created and existing user accounts edited.
 - .2 Area and feature access can be restricted based on login credentials.
 - .3 Publish Graphical Floor Plan and monitors status of lights, occupancy of areas, and daylighting status.
 - .4 Back-Up Project Database.
 - .5 Publish Project Database.

- .6 Collect and display real-time and historical energy savings data from all components in system or from meters in system. Data to be accessible for display on computer monitor.

2.3 SYSTEM TERMINAL AND SERVER

- .1 PC terminal suitable for programming, monitoring, and control of digital network lighting controls. Includes colour LCD/LED colour monitor, keyboard, mouse and cables.
- .2 Server suitable for 24 hour per day, 7 day per week programming, monitoring, control, and data logging of digital-network lighting controls. Suitable to handle client machine request in multi-computer systems.
- .3 System software pre-loaded and tested. Include required licenses. Include copy of system software and manuals on USB type flash drives for back-up.
- .4 Complete with uninterruptible power supply unit meeting system manufacturer specifications and requirements.

2.4 DIMMING REQUIREMENTS

- .1 Solid state dimming to UL 1472.
- .2 Incorporate electronic "soft-start" default at initial turn-on that smoothly ramps lights up to appropriate levels within 0.5 seconds.
- .3 Utilize air gap off to disconnect load from line supply.
- .4 Control light sources in smooth and continuous manner.
- .5 Assigned load type to each dimmer that will provide proper dimming curve for specific light source controlled.
- .6 Field-configured to have load types assigned per circuit.
- .7 Minimum and Maximum Light Levels: User adjustable on a circuit-by-circuit basis.
- .8 Dimming Modules:
 - .1 Controlling following light sources:
 - .1 0-10 V analog voltage signal.
 - .2 10-0 V reverse analog voltage signal.
 - .3 Non-proprietary digital addressable communication.
- .9 Integrated Wireless Capability:
 - .1 Wireless communication inputs for sensors and controllers.
 - .2 RF Range: 9 m between sensor and compatible RF receiving devices.

2.5 POWER PANELS

- .1 CSA approved, factory-assembled panel.
- .2 Field wiring accessible from front of panel without removing dimmer assemblies or other components.
- .3 Passively cooled via free-convection, unaided by fans or other means.

- .4 Provided with branch circuit protection for each input circuit unless panel is a dedicated feed-through type panel.
- .5 Breakers are molded case circuit breakers for use on lighting circuits and be replaceable without moving or replacing dimmer/relay assemblies or other panel components. Breakers are complete with:
 - .1 Visual trip indicator.
 - .2 Interrupting capacity as required to provide required short circuit current rating.
 - .3 Thermal-magnetic construction for overload, short-circuit, and over-temperature protection.
 - .4 Provision for tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
- .6 Panel Processor:
 - .1 Operates circuit for system diagnostics and provides feedback of system operation.
 - .2 Electronically assigns each circuit to any zone in lighting control system.
 - .3 Determines normal/emergency function of panel and set emergency lighting levels.
- .7 Diagnostics and Service:
 - .1 Includes diagnostic LEDs for dimmers/relays to verify proper operation and assist in system troubleshooting.
 - .2 Includes tiered control scheme for dealing with component failure that minimizes loss of control for occupant:
 - .3 If lighting control system fails, lights to remain at current level. Panel processor provides local control of lights until system is repaired.
 - .4 If panel processor fails, lights to remain at current level. Circuit breakers can be used to turn lights off or to full light output, allowing non-dim control of lights until panel processor is repaired.
 - .5 If dimmer fails, factory-installed mechanical bypass jumpers to allow each dimmer to be mechanically bypassed. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.

2.6 DIMMING PANELS

- .1 Various types to suit specific applications.
- .2 Modular construction panels in surface mounted enclosures.
- .3 Dimmers designed and tested specifically to control required type of lamp loads.
- .4 As required, utilize multiple load type 16 A feed continuous-use listed dimming/switching modules.
- .5 For switching only circuits, utilize relays rated for minimum of 1,000,000 cycles at fully rated current for all lighting loads.

- .6 For loads requiring 0-10 V control, utilize compatible multiple load type low voltage dimming modules.

2.7 LIGHTING MANAGEMENT HUBS

- .1 Pre-assembled NEMA listed enclosure with:
 - .1 Microprocessor.
 - .2 Ethernet switch.
 - .3 Terminal blocks listed for field wiring.
- .2 Connects to controls and power panels via RS485.
- .3 Enables management software to control and monitor compatible dimming modules, power panels and power modules.
- .4 Utilizes Ethernet connectivity to light management computer.
- .5 Integrates control station devices, power panels, preset lighting controls, and external inputs into a single customizable lighting control system with:
 - .1 Multiple Failsafe Mechanisms:
 - .1 Power failure detection via emergency lighting interface.
 - .2 Protection: Lights go to full on if ballast wires are shorted.
 - .3 Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights connected to other lighting management hubs.
 - .2 Manual overrides.
 - .3 Automatic control.
 - .4 Central computer control and monitoring.
 - .5 Integration with BAS via BACnet IP.
 - .6 Provide ability to send custom output strings over Ethernet.
- .6 Astronomical time clock.
- .7 Backup of programming in a non-volatile memory capable of lasting more than ten years without power.
- .8 BACnet Integration License: Communicate by means of native BACnet IP communication to lighting control system.

2.8 LIGHTING CONTROL MODULES

- .1 Lighting control modules as required to control loads.
- .2 Passively cooled via free-convection, unaided by fans or other means.
- .3 Connection without interface to wired:
 - .1 Occupancy sensors.
 - .2 Daylight sensors.
 - .3 IR receivers for personal control.
- .4 Connects to lighting management hub via RS485.

- .5 LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
- .6 Contact Closure Input: Directly accept contact closure input from a dry contact closure or sold-state output without interface to activate scenes, enable or disable after hours and activate or deactivate demand response (load shed).
- .7 Emergency Contact Closure Input: Turn all zones to full output during emergency state via direct contact closure input from emergency lighting interface, security system or fire alarm system. Disables control operation until emergency signal is cleared.
- .8 Supplies power for control link for keypads and control interfaces.
- .9 Distributes sensor data among multiple lighting control modules.
- .10 Switching Lighting Control Modules and 0-10 V Lighting Control Modules: modules to integrate multiple individually controlled zones.
- .11 Digital Fixture Lighting Control Modules: provides smart diagnostics for system verification. Testing capability using manual override buttons.

2.9 CONTROLS

- .1 Remote wireless controls with 2 buttons, raise/lower controls, IR transmitter/receiver and designer style screwless wall plates. Communicates via radio frequency to compatible dimmers, switches, and modules. Does not require external power packs, power or communication wiring. Allows for easy reprogramming without replacing unit.
- .2 Remote wired controls with 2 buttons, raise/lower controls and designer style screwless wall plates.
- .3 Remote wall stations with pushbutton scene recall, info screen that displays energy savings and status, IR transmitter/receiver, astronomic time clock, contact closure input, and engravable backlit buttons. Include recessed multi-gang wall box.
- .4 Faceplate finishes and button nomenclature to be confirmed with Departmental Representative.
- .5 Refer to drawings for additional station requirements.

2.10 ACCESSORIES

- .1 Emergency Lighting Interface: Provides an output to power panels or digital ballast interfaces if power on any phase fails and sends all lights controlled by these devices to emergency light level setting (typically 100 percent intensity). Lights to return to their previous intensities when normal power is restored. Accepts a contact closure input from a fire alarm control panel.
- .2 Power interfaces as required to control loads. Replacing power interface does not require re-programming of system or processor.
- .3 Power supplies as required to power system devices and accessories. Include junction box-mounted power supply for

keypads and accessories, and for providing additional low voltage power to communication links.

- .4 Low-voltage control interfaces as required to control the loads. Interfaces to include contact closure types, wall box input closure types, BACnet IP interface to BAS, DMX types and communications RS232/Ethernet types. Coordinate BAS communications interface with BAS vendor.
- .5 Sensor modules with both wired and wireless inputs, as required for integrations to:
 - .1 Occupancy sensors.
 - .2 Daylight sensors.
 - .3 IR receivers.
 - .4 Digital ballasts/drivers.
 - .5 Wireless controllers.
- .6 Cabling and ancillary devices according to system manufacturer recommendations.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF LIGHTING CONTROL SYSTEM

- .1 Submit as part of shop drawings, detailed design drawings, single line drawing, block drawings, equipment literature cuts, station finishes, and proposed sequence of operation of entire integrated system. Confirm sequence with Departmental Representative prior to start of Work.
- .2 Provide required components for centralized low voltage control of lighting. Where required, integrate system such that dimming system and Mechanical Divisions BAS system can provide control as required. Refer to drawings details and notes.
- .3 Dimming control system components and programming to be integrated to sensors to perform an integrated lighting control system that provides dimming and ON/OFF control of designated luminaires. Zoning and sequence of operations to be pre-programmed and user friendly in any program changes. Confirm exact zoning and proposed sequence of operation via shop drawings submission stage.
- .4 Review emergency sequence of operation with Departmental Representative prior to start of Work and include required hardware and software and interfaces to other integrated systems. Coordinate interfaces with respective system vendors.
- .5 Obtain training from manufacturer representative on special installation procedures. Install products in accordance with manufacturer instructions to suit intended applications.

- .6 Install dimmer panels in locations. Locate panels allowing sufficient access conforming to local governing code requirements. Provide power source and connections to panels. Provide schedule of dimmers in plastic sleeve attached to panel. Connect power feeders as required. Provide relays as required.
- .7 Integrate system to fire alarm system, BAS and other systems, as required. Extend wiring in conduit to required interconnection panels of systems. Typically terminate in junction box adjacent to system panel, leaving a loop of 3 m of un-terminated wiring for final termination by respective system vendors. Coordinate exact requirements with work of vendors of Division 25 and Division 28. Coordinate with other Divisions and to provide conduit and wiring to integrate systems.
- .8 Include for and arrange for manufacturer authorized representative to perform programming work and adjustments. Final program features must be approved by Departmental Representative.
- .9 Locate and install devices.
- .10 Provide flush wall box for control stations in locations and connect to control lighting. Review locations with Departmental Representative prior to roughing-in. Equip each control station with faceplate. Review faceplate colour and finish with Departmental Representative prior to ordering.
- .11 Reference electrical drawings for general device location and circuiting.
- .12 ON/OFF pushbuttons and preset buttons to fade into operation, not instant operation. Set cleaning presets to control circuits at levels as reviewed with Departmental Representative.
- .13 Provide wiring in accordance with manufacturer instructions and approved manufacturer system wiring diagrams and run wiring in conduit. Oversize wiring according with manufacturer instructions to compensate for voltage drop. Do not splice wiring between control stations or between dimmer/relay panels/racks.
- .14 Review final locations of controls with Departmental Representative prior to roughing-in. Review component finishes with Departmental Representative during shop drawing submissions.
- .15 Connect controls to lighting circuits. Install flexible or rigid conduit for luminaires, as specified.
- .16 For emergency lighting controls, provide relays compliant with UL 924 and applicable local governing electrical code requirements.
- .17 Ground and bond system in accordance with local governing electrical code requirements.
- .18 Identify circuits and components as specified, and in manner reviewed with Departmental Representative.
- .19 Prepare testing and verification reports, signed by testing technician. Submit copies to Departmental Representative.
- .20 Install components in accordance with manufacturer instructions to suit specific installation requirements.

- .21 Provide engraved lamaroid identification nameplate for each station, panel and controller. Clearly label each dimmer/panel and label low voltage circuits.
- .22 Review nomenclature with Departmental Representative prior to ordering.
- .23 Provide onsite training of operating and maintenance of system to end users.

3.3 TESTING AND VERIFICATION

- .1 When installation is complete, inspect, start-up, check and test operation of system components and sequence of operations. Check each dimmer and adjust.
- .2 Verify that each dimmer is properly sized and of type to suit connected load.
- .3 Repair or replace failed components. Re-verify.
- .4 Prepare testing and verification reports, signed by testing technician.
- .5 Submit copies of reports to Departmental Representative.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 5-16, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures (Tri-national Standard with UL 489 and NMX-J-266-ANCE-2016.
 - .2 CSA C22.2 No. 29-15(R2019), Panelboards and Enclosed Panelboards.
 - .3 CSA C22.2 No. 269.1-17, Surge Protective Devices - Type 1 - Permanently Connected.
- .2 Underwriters Laboratories (UL)
 - .1 UL 489 Edition 13-2016, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
 - .2 UL 1449 Edition 4-2014, Standard for Surge Protective Devices.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.
 - .2 Provide copies of completed and typed breaker circuit directory cards.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 PLANT ASSEMBLY

- .1 Assemble panelboard interiors before shipment. Ship fuses loose for on site installation.
- .2 Install circuit breakers or fused switches in panelboards before shipment.

- .3 In addition to CSA requirements, manufacturer nameplates to identify fault current that panelboards, breakers and fused switches are built to withstand.

2.2 BRANCH CIRCUIT PANELBOARDS - BREAKER TYPE

- .1 Panelboards: To CSA C22.2 No. 29 and product of one manufacturer.
- .2 250 V panelboards: Bus and breakers rated as indicated on drawings or schedules.
- .3 600 V panelboards: Bus and breakers rated as indicated on drawings or schedules.
- .4 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
- .5 Panelboards: Mains, number of circuits, and number and size of branch circuit breakers as indicated on drawings or schedules.
- .6 Enclosures in climate controlled areas: NEMA 1 or NEMA 2 types, with sprinkler protection. Enclosures constructed of code gauge galvanized steel with removable box ends, wiring gutter space on sides, and dead-front construction to shield user from energized parts. Conduit entries sealed water-tight. Trim for flush or surface wall mounting to suit installation as indicated on drawings. Trim and door finish of baked enamel grey, except where identified on drawings.
- .7 Hinged door with concealed fasteners, concealed hinge, chrome plated door latch and keyed alike lock with key. Front panel not removable with door locked. Provide minimum of 2 flush locks for each panel board and 2 keys for each panelboard. Key panelboards alike.
- .8 Steel frame holder and typed circuit directory card protected by clear acetate and secured to back of door, and Mylar circuit breaker identification strips.
- .9 Main breakers as indicated on drawings or schedules.
- .10 Copper bussing with neutral of same ampere rating of mains.
- .11 Provide 200% neutrals for panelboards as indicated on drawings or schedules, and with surge protective device connected.
- .12 Mains: Suitable for bolt-on breakers.
- .13 Isolated ground bus.
- .14 Drip shield for surface mounted panelboards.
- .15 Filler plates covering unused mounting space.
- .16 Integral surge protection device (SPD) for panelboards as indicated on drawings or schedules. Unit factory installed and connected onto bussing through integral disconnect or breaker as recommended by manufacturer.
- .17 Include grounding busbar with 3 of terminals for bonding conductor equal to breaker capacity of panel board.

2.3 BREAKERS

- .1 Breakers with thermal and magnetic tripping in panelboards as indicated on drawings or schedules, and provide inverse time current tripping and instantaneous tripping for short circuit protection.
- .2 Main breaker: Separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position opens breaker.
- .3 Series rated breakers: Manufacturer tested and listed. Installed and applied following manufacturer guidelines and accepted best practice.
- .4 Lock-on devices for 10% of 15 to 30 A breakers installed. Turn over unused lock-on devices to Departmental Representative.
- .5 Lock-on devices for circuits: As indicated on drawings or schedules.
- .6 Breaker accessories: As indicated on drawings or schedules.

2.4 MOULDED CASE CIRCUIT BREAKERS

- .1 To CSA C22.2 No. 5 and UL 489.
- .2 Circuit breakers types, sizing and ratings: As indicated on drawings or schedules.
- .3 Features
 - .1 Fixed mounted, moulded case circuit breaker with minimum interrupting capacity as scheduled.
 - .2 Where scheduled, ULC listed for application of 100% of its trip setting and carry its full rated ampere capacity, indefinitely without tripping.
 - .3 Bolt-on, quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40 degrees C ambient.
 - .4 Common-trip breakers equipped with single handle for multi-pole applications.
 - .5 Magnetic instantaneous trip elements in circuit breakers operate only when value of current reaches setting.
 - .6 Trip settings on breakers with adjustable trips ranging from 3-8 times current rating.
 - .7 Circuit breakers with interchangeable trips as indicated on drawings.
- .4 Solid State Tripping Units
 - .1 Equipped on breakers of frame size greater than 225 amperes. Breakers operate by means of solid-state adjustable trip unit with associated current monitors and self-powered shunt trip units.
 - .2 Adjustable tripping functions: Long time pick-up, long time delay; short time pick-up; short time delay; instantaneous pick-up; ground fault pick-up; and ground fault delay.
 - .3 3 sensors, one on each phase conductor, arranged such that trip signal from sensor opens all 3 - poles of breaker.

- .4 Provide functions and settings to suit project specific short circuit and coordination studies.
- .5 Accessories
 - .1 Shunt trip.
 - .2 Auxiliary switch.
 - .3 Motor-operated mechanism time delay unit.
 - .4 Under-voltage release.
 - .5 On-off locking device.
 - .6 Handle mechanism.
 - .7 Engraved identification lamacoid nameplates except for branch circuit panelboard breakers.

2.5 SURGE PROTECTIVE DEVICES (SPD) - GENERAL FEATURES

- .1 CSA approved or ULC listed and labelled.
- .2 In accordance with UL 1449 and CSA C22.2 No. 269.1.
- .3 IEEE Exposure: Category C.
- .4 Type 1 units with ratings as indicated on drawings, and to suit intended applications, and as follows:
 - .1 Maximum voltage protection rating to not exceed:
 - .1 700 V (120/208 V) or 1500 V (600/347 V): L-N, L-G, N-G.
 - .2 1200 V (120/208 V) or 3000 V (600 V): L-L.
 - .2 Minimum nominal discharge current rating: 10 kA.
 - .3 Minimum short circuit current rating: 100 kA.
 - .4 Peak surge current for distribution panelboards: 150 KA per phase.
 - .5 Peak surge current for branch circuit panelboards: 100 KA per phase.
- .5 Connected panelboard through dedicated breaker as recommended by manufacturer.
- .6 Indicator LEDs on units identify protection integrity status of metal-oxide varistors.
- .7 High-performance EMI/RFI noise rejection filter.
- .8 Diagnostic package with status indicators on each phase.
- .9 LCD surge counter display.
- .10 Audible alarm with silence button.
- .11 Form C alarm contacts.
- .12 Internal disconnect.
- .13 Maintenance free and not require user intervention throughout its life.
- .14 Standard manufacturer minimum 5 years parts and labour warranty.
- .15 Operating Temperatures: Minus 40°C to 60°C.

.16 Enclosures:

- .1 Power coated or enamel painted steel construction.
- .2 Climate controlled areas: Minimum NEMA 2 sprinkler-resistant or NEMA 12.
- .3 Non-climate controlled areas: Minimum NEMA 3R or NEMA 4, outdoor weatherproof, and corrosion resistant.

2.6 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 26 05 00.
- .2 Nameplate for each panelboard: Size 4 engraved as indicated on drawings or schedules.
- .3 Nameplate for each circuit breaker and disconnect switch in distribution panelboards: Size 2 engraved as indicated on drawings or schedules.
- .4 Branch circuit panelboards with circuit directory with typewritten legend showing location and load of each circuit, mounted in plastic envelope at inside of panel door.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF PANELBOARDS

- .1 Provide panelboards with required, breakers, switch and fuses, and accessories.
- .2 Locate panelboards and mount securely, plumb, true and square, to adjoining surfaces. Install panelboards with clearance for access for operation and maintenance, in accordance with local governing codes. Support cabinets and enclosures independent of connecting conduit, and install with reference to wall finishes.
- .3 Install surface mounted panelboards on plywood backboards. Where practical, group panelboards on common backboard.
- .4 Install floor mounted panelboards on concrete housekeeping pads. Provide seismic restraints as specified.
- .5 Equip each panelboard with lugs to accommodate main and branch conductors as scheduled.
- .6 Mount panelboards to height specified in Section 26 05 00 or as indicated on drawings. Review height with Departmental Representative prior to roughing-in.
- .7 Connect loads to circuits.
- .8 Connect neutral conductors to common neutral bus.
- .9 Where SPD is required for panelboards, install and test in accordance with SPD manufacturer instructions.

- .10 Ground and bond equipment in accordance with local governing electrical code and inspection authority requirements.
- .11 Identify breakers in permanent manner, and for branch circuit panelboards, provide typed circuit directories identifying circuit number and type and location of loads supplied from each breaker.
- .12 Identify distribution panelboard and breakers/switches with lamicaid identification nameplate.
- .13 Review nameplate nomenclature with Departmental Representative.
- .14 Seal openings and conduit entries of enclosures and drip shield, watertight.

3.3 INSTALLATION OF BREAKERS

- .1 Provide breakers factory installed in panelboards. Refer to drawings and schedules for types and ratings.
- .2 Provide additional breakers installed into existing panelboards as indicated on drawings. Additional breakers to match standards and types and be 100% compatible with existing panelboard in which it is to be installed. Make necessary modifications to existing panelboard to accommodate additional breaker. Replace existing breaker directory card with revised card incorporating additional breakers.
- .3 Install and connect breakers for circuits as indicated on drawings or schedules, in accordance with manufacturers instructions.
- .4 Set and adjust trip settings in accordance with coordination study findings.
- .5 Test in accordance with manufacturer instructions.
- .6 Identify each breaker in manner previously specified.
- .7 Provide engraved lamicaid identification nameplate on additional components.
- .8 Prepare testing and verification reports, signed by testing technician. Submit copies to Departmental Representative.

3.4 INSTALLATION OF SPDS

- .1 Obtain required training from manufacturer representative on special installation procedures. Install units in accordance with manufacturer instructions to suit intended installation requirements.
- .2 Coordinate installation with manufacturers of equipment to which SPDs are connected. Install dedicated disconnect/breaker device of type and rating in accordance with SPD manufacturer requirements. Mount SPD units adjacent to panelboards such that connecting conductors to dedicated breaker do not exceed length in accordance with SPD manufacturer requirements.
- .3 Mount units so that MOV condition LED indicator is visible from front of board/panel.

- .4 Connect and make incoming and outgoing power cable connections to equipment in accordance with equipment manufacturer recommendations. Check wire range on lugs for SPD, verifying that wire size and number of conductors being connected, are within range of lugs.
- .5 Provide alarm and communications circuits. Integrate equipment to building automation system (BAS). Extend wiring in conduit to interconnection terminal cabinet. Provide wiring in conduit from cabinet to respective BAS panel serving area. Make connections. Coordinate requirements with respective equipment vendors.
- .6 Ground and bond components in accordance with local electrical code requirements.
- .7 In accordance with manufacturer recommendations, do not perform hi-pot testing (meggering) of cabling or other equipment, with SPDs connected.
- .8 Test units in accordance with manufacturer recommendations.
- .9 Prepare testing and verification reports signed by testing technician. Submit copies to Departmental Representative.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
- .2 .1 CSA C22.2 No. 62-1993(R2017), Surface Raceway Systems.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.

PART 2 - PRODUCTS

2.1 SURFACE RACEWAYS

- .1 CSA certified and according to CSA C22.2 No. 62, or ULC listed and labelled, anodized finished aluminum alloy, surface mounted, service raceways, as follows:
 - .1 Single channel with single snap-on cover.
 - .2 Size: Minimum 65 mm wide x 45 mm deep x length to suit installation on site based on drawings.
 - .3 Single or duplex grounding receptacles and mounting knockout plates.
 - .4 Conduit entry cap ends and close cap ends.
 - .5 Clips, couplings, brackets, fittings, elbows, boxes, tees mounting hardware, as required for complete raceway system.
 - .6 Wiring for power.
- .2 Coordinate and measure exact dimensions for lengths, to meet site installation. Where horizontal sections meet vertical sections, provide manufacturer proper connecting fitting such that there are no openings or exposed conductors. Ensure that bending radii requirements of various cabling standards are met.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 GENERAL INSTALLATION REQUIREMENTS

- .1 Provide surface mounted, service raceway assemblies complete with specified and required accessories necessary for complete electrical raceway system. Site measure for proper lengths. Provide required type and quantity of receptacles. Review exact types for each application with Departmental Representative prior to ordering. Review finishes with Departmental Representative prior to ordering.
- .2 Obtain required training from manufacturer representative on any special installation procedures. Install raceways in accordance with manufacturer instructions to suit specific installation requirements. Use manufacturer recommended tools for cutting and installing raceways.
- .3 Assemble and secure raceways, boxes and other components to surfaces in accordance with manufacturer instructions and requirements. Connect complete. Where possible butt raceway ends to adjacent walls, cabinets, counters, and similar construction. Where raceway is attached to equipment or sections of millwork, install raceway for full length of equipment/millwork, unless otherwise noted. Keep number of elbows, offsets and connectors to a minimum.
- .4 Do not exceed wire fill requirements given in manufacturer instructions.
- .5 Provide barriers for systems with different voltages in raceway.
- .6 Provide wiring devices of types and standards as specified in Section 26 27 26.
- .7 Test prewired raceways after installation work is complete.
- .8 Submit signed test reports to Departmental Representative.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 42-10(R2020), General Use Receptacles, Attachment Plugs and Similar Wiring Devices.
 - .2 CSA C22.2 No. 42.1-13(R2017), Cover Plates for Flush-Mounted Wiring Devices (Bi-National Standard, with UL 514D).
 - .3 CSA C22.2 No. 55-15(R2020), Special Use Switches.
 - .4 CSA C22.2 No. 111-18, General-Use Snap Switches (Trinational Standard with UL 20 and NMX-J-005-ANCE).

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.
- .4 Samples
 - .1 Submit samples of each typical wiring device, faceplates, finishes and colours. Mount to sample board, clearly labelling devices and finishes. Submit for review with Departmental Representative. Do not order devices without review with Departmental Representative.
- .5 Submit testing and verification reports.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 CERTIFICATIONS, RATINGS AND TYPES

- .1 CSA approved, ULC listed.
- .2 As specified and as indicated on drawings.

2.2 SWITCHES

- .1 Ratings and Poles
 - .1 15 A and 20 A as indicated on drawings.
 - .2 347 VAC, 208 VAC and 120 VAC as indicated on drawings.
 - .3 Single pole, double pole, three-way and four-way switches as indicated on drawings, and to CSA C22.2 No. 55 and CSA C22.2 No. 111.
- .2 Manually-operated general purpose AC toggle type switches with following features:
 - .1 CSA approved, ULC listed, heavy duty, industrial grade.
 - .2 Heavy duty nylon toggle and elastomer rocker, permanently lubricated assembly.
 - .3 One piece thermoset base and one piece high impact-resistant thermoplastic front face.
 - .4 Steel-nickel plated bridge, and one-piece rivetless copper alloy spring contact arm and terminal plate.
 - .5 Brass binding head screws.
 - .6 One-piece integral grounding terminal and stainless-steel automatic grounding clips.
 - .7 Silver alloy contacts.
 - .8 Suitable for back and side wiring.
- .3 Manually-operated general purpose decorative style AC rocker type switches with following features:
 - .1 CSA approved, ULC listed, heavy duty grade.
 - .2 Heavy duty nylon rocker, permanently lubricated assembly.
 - .3 Steel-zinc plated bridge, and one-piece rivetless copper alloy spring contact arm and terminal plate.
 - .4 Brass binding head screws.
 - .5 One-piece integral grounding terminal and stainless-steel automatic grounding clips.
 - .6 Silver alloy contacts.
 - .7 Suitable for back and side wiring.
- .4 Locking or toggle operated as indicated on drawings, for specific applications, fully compatible and rated for lamp loads, and up to 80% of rated capacity of motor loads and heating loads.
- .5 Illuminated toggle type switches similarly as specified for above toggle types but with illuminated LED pilot light in toggle and operate as follows and as indicated on drawings:
 - .1 Illuminated light ON with load OFF.
 - .2 Illuminated light ON with load ON.
- .6 Provide switches of one manufacturer throughout project.
- .7 Review finishes with Departmental Representative, prior to ordering.

2.3 RECEPTACLES

- .1 Standard Duplex Receptacles: CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V, U ground, with following features:
 - .1 Extra heavy duty, specification grade.
 - .2 To CSA C22.2 No. 42.
 - .3 One piece thermoplastic polyester base and one piece high impact-resistant nylon front face.
 - .4 One piece nickel-plated brass mounting strip with integral ground retention clips.
 - .5 Nickel-plated brass wiring clamps with brass line terminal screws.
 - .6 Front circuit identification area.
 - .7 Suitable for No. 10 AWG for back and side wiring.
 - .8 Break-off links for use as split receptacles.
 - .9 Eight back wired entrances, four side wiring screws.
 - .10 Triple wipe brass contacts and rivetted grounding contacts.
- .2 Decorative Duplex Receptacles: CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V, U ground, with following features:
 - .1 Extra heavy duty, specification grade.
 - .2 To CSA C22.2 No. 42.
 - .3 One piece nylon base and one piece high impact-resistant nylon front face.
 - .4 One piece galvanized steel mounting strip with integral ground retention clips.
 - .5 Steel-nickel finished wiring clamps with brass line terminal screws.
 - .6 Suitable for No. 10 AWG for back and side wiring.
 - .7 Break-off links for use as split receptacles.
 - .8 Eight back wired entrances, four side wiring screws.
 - .9 Triple wipe brass contacts and rivetted grounding contacts.
- .3 Single Standard Receptacles: CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V, U ground with following features:
 - .1 Extra heavy duty, specification grade.
 - .2 One piece thermoplastic polyester base and one piece high impact-resistant nylon front face.
 - .3 Brown or ivory or other finish colour as reviewed with Departmental Representative.
 - .4 One-piece nickel-plated brass mounting strip with integral ground retention clips.
 - .5 Nickel-plated brass wiring clamps with nickel-plated brass line terminal screws.
 - .6 Suitable for No. 10 AWG for back and side wiring.
 - .7 Four back wired entrances, 2 side wiring screws.
- .4 Other receptacles with ampacity and voltage as indicated on drawings.

- .5 20 A Receptacles: "T" slot type of respective series of receptacles.
- .6 Provide receptacles of one manufacturer throughout project.
- .7 Review finishes with Departmental Representative, prior to ordering.

2.4 SPECIAL WIRING DEVICES

- .1 Ground Fault Circuit Interrupting (GFCI) Receptacles:
 - .1 Extra heavy-duty grade, CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V, duplex, ULC Class "A", Group One.
 - .2 Tamper resistant, weather resistant.
 - .3 Automatic self-test diagnostics.
 - .4 Green power ON LED, red ground fault LED.
 - .5 10 KA short circuit current rating.
- .2 Power Receptacles with USB Charging Ports
 - .1 2- USB ports (5 A, 5 V DC, type A and type C port configurations, class 2.0, 3.0 and 3.1).
 - .2 CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V rated duplex decorative style power receptacles.
 - .3 Tamper resistant, back and side wired.
 - .4 Review requirements for USB port configuration and 15 A or 20 A power receptacles with Departmental Representative, prior to ordering.
- .3 Tamper Resistant, Safety Shutter Receptacles
 - .1 Specification grade.
 - .2 CSA type 5-15R or 5-20R, 15 A or 20 A, 125 V, 2-pole, 3-wire.
- .4 Half-Plug Load Controlled Receptacles
 - .1 Industrial grade, 15/20 ampere, 125 V, grounding, duplex receptacles.
 - .2 For use with automatic outlet control systems, and with factory broken split circuit tab allowing control of half of receptacle.
 - .3 Interconnected to control module relays of lighting control system or other building control systems.
 - .4 Permanently marked with symbol identifying controlled receptacle.
 - .5 Nylon face and body construction.
 - .6 Back and side wired.
- .5 Full-Plug Load Controlled Receptacles
 - .1 Industrial grade, 15/20 ampere, 125 V, grounding, duplex receptacles.
 - .2 For use with automatic outlet control systems, allowing control of full receptacle.
 - .3 Interconnected to control module relays of lighting control system or other building control systems.

- .4 Permanently marked with symbol identifying controlled receptacle.
- .5 Nylon face and body construction.
- .6 Back and side wired.
- .6 Electric Range Receptacles: NEMA type 14-50R, 50 A, 125/250 V, 3-pole, 4-wire single receptacle with steel faceplates.
- .7 20 A receptacles: "T" slot type of respective series of receptacles.
- .8 Refer to drawings for other special wiring devices.
- .9 Review finishes with Departmental Representative, prior to ordering.

2.5 COVER PLATES (FACEPLATES)

- .1 Cover plates for wiring devices: To CSA C22.2 No. 42.1.
- .2 Type 302/304 stainless steel faceplates.
- .3 Provide cover plates from one manufacturer throughout project.
- .4 Review finishes with Departmental Representative, prior to ordering.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF SWITCHES, RECEPTACLES AND COVER PLATES

- .1 Provide devices and install in electrical outlet boxes. Refer to drawings to determine flush or surface mounting requirements. Typically, flush mount devices in finished areas. Size electrical boxes to suit device requirements in accordance with device manufacturer recommendations. Ground device to box and ground system in accordance with local governing electrical code requirements and manufacturer instructions.
- .2 Review final device finishes with Departmental Representative, with sample board submission.
- .3 Review locations and nomenclature of nameplates and labelling with Departmental Representative, prior to ordering of labels and nameplates.
- .4 Switches
 - .1 Install single throw switches with handle in "UP" position when switch closed.
 - .2 Install switches in gang type outlet box when more than one switch is required in one location.
 - .3 Mount toggle switches at height as indicated or in accordance with Section 26 05 00 and reviewed with Departmental Representative.

- .4 Switches connected to essential (emergency) power circuits, are illuminated toggle type.
- .5 Install switches located adjacent to doors on strike side of door. Review door swing requirements on architectural drawings, not on electrical drawings.
- .6 Coordinate installation of door switches with trades responsible for provision of doors and frames.
- .7 Locate switches to provide optimum operation of switch to door position.
- .5 Receptacles
 - .1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
 - .2 Mount receptacles at height as indicated or in accordance with Section 26 05 00, and as reviewed with Departmental Representative.
 - .3 Where split receptacle has one portion switched, mount vertically and switch upper portion.
 - .4 Install GFCI type receptacles in locations as indicated on drawings and in locations as required by local governing codes.
 - .5 Locate safety shutter type receptacles as indicated on drawings and in locations as required by local governing codes.
 - .6 Install USB charger receptacles in extra deep boxes in accordance with manufacturer recommendations.
 - .7 Install plug load controlled receptacles of type compatible with and coordinated with connected control system. Review compatibility of receptacle with control system vendor. Circuit split controlled receptacles in accordance with local governing electrical code requirements.
 - .8 Provide typed label identifying circuit number and panelboard from where each device is fed, permanently identified at outlets. Review location for identification with Departmental Representative.
 - .9 For receptacles installed in counters and benches, provide box cut-out in counter and bench. Provide box, receptacle, plate and branch circuit wiring. Provide flexible armoured cable, in accordance with local governing electrical code and connect devices.
- .6 Cover Plates
 - .1 Provide each device with cover plate or faceplate with opening or openings suitable for device it conceals and covers openings around boxes. Secure faceplates to device frames with screws to match faceplates. Provide larger than standard type faceplates for devices that require engraved nomenclature to define special purpose for that device.
 - .2 Install weather-proof in-use type cover plates for receptacle devices in non-climate controlled areas.
 - .3 Install common cover plates where wiring devices are grouped.

- .4 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.
- .5 Provide faceplates with suitable identification labels for devices. In addition to identification requirements specified with devices, provide faceplates with printed self-adhesive label on inside faces and to wall under faceplate, identifying circuit number and panel feeding device. Apply a layer of a clear coat finish over each label. Review exact requirements for labelling with Departmental Representative. Label adhesive to be heavy duty strength, and water-resistant.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 4-16, Enclosed and Dead-Front Switches (Tri-National standard, with NMX-J-162-ANCE-2016 and UL 98).
 - .2 CSA C22.2 No. 39-13(R2017), Fuseholder Assemblies.
 - .3 CSA C22.2 No. 248.1-11(R2016), Low-Voltage Fuses - Part 1: General Requirements (Tri-national Standard, with UL 248-1 and NMX-J-009/248/1-ANCE).
 - .4 CSA C22.2 No. 248.8-11(R2016), Low-Voltage Fuses - Part 8: Class J Fuses (Tri-national Standard, with UL 248-8 and NMX-J-009/248/8-ANCE).

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

- .1 To CSA C22.2 No. 4.
- .2 Types and ratings: As indicated on drawings or schedules.
- .3 Heavy duty, CSA approved, disconnect (safety) switches. Features include:
 - .1 Front operated with handle suitable for padlocking in "OFF" position and arranged so that enclosure cover cannot be opened while handle is in "ON" position.
 - .2 ON-OFF switch position indication on switch enclosure cover.
 - .3 Operating mechanisms: quick-break, positive acting with visible blades and line terminal shield.

- .4 100% load break make rated.
- .5 Non-fusible units.
- .6 Fusible units with fuse clips suitable for HRC fuses, or as scheduled.
- .7 Factory primed and painted switch enclosures.
- .4 Fuses and fuse ratings: As indicated on drawings or schedules, and as required for specific application.
- .5 Fuse holders: To CSA C22.2 No. 39, suitable without adaptors, for type and size of fuses.
- .6 Disconnects for variable speed drives: Suitable for use with such drives and include auxiliary switch or contacts to de-energize control power circuit.
- .7 Enclosures
 - .1 For interior climate-controlled areas and standard non-climate controlled areas: Minimum NEMA 3R.
 - .2 For corrosive environmental applications: Minimum NEMA 4X.

2.2 FUSES

- .1 Fuses: Product of one manufacturer throughout project.
- .2 As recommended by respective equipment manufacturer to suit intended applications.
- .3 Plug and Standard Cartridge Fuses: To CSA C22.2 No. 248.1.
- .4 Class J Fuses
 - .1 For fuses up to and including 600 A and other high inrush circuits.
 - .2 To CSA C22.2 No. 248.8.
 - .3 For constantly running equipment.
 - .4 Type AJT, time delay, capable of carrying 500% of its rated current for
 - .5 10 s minimum. For use in motor control centres and motor starters.
 - .6 Type J2, fast acting.

2.3 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 26 05 00.
- .2 Indicate name of load controlled on size 4 nameplate.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF DISCONNECT SWITCHES

- .1 Provide disconnects switches and install into locations and connect to equipment.
- .2 Install disconnect switches with fuses as indicated on drawings or schedules.
- .3 Locate disconnects in positions providing clearance for access for operation and maintenance, in accordance with local code requirements. Install as follows:
 - .1 Wherever shown on drawings or required by local governing electrical code.
 - .2 Wherever required by motor control centre (MCC)/variable frequency drive (VFD)/starter schedule drawings.
 - .3 For motorized equipment which cannot be seen from motor starter location or is more than 9 m from starter location (in accordance with local governing electrical code requirements).
 - .4 For "packaged" equipment fed from motor starter panel.
- .4 Where double throw switches are required, connect to provide operations as indicated on drawings or schedules.
- .5 Verify enclosure ratings are suitable for intended applications.
- .6 Provide engraved lamicoid nameplate with nomenclature reviewed with Departmental Representative.
- .7 Inspect, test and verify operation of equipment.
- .8 Prepare testing and verification reports, signed by testing technician. Submit copies to Departmental Representative.

3.3 INSTALLATION OF FUSES

- .1 Provide type and sizes of fuses in accordance with drawings or schedules, or type of fuses suitable for applications as required by local governing electrical codes and in coordination with respective equipment manufacturer recommendations in which fuses are installed.
- .2 Install fuses in mounting devices before energizing circuit.
- .3 Verify correct fuses are fitted to physically matched mounting devices.
- .4 Verify correct fuses are fitted to assigned electrical circuit.
- .5 Fuses for use in motor control centres and motor starters: Class "J" type, dual element, time delay type, except where identified otherwise on drawings or schedules.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 107.1-16, Power Conversion Equipment.
- .2 Federal Communications Commission (FCC)
 - .1 FCC Rules and Regulations Title 47, Part 15 (47 CFR 15)-2020, Code of Federal Regulations.
- .3 Institute of Electrical and Electronics Engineers (IEEE)
 - .1 IEEE C62.41.1-2002(R2008), IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.
- .2 Product Data
 - .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings
 - .1 Submit shop drawings for products of this Section.
- .4 Include following information:
 - .1 Catalogue information.
 - .2 Full load kVA output at 0.9 % lagging power factor.
 - .3 Efficiency of system at 50% and 100% rated load.
 - .4 Battery specifications.
- .5 Submit testing and verification reports.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 UNINTERRUPTIBLE POWER SUPPLY (UPS) UNITS - SINGLE PHASE

- .1 CSA approved and ULC listed, single phase, continuous duty, full sinewave output, on-line double conversion uninterruptible power supplies, as specified and as detailed on drawings, and with following features:
 - .1 Static inverter.
 - .2 Rectifier/charger.
 - .3 Automatic by-pass.
 - .4 LCD display.
 - .5 Monitoring and control components.
 - .6 Microprocessor controlled logic.
 - .7 Surge, spike and continuous brownout protection.
 - .8 Integral battery pack to provide specified battery time at full capacity load.
 - .9 Battery management technology.
 - .10 Communication interface.
 - .11 Desk top type enclosures.
 - .12 Required ancillary devices.
- .2 System software provides control, monitoring and communication requirements of UPS unit and batteries. System software is compatible for use by a wide range of operating systems.
- .3 Standards: In accordance with:
 - .1 CSA C22.2 No. 107.1.
 - .2 IEEE C62.41.1.
 - .3 FCC Rules and Regulations Title 47, Part 15.
- .4 Modes of Operation
 - .1 Normal: During Normal or Double Conversion Mode, rectifier derives power as needed from commercial AC utility or generator source and supplies filtered and regulated DC power to on-line inverter. Inverter converts DC power to highly regulated and filtered AC power for critical loads.
 - .2 Battery: Upon failure of AC input source, inverter continues to supply power to critical loads without switching. Inverter obtains power from battery. There is no interruption in power to critical load upon failure or restoration of AC input source.
 - .3 Recharge: Upon restoration of AC input source, rectifier/battery charger recharges battery. Inverter with no interruption in power, regulates power to critical load.
 - .4 Bypass: Static bypass transfers critical load to mains supply without interruption. Automatic re-transfer to normal operation accomplished with no interruption in power to critical load. Static bypass switch capable of manual operation.

.5 Performance Ratings

- .1 Output Power: Minimum 1500 VA. Minimum 95% efficiency full load at unity power factor.
- .2 Input Voltage: 120 VAC, 1-phase, 60 Hz.
- .3 Output Voltage: 120 VAC, 1-phase, 60 Hz
- .4 Input Power Factor: >0.99 typical.
- .5 Input Current Distortion: 5% THD.
- .6 Output Voltage Regulation: +/-1% static; +/- 5% dynamic resistive load change, <1 ms response time.
- .7 Output Voltage THD: 5% maximum typical.
- .8 Operating Temperature: 10°C to +40°C (without derating).
- .9 Audible Noise: less than 53 dBa (at 1 m) from operator surface.

.6 Features

- .1 Converter (Rectifier):
 - .1 Incoming power filtered and converted to DC by sine-wave rectifier.
 - .2 DC power processed by high-frequency converter to supply power to inverter.
 - .3 Converter corrects input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from utility.
 - .4 In event of utility failure, converter supplied power without interruption from batteries.
- .2 Battery Charger: Charging battery and maintaining full battery charge when AC is applied to UPS.
- .3 Automatic Bypass (Static bypass): Alternate path to commercial AC or generator source in case of overload, load fault or internal UPS failure.
- .4 User Interface Panel:
 - .1 User-friendly interface panel, allows user to perform operations including, change operating modes, set system parameters, check alarm logs and other functions.
 - .2 LCD screen to display system status and functions. LED indicators indicate system status including Standby, Normal, On Bypass, and On Battery. Push Buttons for menu scrolling.
- .5 Communications:
 - .1 Serial (RS-232) Communication Interface: Communicating with manufacturer supplied software package. UPS provides signals for indication of UPS general alarm.
 - .2 Communication cards and slots: For integration to various systems, allowing for monitoring by respective system control panels including building automation systems.

.7 Battery Management

- .1 Battery Recharge: After recharging batteries to full capacity, charger enters rest mode to increase battery lifetime, and not providing continuous float charging of battery. Active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).
- .2 Battery Runtime Monitoring: Monitors batteries and provides status to end user of battery runtime. Runtime calculations based on load demand and analysis of battery health.
- .3 Battery Health Monitoring: Automatic periodic testing and monitoring of battery health and provides warnings visually, audibly and serially when battery capacity falls below 80% of original capacity. Battery testing also user optionally initiated.

.8 Lithium-Ion Batteries

- .1 Uses lithium ion (Li-ion) batteries designed for auxiliary power service in UPS application.
- .2 Battery Pack
 - .1 Integral with UPS.
 - .2 Sealed, maintenance-free, lightweight, compact, long-life Li-ion type batteries.
 - .3 Factory preassembled and prewired.
 - .4 Capacity provides power for at least 20 minutes at 100% full load rating capacity of UPS, and at least 60 minutes at 50% full load rating capacity of UPS.
 - .5 ULC listed and labelled.
 - .6 Battery solution operating temperature rating: 0-45°C.
 - .7 Supplied with impact resistant plastic cases.
- .3 Battery Monitoring
 - .1 Battery monitoring provided at module, rack, and system level. Switched-mode power supply provides power for battery monitoring system.
 - .2 Dry Contact: Communicates with UPS.

.9 Enclosures

- .1 UPS system including accessories and battery packs provided in integral dead front and enamelled painted steel enclosures.
- .2 Features
 - .1 Horizontal or Vertical Enclosures: As specified, or as indicated on drawings or schedules.
 - .2 Rack mounted with racking hardware, or free standing: As specified, or as indicated on drawings or schedules.
 - .3 Casters and leveling feet on larger free standing UPS units.
 - .4 Forced air fan ventilated on larger UPS units, in accordance with UPS manufacturer requirements.

- .5 Ventilation louvres designed to prevent penetration of water spray from activated sprinklers onto live parts.
- .10 Additional Requirements
 - .1 Input Connections: 120 VAC plug and 1.8 long cord.
 - .2 Output provisions: Minimum quantity of six of NEMA type 5-15P output receptacles.
 - .3 Auxiliary Contacts: 1 NC and 1 NO contacts for auxiliary functions, such as for general alarm or general notice conditions.
- .11 Warranty
 - .1 UPS System: UPS manufacturer warrants UPS system against defects in materials and workmanship for 24 months from date of substantial completion. Warranty includes labour and materials with no deductible amounts.
 - .2 Batteries
 - .1 System manufacturer provides full comprehensive warranty on batteries against defects in materials and workmanship, as follows:
 - .1 Li-ion batteries designed for minimum 10 years of service life.
 - .2 Batteries with 24 months full exchange and 60 months prorated warranty, from date of substantial completion.
 - .3 Batteries supplied by UPS manufacturer or UPS manufacturer authorized dealer.
- .12 Testing, Start-up, Verification and Training
 - .1 Manufacturer: Provides standard factory testing and submits copy of detailed reports to Departmental Representative.
 - .2 Manufacturer authorized technician to:
 - .1 Provide onsite service of inspecting installation, perform start-up, testing and verification of equipment.
 - .2 To assist in onsite coordination, installation and testing of equipment.
 - .3 Prepare and sign certification report letter stating system has passed manufacturer testing and performs to manufacturer requirements for application.
 - .4 Be present to assist during third party testing.
 - .5 Provide instructions on system operating and maintenance.
 - .3 Perform testing and verification work at times reviewed with Departmental Representative.
 - .4 Refer to Part 3 for additional requirements.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF SMALL CAPACITY UPS UNITS

- .1 Provide uninterruptible power supply units for backup power to various equipment and systems requiring small capacities units.
- .2 Obtain required training from manufacturer representative on special installation procedures. Install units in accordance with manufacturer instructions to suit intended applications.
- .3 Provide UPS units of capacity size to accommodate fully connected loads and with connection requirements (hardwired or plug-in receptacles) to suit intended applications.
- .4 Mount UPS units in locations reviewed with Departmental Representative. Provide hardware suitable for intended mounting.
- .5 As applicable, plug units into adjacent receptacles or hardwired, fed from dedicated power circuits.

3.3 INSPECTION, TESTING, START-UP, COMMISSIONING AND VERIFICATION WORK

- .1 Include for onsite inspection, testing, start-up, commissioning and verification by manufacturer field service personnel. Arrange for equipment supplier to provide testing and commissioning, witnessed by Departmental Representative, at times reviewed with Departmental Representative.
- .2 Under direction of Departmental Representative, carry out complete performance acceptance tests and associated work at site on installed UPS units. Provide full capacity load banks and monitoring equipment for testing and demonstration of operation.
- .3 Conduct tests without disturbing user wiring and complete testing prior to connection of site critical loads.
- .4 Perform visual inspection, mechanical inspection, electrical inspection, start-up and verification, as follows:
 - .1 Inspect equipment for damage and for proper installation.
 - .2 Perform start-up procedure in accordance with manufacturer instructions and recommendations.
 - .3 Test UPS system for automatic operation. Perform testing to show successful uninterrupted full load transfer upon hydro failure to UPS and uninterrupted transfer from UPS to bypass.
 - .4 Perform load testing and battery system testing.
 - .5 Inspect and test batteries for charge and charging capability.
 - .6 Test battery monitoring system, where applicable.
 - .7 Test system options and features to verify proper operation.
- .5 Rectify deficiencies.

- .6 Prepare testing and verification reports, signed by testing technician. Submit copies to Departmental Representative.

3.4 TRAINING

- .1 Manufacturer technician to perform onsite training of users (including provision of user guides) in operation and maintenances of system, prior to project completion.
- .2 Verify that users are properly trained in operation and maintenances of system.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 American National Standards Institute (ANSI)
 - .1 ANSI C78.377-2017, Electric Lamps - Specifications for the Chromaticity of Solid-state Lighting Products.
- .2 Canadian Standards Association (CSA)
 - .1 CSA C22.2 No. 141-15(R2020), Emergency Lighting Equipment.
 - .2 CSA C22.2 No. 250.13-20, Light Emitting Diode (LED) Equipment for Lighting Applications
 - .3 CAN/CSA-C860-11(R2016), Performance of Internally Lighted Exit Signs.
- .3 Illuminating Engineers Society North America (IESNA)
 - .1 IES LM 79-19, Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
 - .2 IES LM-80-15, Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.
 - .3 IES TM-21-19, Projecting Long-Term Lumen, Photon, and Radiant Flux Maintenance of Led Light Sources.
 - .4 IES TM-30-18, IES Method for Evaluating Light Source Color Rendition.
- .4 Institute of Electrical and Electronics Engineers IEEE)
 - .1 IEEE C62.41.1-2002(R2008), IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
 - .2 IEEE C62.41.2-2002, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
- .5 International Standards Organization (ISO)
 - .1 ISO 3864-1-2011, Graphical Symbols - Safety Colours and Safety Signs - Part 1: Design Principles for Safety Signs and Safety Markings.
 - .2 ISO 7010-2019, Graphical Symbols - Safety Colours and Safety Signs - Registered Safety Signs.
- .6 National Electrical Manufacturers Association (NEMA)
 - .1 NEMA 410-2015, Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- .7 Underwriters' Laboratories
 - .1 UL 20-Edition 14-2018, General-Use Snap Switches.
 - .2 UL 924-Edition 10-2016, Standard for Emergency Lighting and Power Equipment.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00 and Section 26 05 00.

.2 Product Data

- .1 Provide manufacturer printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings

- .1 Submit shop drawings for products of this Section, and on Schedule of Luminaires.
- .2 Submittals for luminaires include:
 - .1 Luminaire dimensions, aperture dimensions, cutout dimensions.
 - .2 Driver information for each luminaire, including maximum circuit loading limitations, and dimming details.
 - .3 Total input watts.
 - .4 Lumen rating in accordance with IESNA testing procedures.
 - .5 Candlepower summary, candela distribution zonal lumen summary.
 - .6 Luminaire efficiency.
 - .7 Lamp life rating (in accordance with IES LM-80 and IES TM-21).
 - .8 Colour temperature.
 - .9 Colour fidelity (in accordance with IES TM-30 preferred).
 - .10 Finishes.
 - .11 Options being provided.
 - .12 Other relevant information to verify design intent.
- .4 Submit samples where specified, or indicated on drawings or schedules.
- .5 Submit LED/drivers and controls manufacturers documentation verifying compatibility.
- .6 Submit testing and verification reports.

1.3 QUALITY ASSURANCE

- .1 Products and Workmanship: To requirements of Section 26 05 00.

1.4 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 and with manufacturer written instructions.
- .2 For existing applications:
 - .1 Disposal and recycling of fluorescent lamps in accordance with local governing regulations.
 - .2 Disposal of old PCB filled ballasts in accordance with local governing regulations.

1.5 WARRANTY

- .1 Warranty requirements for luminaires are as follows:
 - .1 Full comprehensive product replacement direct from luminaire manufacturers.
 - .2 When LEDs and drivers are supplied with luminaire by luminaire manufacturer, warranty is responsibility of luminaire manufacturer.
 - .3 Warrant LED luminaires and drivers for period of minimum 5 years. Include for personnel, equipment and labour for replacing products onsite, for duration of contract warranty period. For remainder of 5 years extended warranties beyond contract warranty period, include typical conditions of product manufacturer replacement warranty.

1.6 PRODUCT COMPATIBILITY

- .1 Provide luminaires 100% compatible with lighting controls, when integrated together for control purposes.
- .2 Coordinate with driver and LED manufacturers and dimmer/light sensor/occupancy control manufacturers to verify that components are compatible with each other and that interconnections do not adversely affect performance, life or warranties.
- .3 Submit manufacturer documentation verifying compatibility.

1.7 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00 and Section 26 05 00.
- .2 Operation and Maintenance Data: Submit operation and maintenance data for products for incorporation into manuals.

PART 2 - PRODUCTS

2.1 LUMINAIRES

- .1 Provide luminaires in accordance with Schedule of Luminaires.
- .2 Features
 - .1 CSA approved or ULC listed and labelled.
 - .2 Certified and tested with LEDs and drivers, as complete assembly.
 - .3 Luminaires and integrated LEDs and drivers tested for full compatibility operation, prior to shipping to site.
 - .4 Provide thickness of metal as indicated in Schedule of Luminaires and details, or as required so that luminaires are rigid, stable and resists deflection, twisting, warping or bending under normal installation procedures, re-lamping and maintenance and cleaning.
 - .5 Linear and continuous linear architectural LED luminaires bodies constructed of extruded aluminum and of rigid construction, except where scheduled.

- .6 Body finishes of corrosion resistant, chemically treated and electrostatically applied post powder coat finish, except where scheduled.
- .7 Vandal resistant luminaires constructed of heavy duty extruded aluminum with stainless steel tamperproof head set screws and lens of extruded UV stabilized polycarbonate, except where scheduled.
- .8 Neoprene or silicone gasketing, barriers and stops to prevent light leaks or water/water vapour penetration.
- .9 Fabricated housings allowing for easy accessibility and replacement of parts.
- .10 Fabricated luminaires:
 - .1 Minimum number of joints.
 - .2 Make unexposed joints by welding, brazing, screwing or bolting. Soldered joints are unacceptable.
 - .3 Do not use blind metal tapping methods or rivets for fastening parts need removal during service, or for fastening electrical components and supports.
 - .4 Cast parts including die-cast members, of uniform quality, close grained, rigid, true to pattern, free from blow holes, pores, discoloration, hard spots, shrinkage defects, and cracks or other imperfections affecting strength and appearance or indicative of inferior metals or alloys.
- .11 Reflectors and reflecting cones or baffles free of tooling marks, spinning lines or marks by other assembly techniques.
- .12 Lenses and louvres in accordance with local governing code flame spread rating requirements.
- .13 Recessed luminaries with replaceable/serviceable parts accessible from lens side (room side) of luminaires allowing for proper accessibility.
- .3 Submit samples where specified, or indicated on drawings or schedules.
- .4 Review colours and finishes of luminaires with Departmental Representative, prior to ordering.
- .5 Where luminaires are of same or similar types, provide from same manufacturer.
- .6 Seismic restraints as required in accordance with requirements of local governing building codes.

2.2 LIGHT EMITTING DIODES (LEDS) AND DRIVERS

- .1 General Features
 - .1 CSA approved, ULC listed and labelled.
 - .2 CSA C22.2 No. 250.13 compliant.
 - .3 NEMA 410 compliant drivers.

- .4 Typical operating temperatures:
 - .1 Luminaires for applications in extreme cold, non-climate-controlled area: Operating temperature range through -40°C to 60°C.
 - .2 Luminaires for applications in climate-controlled area: Operating temperature range through -20°C to 50°C.
- .5 Standards in accordance with IES LM 79 and IES LM-80.
- .6 Where connected to dimmers, are 100% compatible with connected dimmer controls, providing dimming down to 1%.
- .7 Review with dimming controls vendors, verifying that technical operations of dimmers such as forward phase or reverse phase, match and are compatible with LED/driver technology.
- .2 LED Features
 - .1 LEDs selected from same colour bin size for consistency in chromaticity and in accordance with ANSI C78.377.
 - .2 Colour temperature range:
 - .1 Typically 2700 K to 6500 K.
 - .2 Specific temperature requirements identified on Schedule of Luminaires.
 - .3 CRI: At least 90, unless otherwise scheduled.
 - .4 Rated life: In accordance with IES LM-80 and IES TM-21, ranging from 50,000 to 70,000 hours.
- .3 Driver Features
 - .1 Operate from 60 Hz input source of 120 VAC/347 VAC (as applicable) with sustained variations of $\pm 10\%$ (voltage and frequency) with no damage to driver.
 - .2 Output Regulated: $\pm 5\%$ across load range.
 - .3 Power Factor: Greater than 0.90.
 - .4 Total Harmonic Distortion: Less than 20%.
 - .5 Class A sound rating.
 - .6 In accordance with IEEE C62.41.1 Category A for transient protection.

2.3 SURGE PROTECTION FOR LED SYSTEMS

- .1 Exterior LED luminaires
 - .1 Include surge protection for LED systems in accordance with IEEE C62.41.2 transient surge requirements.
 - .2 Surge protection of 6 kV/3 kA for low exposure conditions (low grade level landscape lighting).
 - .3 Surge protection of 10 kV/10 kA for high exposure conditions (pole mounted lighting).

2.4 EXIT SIGNS

- .1 Refer to additional requirements on Luminaire Schedules. Typically to match existing types.
- .2 Pictogram types to CSA C22.2 No. 141.
- .3 Exit wording types to CAN/CSA-C860.
- .4 Housing: Extruded aluminum housing, except otherwise scheduled.
- .5 Faceplates: Extruded aluminum, except otherwise scheduled.
- .6 Lamps: Multiple LEDs.
- .7 Operation: Designed for over 75,000 hours of continuous operation.
- .8 Energy Efficient: Consumes less than 2.5 W.
- .9 Pictogram Graphics: Green pictogram and white graphical symbol and directional arrows to ISO 3864-1. Dimensions to ISO 7010.
- .10 Exit Wording: Lettering to match existing signs.
- .11 Faceplate to remain captive for re-lamping.
- .12 Voltage: 120 V or 347 V AC, as indicated on drawings or schedules.
- .13 Tamperproof hardware.
- .14 Wire guards or polycarbonate covers.

2.5 FINISHES

- .1 Luminaire Finishes and Construction
 - .1 In accordance ULC listings and CSA certifications related to intended application.
 - .2 Exposed parts and hardware of luminaires located in non-climate controlled areas:
 - .1 Corrosion resistant and weather resistant.
 - .2 Tamper-resistant hardware.
 - .3 Reviewed with Departmental Representative with samples and shop drawing submissions.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTRUCTIONS

- .1 Compliance: Comply with manufacturer written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF LUMINAIRES

- .1 Do not use dimensions for coves, valances, linear and continuous linear LED luminaires indicated on drawings for construction purposes. Job measure for exact dimensions to suit installation locations.

- .2 Make shop drawing submissions for review with Departmental Representative. Before placing luminaire orders:
 - .1 Review Departmental Representative reviewed shop drawings and address comments.
 - .2 Verify quantity requirements.
 - .3 Review ceiling types, finishes and construction details. Verify ceiling types with architectural drawings.
 - .4 Verify type of mounting assemblies, frames, rings and ancillary devices for installation.
 - .5 Review colours and finishes with Departmental Representative.
- .3 Obtain training from manufacturer representative on special installation procedures. Install products in accordance with manufacturer instructions to suit intended applications.
- .4 Locate and install luminaires.
- .5 Provide supports to suit ceiling system.
- .6 Reference electrical drawings for general luminaire location, circuiting, and controls. Reference Architectural reflected ceiling plans (RCPs) for more detailed location of luminaires. Consult both sets of drawings in preparation for installation. Install luminaires in accordance with reflected ceiling plans, wall elevations, or field instructions issued by Departmental Representative.
- .7 Review final locations of luminaires with Departmental Representative prior to roughing-in.
- .8 In equipment rooms, shafts and similar secondary areas, install luminaires after mechanical and other major work is roughed-in and adjust luminaire locations to suit.
- .9 Include for assembly and mounting of luminaires and lamps, complete with:
 - .1 Wiring and connections.
 - .2 Fittings and hangers.
 - .3 Aligners.
 - .4 Box covers.
 - .5 Other accessories for complete, safe and fully operational assembly.
- .10 Where outlet boxes locations are indicated, they are diagrammatic only. Position outlet boxes to coincide with suspension hangers and knockouts.
- .11 Install ceiling luminaires in centre of tiles, except dimensioned otherwise on Reflected Ceiling Plans. Locate hangers on tile centres or intersections. Mount recessed downlights, troffers, and surface mounted luminaires in or on full tiles. Install luminaires in and on acoustical tile ceilings in alignment with tile joints.
- .12 Cut holes for recessed luminaires to size so that gaps are not visible, or luminaire trims cover gaps.

- .13 Mount surface ceiling luminaires level or plumb, tightly to ceiling without showing space or light leak between frame and ceiling.
- .14 Align linear luminaires indicated in continuous lines or rows, so that rows appear as straight lines. Variation in alignment not to exceed 6 mm for 5 m runs.
- .15 Align luminaires mounted individually parallel or perpendicular to building grid lines.
- .16 Provide spacers for luminaires mounted on low density ceiling material.
- .17 Provide plaster frames for recessed luminaires in plaster or gypsum board ceilings.
- .18 Prepare luminaires, trim and poles and standards requiring onsite painting.
- .19 Connect luminaires to lighting circuits. Install flexible or rigid conduit for luminaires, as specified.
- .20 Protect wiring with tape or tubing at points where abrasion occurs. Conceal wiring within luminaire construction except where design or mounting dictates otherwise.
- .21 Splices
 - .1 Minimize number of splices.
 - .2 Make with mechanical insulated steel spring type connectors, suitable for temperature and voltage conditions to which splices are subjected.
 - .3 Mask splices properly terminated in accessible identified junction boxes.
- .22 Support luminaires directly by ceiling slab structure and not to formed steel decking, ceiling hangers, ductwork, piping, cable trays, or other similar materials. Review requirements with Departmental Representative, prior to start of work.
- .23 Do not tighten wing nuts, bolts, or screws that allow luminaire adjustment for recessed adjustable luminaires.
- .24 Install spread lenses where specified on Schedule of Luminaires.
- .25 Use cloth gloves when handling reflector cones, louvers, lamps, glass, sconces and exposed surfaces of luminaires.
- .26 Co-ordinate luminaire installation with work of other trades, to provide required recessing depths and mounting spaces.
- .27 Align and position adjustable luminaires and position luminaires with adjustable lamp holders to correspond to lamps.
- .28 Comply with requirements of local governing electrical code regarding support of luminaires in suspended ceilings.
- .29 Independently suspend luminaires in suspended ceilings from ceiling slab. For each luminaire, provide minimum two cable supports secured to ceiling slab and to luminaire.

- .30 Connect luminaires to power circuits and controls. Circuit for both normal and emergency power circuits as indicated on drawings.
- .31 For emergency lighting controls, provide relays compliant with UL 924 and applicable local governing electrical code requirements.
- .32 Notify Departmental Representative of following conditions:
 - .1 Luminaire placement conflicts with structural beam, mechanical duct, plumbing pipe, or other similar material.
 - .2 Space above ceiling is not sufficient.
 - .3 Reasons that luminaire cannot be located where dimensioned or indicated on construction documents.
- .33 Existing luminaires designated for relocation and reuse:
 - .1 Disconnect, remove and store in area as reviewed with Departmental Representative, until ready for re-installation.
 - .2 Inspect and clean.
 - .3 Identified to Departmental Representative, of requirement for replacement parts for broken lenses, faulty ballasts/drivers, broken mounting hardware, lamps not working, in order to return luminaires to working conditions.
 - .4 Repair and re-lamp, as required.
- .34 Provide seismic restraints as required.
- .35 Ground and bond luminaires in accordance with local governing electrical code requirements.
- .36 Energize installed luminaires for testing of installation, and de-energized until system commissioning. Do not use installed luminaires for construction lights.
- .37 Retain protective material on luminaires (remove as required for testing), until prior to commissioning.
- .38 Demonstrate operation of luminaires intended for special applications such as building floodlights and other decorative purposes. Adjust their locations within reasonable distance, obtaining desired effects.
- .39 Identify circuits and components as specified, and in manner reviewed with Departmental Representative.
- .40 Prior to turn over of Work, clean luminaires in manner recommended by manufacturer, and as reviewed with Departmental Representative.
- .41 Provide lamps in new condition and intact when project is complete and ready for acceptance.
- .42 Include full lamp listing in Operating and Maintenance Instruction Manuals.
- .43 Prepare testing and verification reports, signed by testing technician. Submit copies to Departmental Representative.

3.3 INSTALLATION OF EXIT SIGNS

- .1 Install exit lights to manufacturer recommendations, listing requirements and local governing code requirements.
- .2 Review each respective installation location and determine installation accessories to suit support from either wall or ceiling construction. Provide brackets and stem assemblies. Review with Departmental Representative.
- .3 Locate exit signs in final locations reviewed with Departmental Representative and approved by local building code authority. Connect to power circuits, normal and emergency. Where applicable for emergency power requirements, connect to emergency battery units. Relocate exit sign and re-direct direction arrows to suit local building code authority requirements and directions, and as reviewed with Departmental Representative.
- .4 For suspended from ceiling installation of exit signs, mount signs with stem assembly from ceiling structure, and provide assembly that connects to sign frame directly (not with electrical box mounted onto frame). Provide continuous no smaller than 13 mm threaded conduit (finished painted as reviewed with Departmental Representative) extending from ceiling mounted junction box, with ball align hanger to threaded connector directly mounted into top of specified exit sign.
- .5 Connect fixtures to exit light circuits.
- .6 Connect emergency power provisions to emergency circuits of units.
- .7 Lock exit light circuit breaker in on position.
- .8 Direct heads where applicable.
- .9 Do not load device circuits more than 80% capacity. Include for voltage drop requirements in accordance with manufacturer instructions.
- .10 Install wire guards or polycarbonate covers where indicated on drawings or as noted.
- .11 Test units and for units with lighting heads, perform illumination level test to verify compliance with local governing building requirements. Document testing.
- .12 Co-ordinate, arrange and obtain required local authority building inspector approvals.
- .13 Prepare testing and verification reports, signed by testing technician.
- .14 Submit copies of reports and approval certificates to Departmental Representative.

END OF SECTION

PART 1 - GENERAL

1.1 GENERAL

- .1 "Provide" shall mean "supply, install and connect".
- .2 Provide new materials, equipment and plant of proven design and quality, and of current models with published specifications for which replacement parts are readily available
- .3 Refer to Section 28 12 01 Access Control General Requirement.

1.2 DEFINITIONS

- .1 Refer to Section 28 12 01 Access Control General Requirement.

1.3 REFERENCE STANDARDS

- .1 Refer to Section 28 12 01 Access Control General Requirement.

1.4 DESIGN REQUIREMENTS

- .1 General Scope:
 - .1 This document defines the Access Control Door, to include field devices, termination hardware, supporting hardware, locking hardware and miscellany required to provide a complete system.
The intent of this document is to provide all pertinent information to supply the equipment, labor, supervision, tooling, and miscellaneous mounting hardware and consumables to install a complete operational and functional system. Propose in their bid any and all items required for a complete system if not identified in this specification.
 - .2 Be responsible for the entire scope specified herein.
 - .3 Supply and install one full functional access control door with reader, door contacts, request to exit device and electrified door hardware, integrated to the existing access control system and Departmental Representative's existing Security Central Control Computer System.
 - .4 Be responsible for the procurement, detailed design, installation, terminations, programming, configuration, integration, testing and demonstrating system functionality.
 - .5 Install all required cabling, connectors, door hardware, software, hardware and software updates, hardware to allow for the required functionality under this specification.
 - .6 Provide at all times sufficient competent trained labor, materials, and equipment to properly carry on construction work

and insure completion of each part in accordance with the Work Schedule.

- .7 Provide necessary labor, and material to comply with manufacturer's requirements and applicable standards and codes for grounding of devices.
- .8 Equipment shall be installed as per manufacturer recommendations or as otherwise noted in this specification and specification drawings.
- .9 Be responsible for the safe keeping and protection of the system equipment until the system is fully accepted by the Departmental Representative after the commissioning process.
- .10 Coordinate all Work with the Departmental Representative and applicable trades on site.
- .11 Coordinate all Work regarding the network and IP addressing schemes with the Departmental Representative if required.
- .12 Equipment and material shall be UL, CSA or ULc certified. Where there is no existing rating to equipment specified, obtain special prior written approval from the Departmental Representative.
 - .1 Warrant the completed Access Control System including all equipment/hardware, and documentation. Maintain the Access Control System in compliance with manufacturer specified preventative maintenance schedule during the project installation period.
- .13 Preventive and corrective maintenance performed by another maintenance provider other than the installer, after or during warranty period shall not void warranty on labor, hardware or software provided.
- .14 System testing shall follow the testing, commissioning and Certificate of Acceptance process outlined in Section 28 12 01.
- .15 The card reader and operator controls shall be installed between 800-1200MM above Fixed floor level to meet CSA/B651-18 -Accessible design for the built environment.
- .2 System Description:
 - .1 Integrate the new access control door to the existing facility security access control system.
- .3 Access Control System Deployment:
 - .1 The Access Control System shall consist of card reader compatible with existing card readers and card format deployed by the Departmental Representative, door contacts, REX devices and monitoring devices integrated to the door hardware, and electronic locking devices necessary to provide a fully automated and monitored system to control authorized pedestrian

- traffic in and out of controlled door of the facility.
- .2 The conduit installation from the doors to the existing DGP shall be provided by Section 26 and shall be consistent with the specification drawings and all norms and regulations applicable. In the event the proposed pathway becomes infeasible source an alternative route and propose to the Departmental Representative for approval. Alternative routing of pathways shall not incur any additional costs to the project.
 - .3 The Access Control System shall consist of the elements in the quantities specified in the drawings and schedules.
 - .1 For card reader door locations, supply and install all necessary field devices as shown on the Security drawings including, but not limited to:
 - .1 Card Reader
 - .2 Request to Exit Motion Detector / REX Switch
 - .3 Concealed Door Contact
 - .4 Supply and install all necessary Control Equipment including, Transformers, Power supply unit:
 - .1 Equipment shall not carry any logos or text without prior formal approval from the Departmental Representative.
 - .4 Portal Definition:
 - .1 Common Portal Functions
 - .1 The below functions are general to all portal's where applicable, and unless otherwise stated within the respective portal sub-sections.
 - .1 Valid Access Trigger - The following are valid triggers which shunt the door alarms, and allow proper access through the respective portal.
 - .1 Valid Access Card swiped
 - .2 Request to Exit Motion Detector or Pushbutton
 - .3 Remote access granted.
 - .2 Invalid Card Reader Swipe
 - .1 Upon presentation of an invalid access card, the card reader shall provide an audio/visual indication of the invalid access attempt.
 - .3 Door Forced Open Alarm
 - .1 In the event that the Door Position Switch or Lock Status Switch activate without a Valid Access Trigger, generate a "Door Forced Open" alarm at the access control head end and activate the local annunciator.
 - .2 Local annunciator shall remain active until

door is closed and a valid access card is swiped. Alarm can also be reset by the operator remotely from the Central control system.

.4 Door Held Open Alarm

- .1 Door not closed during shunt time will activate "Door Held Open" indication in the Central control system, activate local annunciator and pop up cameras in the area on security monitors through integration. The system should have the ability to keep the local annunciator active until door is closed and a valid card is swiped. Alarm can also be reset by the operator remotely from the Central control system.

.5 Equipment Rooms

- .1 Prior to start of installation of any equipment remove all water, dirt and debris of any kind from the room. Keep room clean and free of dust at all times.

.6 Monitoring & Control Locations

- .1 Access Control Server
 - .1 The access control system components installed shall be configured, operated and maintained by the existing access control system infrastructure, operational at the Central Security Control.
 - .2 Coordinate with the Departmental Representative to configure and test the functionality of the installed system.

.7 Third Party Interfaces

- .1 All third-party interfaces shall be directly supported by the individual system manufacturer(s). "Middleware" created and deployed by a 3rd party is not acceptable and shall not be used on this project.

.8 Network Time Protocol

- .1 The Access Control System shall be maintained with NTP time. The NTP master clock Link, shall be by the Departmental Representative.

.9 Power

- .1 Refer to Section 28 12 01 Access Control System General Requirements.

.10 Labelled Fire Doors and Frames

- .1 In no instance shall any labelled fire door or frame be cut, penetrated, drilled or modified in any way that has not been designated as requiring such in the security drawings.
- .2 Any labelled fire door or frame which will require modification to meet the system specifications must be immediately brought to the attention of the Departmental Representative.
- .3 Be responsible for replacing any labelled fire door or frame that is modified, without written approval from the Departmental Representative.

1.5 SUBMITTALS

- .1 Refer to Section 28 12 01 Access Control System General Requirements.

1.6 WASTE MANAGEMENT AND DISPOSAL

- .1 Refer to Section 01 74 21 Construction/Demolition Waste Management and Disposal.

1.7 WARRANTY

- .1 Refer to Section 28 12 01 Access Control System General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- .1 Be fully responsible for the ultimate design and implementation of the system topology (physical and logical) best suited for the project, given identified and recognized physical infrastructure and constraints.

2.2 TECHNICAL REQUIREMENTS - FIELD DEVICES

- .1 Electronic Locking Devices
 - .1 Door hardware such as electric lock Sets, Electromagnetic locks, electric strikes, power transfer hinges, door cords or electrified panic hardware, these units shall be supplied, by the Contractor.
 - .2 Fire release of electromagnetic lock permits and installations if required shall be coordinated with the Departmental Representative.
- .2 Door Position Switches
 - .1 Supply and install door position switches for all card access controlled doors, in consultation with the Departmental Representative.

- .2 Door position switches shall be recessed / concealed contact type unless otherwise noted and shall not be integral to other devices such as strikes, maglocks, etc.
- .3 The maximum diameter for the concealed contact and magnet shall be 26mm.
- .4 All End of Line resistors shall be installed at the door contact.
- .5 Frame mounted magnetic door contacts, hinge mounted plunger type switches, are not acceptable.
- .3 Card Readers
 - .1 Departmental Representative approved card reader compatible with the existing card readers and Access Cards, shall be installed on the new access controlled door.
- .4 Request to Exit Motion Detector
 - .1 Requests to exit motion detectors shall be installed for hands free exit.
 - .1 Request to Exit Motion (REX) detectors shall be an infrared exit detector for access control applications suitable for mounting in a single gang box above doorways.
 - .1 For electric strike applications the REX shall shunt the door contact only, where applicable, for the programmed activation duration but shall not energize the electric strike, or unlock door.
 - .2 Request to exit motion detector case color should be confirmed with the Departmental Representative.
- .5 Request to Exit
 - .1 Request to exit Wave to Exit devices shall be used at location if shown on the drawings.
 - .1 Request to exit wave to exit devices shall be equipped with a heavy-duty tamper resistant Double Pole Double Throw contacts (DPDT).
 - .2 Back plate shall be a minimum ¼" (6.35mm) thick brushed aluminum.
- .6 Edge Device Environmental Requirements
 - .1 System shall be capable of operating within the temperature range of +4°C to +50°C (+40°F to +122°F).
 - .2 Outdoor edge devices should have an Ingress Protection Rating of IP67 minimum. Outdoor devices shall be capable of operating within the temperature range of -40°C to +50°C (-40°F to +122°F).

2.3 ACS CONFIGURATION

- .1 Provide all information including up loadable floor plan drawings with all access control devices shown, as required by the Central Control Server Administrators to configure and make operational the installed devices.
- .2 Coordinate and test all door devices with the remote administrators to meet each door functionality requirement.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Programming
 - .1 Include all associated costs to assist Central System administrators to program the system and ensure all configuration and naming conventions are approved by the Departmental Representative.
 - .2 Attend pre-installation meetings as required with the Departmental Representative to identify the specifics of the system configuration and programming.
 - .3 Be responsible to document all decided on software configuration parameters and submit for approval.
 - .4 Include all approved software configuration parameters in final revisions of the shop drawings.
 - .5 Be responsible to ensure final programming configuration and system documentation match the newest door numbers to be provided by the Departmental Representative.

3.2 MECHANICAL AND ELECTRICAL REQUIREMENTS

- .1 Refer to Section 28 12 01 Access Control General Requirements.

3.3 COMMISSIONING

- .1 Refer to Section 28 12 01 Access Control General Requirements.

3.4 DOCUMENTATION

- .1 Refer to Section 28 12 01 Access Control General Requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 National Building Code of Canada 2015
- .2 Ontario Building Code 2012
- .3 CSA B651-18, Accessible design for the built environment
- .4 Ontario Fire Code 2019
- .5 CSA C22.1-18, Canadian Electrical Code, Part 1 (24th edition) Safety Standard for Electrical Installations.
- .6 UL 294-Edition 7 - 2018, Standard for Access Control System Units.
- .7 CSA C282:19 Emergency Electrical Power Supply for Buildings.
- .8 ANSI/TIA-568-B.1-3
- .9 BICSI Telecommunications Distribution Methods Manual - 14th Edition
- .10 Manufacturer's installation and specification manuals latest issue.
- .11 All applicable Provincial regulations respecting Health and safety.
- .12 National Fire Code of Canada (NFC) 2015
- .13 National Fire Protection Association (NFPA)
- .14 Hamilton Fire Department

1.2 DEFINITIONS

- .1 CSA - Canadian standards Association
- .2 UL - Underwriter Laboratories
- .3 ANSI - American National Standards Institute
- .4 EIA - Electronic Industries Alliance
- .5 BICSI - Building Industry Consulting Service International
- .6 IP - Internet Protocol
- .7 ACS - Access Control System

- .8 DGP - Data Gathering Panel
- .9 RXP - Request to Exit Push Button
- .10 REX - Request to Exit Motion Detector
- .11 NTP - Network Time Protocol

1.3 SCHEDULE

- .1 The Departmental Representative is seeking a Division 28 capable of providing a comprehensive, cost effective security solution based on all the requirements encompassed within this document. A solution with a well-defined architecture and which includes a comprehensive plan for continuing service and support. It is required to architect and propose a solution that best meets stated requirements using industry best practices.

1.4 GENERAL REQUIREMENTS

- .1 Provide an additional card reader integrated to existing Access Control system and issued cards, door position sensor, request to exit and electrified door hardware as shown on the drawing based on expanding the existing Access Control system. A solution with a well-defined architecture and which includes a comprehensive plan for continuing service and support. Engineer and propose a solution that best meets stated requirements using industry best practices.
- .2 This specification outlines the requirements for system installation, configuration, integration, operation, products, components and materials.
- .3 This document details the required submittals, testing procedures and installation procedures for all parts of the system.
- .4 Provide documentation for all items as detailed in this specification.
- .6 System components to comply with all relevant requirements of CSA, ULc or UL.
- .7 Coordinate all work with the Departmental Representative as well as with other Sections working on site.
- .8 Examine all project documents to determine whether there are any impediments to the installation of a fully functioning and operational Access Control door. At the time of bidding, provide written notification to the Departmental Representative of any omission, irregularities, errors, or ambiguities. Failure to supply

notification shall not relieve the responsibilities for providing a fully functional and operational system at the Contract Amount.

- .9 Include in the bid all required labour and material to integrate the system outlined in these documents to the Departmental Representative's existing Access Control System. This includes configuration of the existing system with new access levels, floor plans and access control devices for real time display and control of the new Access Controlled Door.

1.5 DOCUMENTS

- .1 The Security drawings are performance drawings, diagrammatic, and show approximate locations of equipment and materials. The drawings are intended to convey the intended design and do not show architectural and structural details. The locations of materials and equipment shown may be altered, when reviewed and accepted by the Departmental Representative to meet requirements of the material and/or equipment, other equipment and systems being installed in the building. The work shall be installed in such a manner as to avoid conflicts between other systems and architectural features. Provide all fittings, offsets, transformations, and similar items required as a result of obstructions and other architectural or structural details not shown on the Security drawings.
- .2 Shall be responsible for reviewing Drawings, Schedules, and Specification requirements of the Security Systems prior to commencing and confirm the exact intended design.

1.6 SUBMITTALS

- .1 Along the course of design and implementation the submit to the Departmental Representative; shop drawings, as-built documentation, and other supporting documents. Provide a schedule for the following document submissions within one-week of award, for review and approval by the Departmental Representative. All submittals shall be in accordance with this Section unless stated otherwise.
- .2 Shop Drawings:
 - .1 Each drawing shall include all changes and be upgraded to reflect the latest configuration.
 - .2 The first drawings submitted shall be reviewed for conformance to the requirements herein. Once approval is given, the approved drawing shall be used as the standard.
 - .3 Each drawing prepared and submitted for review shall have in the lower right-hand corner, just above the title block, a five-inch square blank space in which the Departmental Representative may indicate the action taken.

- .4 Shop drawings shall be prepared and submitted in the native (editable) electronic format (.vsd, .dwg, .xls, rvt .doc) All documents produced shall be property of the Departmental Representative, Section 28, shall have no rights over the entire documentation package or any parts of the documentation package.
- .5 All Shop Drawings must be submitted as follows:
 - .1 Cover Sheet - Job Name, Date
 - .2 Table of Contents with following columns
 - .1 Device Name
 - .2 Model #
 - .3 Symbol Name on Drawings
 - .3 All Shop drawings shall include as a minimum:
 - .1 Details necessary for the procurement, installation, maintenance, and repair of all components or facilities equipment provided.
 - .2 List of equipment to be installed organized by location and including the part number and the manufacturer.
 - .3 Manufacturer specification sheet for each new piece of equipment. Each sheet should clearly identify the particular model number of the hardware being provided. Where such information is not provided, at the discretion of the Departmental Representative, the most expensive option will be assumed.
 - .4 Wiring diagrams for the location.
 - .5 Point allocation table
 - .6 Software configuration parameters.
 - .4 Testing and commissioning plan
 - .1 Safety Plan
 - .2 Software Materials Licenses
 - .3 Operator Manuals and Procedures
 - .4 System Administrator's Manuals and Procedures
 - .5 Operator/Maintenance Manuals
 - .6 Testing procedures for each functional module.
- .6 Endorse each shop drawing copy "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS". Include company name, submittal date, and sign each copy. Shop drawings that are received and are not endorsed, dated and signed will be returned to be resubmitted. Submit minimum three (3) copies of shop drawings unless otherwise directed by Departmental Representative. Confirm exact quantity with Departmental Representative.

- .7 The Departmental Representative will review shop drawings and will indicate his review status by stamping shop drawing copies as follows:
- .8 "REVIEWED" or "REVIEWED AS NOTED" - If the Departmental Representative's review of shop drawing is final, the Departmental Representative will stamp the shop drawing "REVIEWED" or "REVIEWED AS NOTED" (appropriately marked).
- .9 "RETURNED FOR CORRECTION" If the Departmental Representative's review of shop drawing is not final, the Departmental Representative will stamp the shop drawing "RETURNED FOR CORRECTION", mark the submission with his comments, and return the submission. Revise the shop drawing in accordance with the Departmental Representative's notations and resubmit.
- .10 It is understood that the following is to be read in conjunction with the wording on the Departmental Representative's shop drawing review stamp applied to each and every shop drawing submitted:
 - .1 "THIS REVIEW BY THE DEPARTMENTAL REPRESENTATIVE IS FOR THE SOLE PURPOSE OF ASCERTAINING CONFORMANCE WITH THE GENERAL DESIGN CONCEPT. THIS REVIEW DOES NOT MEAN THAT THE DEPARTMENTAL REPRESENTATIVE APPROVES THE DETAIL DESIGN INHERENT IN THE SHOP DRAWINGS, RESPONSIBILITY FOR WHICH REMAINS WITH SECTION 28, AND SUCH REVIEW DOES NOT RELIEVE THE RESPONSIBILITY FOR ERRORS OR OMISSIONS IN THE SHOP DRAWINGS OR OF RESPONSIBILITY FOR MEETING ALL REQUIREMENTS OF THE DOCUMENTS. BE RESPONSIBLE FOR DIMENSIONS TO BE CONFIRMED AND CORRELATED AT THE JOB SITE, FOR INFORMATION THAT PERTAINS SOLELY TO FABRICATION PROCESSES OR TO TECHNIQUES OF CONSTRUCTION AND INSTALLATION, AND FOR COORDINATION OF THE WORK OF ALL SUBTRADES".

1.7 SECURITY SYSTEMS TESTING PROCEDURE

- .1 General: Overall testing algorithm shall consist of three phases per system and final Integrated Test(s) of all subsystems.
 - .1 Field devices (Field Layer).
 - .2 Termination equipment (Distribution Layer).
 - .3 Monitoring locations, integrated system functionality - within the system (Core Layer).
- .2 Exact testing schedule on day by day basis (including exact list of devices that should be tested during allocated time) should be submitted two weeks prior to commencement of testing.
- .3 The test shall be conducted according to the following algorithm:
 - .1 Verify prerequisites

- .2 Verify presence of all required witnesses of the test in accordance with the Specification.
- .3 Verify presence of a test plan, test description.
- .4 Verify presence of all test forms and checklists for proper test recording and documenting.
- .5 Verify presence of all test objects: field devices, panels, racks, equipment, components, cables, hardware, software, programming devices, AC power, etc.
- .6 Verify presence of programming and/or configuration settings, manufacturer's recommended test procedures for every device, predetermined parameter ranges and expected test results. This information may vary and depends on the actual location of testing and commissioning activity.
- .7 Shop and Record Drawings(s).
- .8 Programming/configuration settings.
- .9 Conduct the Test
- .10 Verify record drawings with the site location and the testing package.
- .11 Verify programming sheets with active settings(s).
- .12 Verify installation, workmanship, wiring, cabling, grounding & shielding,
- .13 Verify functionality.
- .14 Document the Test
- .15 Complete all test forms and checklists.
- .16 Record all required and applicable information.
- .17 Compare obtained test results with expected results.
- .18 Provide test report.
- .4 Dealing with Deficiencies
 - .1 Identify deficiencies and record them in a system's log.
 - .2 Deficiencies should be treated on an individual basis, Remediation and correction to be confirmed and approved by the Departmental Representative.
 - .3 Each deficiency should be corrected in a prompt manner. All deficiencies shall be identified with proper correction schedule, dates, responsible parties, and names.

1.8 WARRANTY

- .1 The Contractor must pay the transportation cost associated with returning the Work or any part of the Work to the Contractor's plant for replacement, repair or making good. The Contractor must also pay the transportation cost associated with forwarding the replacement or returning the Work or part of the Work when rectified to the delivery point specified in the Contract or to another location

- as directed by Canada. If, in the opinion of Canada, it is not expedient to remove the Work from its location, the Contractor must carry out any necessary repair or making good of the Work at that location. In such cases, the Contractor will be responsible for all Costs (including travel and living expenses) incurred in so doing, Canada will not reimburse these Costs.
- .2 Shall warrant the completed solution including all equipment, device software, device firmware, documentation and latent defects delivered shall perform in accordance with and conform to all applicable standards, requirements, specifications, descriptions, and other requirements included in their proposal and shall be without defects in materials, workmanship and design. The warranty shall commence upon Certificate of Completion as defined by the Departmental Representative.
 - .3 Expose, and assign to the Departmental Representative, any manufacturer's warranties. Include for 12-month all-inclusive parts and labor with 12-month warranty as part of the bid amount. Also, include software, Firmware, maintenance for a period of 12 months.
 - .4 As a minimum during the warranty period and at no extra cost to the Departmental Representative, include a guaranteed response time of two (2) hours for a major system failure and eight (8) hours for a minor system failure on a 24 hour per day, 7 days per week basis. A major system failure shall be defined as the failure of any operator controls as well as any system controller, processor or communication link which renders more than 10% of a specific security subsystem or systems inoperative. A minor system failure shall be defined as the failure of a single security device such as a card reader, egress device etc.
 - .5 As part of the submission, provide a complete list of recommended spare parts which should be held in the facility as well as a list of parts available on premises for fast system repairs and/or replacements.

1.9 LICENSE FEES

- .1 Provide licenses for every edge device added and remote Central Control computer systems that would require licenses.
- .2 All firmware and software shall be guaranteed for up to five (5) years, during which period any patches, bug fixes or related upgrades shall be implemented without additional cost to the Departmental Representative.
- .3 All software and firmware delivered shall become the property of the Departmental Representative. The Departmental Representative's

right to use all software and firmware delivered for this project shall not expire, regardless of other upgrade and warranty arrangements agreed with the Departmental Representative.

PART 2 - PRODUCTS

2.1 INSTALLATION OF PRODUCTS

- .1 Comply with manufacturer's instructions and recommendations so as to meet the requirements of the specification in all respects with regards to performance and functionality. Anchor each product securely in place, accurately located, coordinated and aligned with other Sections. Conflicts between the manufacturer's instructions and the Specification shall be promptly brought to the attention of the Departmental Representative prior to the initiation of any related Work.
- .2 Installation shall comply with all applicable norms and regulations, Departmental Representative standards and Base Building standards.
- .3 Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration,
- .4 Thoroughly clean areas and spaces where work is performed or used as access to work. Remove completely, paint, mortar, oils, putty and items of similar nature. Thoroughly clean piping, conduit and similar features before painting or other finishing is applied. Restore all surfaces to their original condition.
- .5 Termination equipment is to be mounted according to manufacturer's instructions unless specified otherwise.
- .6 Ensure that all services in the immediate areas of the installation are protected against damage or interference.

2.2 PRODUCT DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle products in accordance with the manufacturer's recommendations, using means and methods that will prevent damage, deterioration and loss, including theft. Materials delivered to the Project site shall be stored and protected to effectively prevent theft or damage from weather or physical abuse, either deliberate or inadvertent.
- .2 The Departmental Representative assumes no responsibility or liability for the loss by theft, vandalism, or burglary of material or equipment stored on or at the Project site.

- .3 Materials shall be received, receipted and stored by Section 28.
- .4 Access to the Project site for on and off-loading of all material, structures and equipment shall be coordinated with and approved by the Departmental Representative.
- .5 Before any Work is started, coordinate with the Departmental Representative, use of areas for staging and storage of materials and equipment.
- .6 Keep all route and site areas free and clean at all times of any dirt, debris or other material resulting from operation.
- .7 Schedule delivery to minimize long-term storage at the site and to prevent overcrowding of construction spaces.
- .8 Coordinate delivery with installation time to ensure minimize holding time for items that are flammable, hazardous, easily damaged or sensitive to deterioration, theft and other losses.
- .9 Deliver products to the site in manufacturer's original sealed containers or other packaging system, complete with Safety Data Sheets (SDS), labels and instruction for handling, storing, unpacking, protecting and installing.
- .10 Inspect products upon delivery, ensure that products are undamaged and properly protected.
- .11 Store products at the site in a manner that will facilitate inspection and measurement of quantity or counting of units.
- .12 Store products subject to damage by the elements above ground, under cover in a weather-tight enclosure, with ventilation adequate to prevent condensation. Maintain temperature and humidity within range required by manufacturer's instruction.

2.3 DAMAGE TO PROPERTY

- .1 Damage done to property, including equipment, base buildings, etc. during the course of installation or testing shall be made good. Any damage whatsoever during installation or testing of equipment supplied shall result in that equipment being replaced by new undamaged equipment.

PART 3 - EXECUTION

3.1 GENERAL

.1 Working Conditions

- .1 The Work shall be scheduled to avoid and/or minimize the impact on business operations. Portions of the Work including portions of the inspection of the Work may be required to be performed outside regular working hours.
- .2 The Departmental Representative's Security Regulations shall be followed at all times during the performance of the Work.
- .3 Obtain any and all permits required to carry out work.

.2 Examination

- .1 Verify that critical dimensions are correct and conditions are acceptable. Proceed with installation only after unsatisfactory conditions have been coordinated.
- .2 Prior to commencement of Work, examine current site conditions and inform the Departmental Representative of any unusual existing conditions that may affect Work

.3 Preparation

- .1 Cooperate and coordinate with the Departmental Representative for the location of all mechanical, plumbing, electrical rights-of-way and access/egress to any area required to remain accessible for maintenance and removal of equipment or related components.
- .2 Coordinate with the Departmental Representative, the overall project schedule, the equipment and layout in relation to the facility, work aisle or equipment removal paths and drive aisles to avoid any conflicts.

.4 Workmanship

- .1 All work shall be performed by manufacturer trained technicians, to standards and best practices as governed by the reference standards mentioned earlier.
- .2 Equipment shall be mounted in accordance with manufacturer's recommended or supplied hardware and fasteners.
- .3 Cabling shall be mounted in accordance with manufacturer's recommended or supplied hardware and fasteners.

.5 Installation

- .1 Be responsible for the installation of all the equipment, units, sub-systems, and components at the required locations in order to meet all requirements specified in this document, drawings and as per all applicable standards.

- .2 Provide all installation materials, accessories, special equipment, services, personnel team, test equipment and tools required for installation.
- .3 Ensure that installation workmanship complies with the best industry quality standard levels.
- .4 Be responsible for the shipment, on site storage, transportation, installation, testing, commissioning of all material and equipment.
- .5 Any spare part/s supplied, but used to replace faulty item/s during the installation, testing and commissioning phases shall be replaced by free of charge, within thirty (30) days.
- .6 Specify the estimated periods, personnel requirement and include costs for the installation of the equipment. The cost of travel, accommodation and subsistence, as well as any related insurance costs for the duration of the installation.
- .7 At least 10 working days (10) days prior to installation, submit for approval to the Departmental Representative a detailed site installation plan. The plan shall contain all necessary information required to install the equipment and integrate it for operation.
- .8 The installation plan shall be updated to reflect changes made to the equipment layout, cabling drawings, installation instructions and test procedures during the installation. A marked-up installation plan shall be provided.
- .9 Final As-Built documents shall be provided within 15 days after completion.
- .6 Cutting and Patching
 - .1 All cutting and patching shall be performed by trades specializing in this type of work and in consultation with the Departmental Representative
 - .2 Any walls, ceiling, windows, finishes and doors damaged during the course of the Work shall be made good to the Departmental Representative's satisfaction.

3.2 MECHANICAL AND ELECTRICAL REQUIREMENTS

- .1 Wire and Cable
 - .1 Supply and install all specified wire and cable, as well as additional conduit extensions or relocations, necessary to achieve the specified security system.
- .2 Replaceable Parts
 - .1 Parts and components that may require replacing or removal for servicing shall not be affixed by rivets, welds, metal tags on other similar means that would prevent ready removal.

.3 Materials

- .1 Materials used in installations shall be selected with due regard to environment, the intended use, durability, safety, retention of appearance and avoidance of corrosion or other chemical effects. The use of wood, natural rubber, toxic materials and other materials capable of supporting fungus or insects is not allowed. The use of electrical tape or masking tape is prohibited.

3.3 COMMISSIONING

.1 Project Schedule

- .1 Upon award, submit a complete project schedule with identified milestones.
- .2 The schedule shall include the scheduled commencement date for each major activity, the duration of each activity, the proposed sequence of activities, dependencies between internal activities and milestone, dependencies between external activities and milestones, identification of the critical path and related milestones.
- .3 The schedule shall be progressively updated as the work progresses and enable the Departmental Representative to readily identify activities by location or resources.
- .4 The schedule shall clearly identify completion dates and shall clearly identify schedule contingencies, free floats and critical path.
- .5 The schedule information shall be sufficiently detailed to enable integration of all interface activities by the Departmental Representative.
- .6 Develop and submit to the Departmental Representative for approval, project design review and audit Schedule.
- .7 Submit, on a weekly basis, a progress report to the Departmental Representative including percentage complete and deliverables of scheduled work. Reports shall provide comparison of actual progress versus baseline and in accordance with the WBS and report any variation from the master schedule. Progress reporting shall include as a minimum:
 - .1 Summary of changes since the prior schedule;
 - .2 Actual dates for activities started during the period;
 - .3 Actual dates for activities completed during the period;
 - .4 Actual human resource allocation during the period;
 - .5 Estimate of percent complete for activities in progress;
 - .6 Duration for remaining activities;
 - .7 Activities behind schedule;

.8 Critical path;

.9 Deliverables.

.2 Acceptance Test Procedures

- .1 Prior to on-site testing, prepare and submit two (2) copies of the Acceptance Test Procedures (ATP) for review by the Departmental Representative.
- .2 The ATP shall be approved when all issues and comments identified by the Departmental Representative have been satisfactorily addressed.
- .3 Upon approval of the ATP forward the documented results to the Departmental Representative.

.3 Site Acceptance Tests (SAT)

- .1 After a review of the preliminary tests as outlined in the ATP, a Site Acceptance Test date shall be established. A date will not be established until all equipment is available for testing. The Departmental Representative shall be entitled to witness testing on the agreed date.
- .2 Demonstrate that all components of the Security System equipment are compliant to the technical specification and requirements. All deficiencies identified shall be corrected by prior to the Final System Acceptance phase.
- .3 Perform all operational and performance tests in the presence of the Departmental Representative. In addition, the Departmental Representative shall perform a visual and mechanical inspection of the installation.

.4 Final System Acceptance (FSA)

- .1 After successful completion of the SAT, submit to the Departmental Representative a final deficiency list.
- .2 Correct all deficiencies and notify the Departmental Representative, when all on-site work is completed.
- .3 The Departmental Representative will conduct a final acceptance of the work only when all requirements of this specification have been fulfilled, the hand over report has been received and all noted deficiencies have been corrected.
- .4 The Departmental Representative will perform spot checks to verify that all deficiencies have been corrected.
- .5 Upon verifying that all the deficiencies have been corrected, the Departmental Representative will issue a letter of Technical Acceptance signifying that the equipment has been accepted. Final Certificate of Acceptance shall be given when all the terms of this section have been met.

3.4 DOCUMENTATION

- .1 The Final Documentation Phase of the project begins upon approval of the Shop Drawings.
 - .1 As-built & Turnover Documentation Approval
- .2 Prepare and submit one (1) hard and soft copies of the As-built Drawings, Specifications and Turnover Documentation for review by the Departmental Representative within one (1) week of on-site commissioning. As-built and Turnover Documentation, Drawings and Specifications shall be taken to site for accuracy verification against the installation. The As-built Drawings, specifications and Turnover Documentation will be approved by the Departmental Representative when all comments have been satisfactorily addressed.
- .3 Deliver two (2) hard and soft copies sets of revised As-built Drawings, Specifications and Turnover Documentation within one (1) month of receiving approval from the Departmental Representative.
- .4 Final documentation soft copies shall be prepared and submitted in the native (editable) electronic format (.vsd, .dwg, .xls, .doc). All documents produced shall be property of the Departmental Representative.

3.5 PROTECTION

- .1 After installing clean-finished surfaces, touch up shop-applied finishes as required to restore damaged area.
- .2 Provide final protection and maintain conditions, in a manner acceptable to manufacturer and installer, which ensure equipment is without damage or deterioration at the time of Initial Acceptance.

3.5 CLEAN UP

- .1 Remove all unnecessary tools and equipment, unused materials, packing materials, and debris from each area where work has been completed unless designated for storage.
- .2 Clean up all areas around system equipment and ensure that internal equipment component area is free from debris.
- .3 Remove protective coverings from accessories and components.
- .4 Adjust all components for correct function.
- .5 Clean housings and system components, free from marks, packing tape, and finger prints, in accordance with manufacturer's written cleaning recommendations.

.6 Clean all components free from dirt and fingerprints.

3.6 CLOSE OUT

- .1 Testing of the system shall be 100% passed before the issuance of the Certificate of Completion.
- .2 Even though the equipment shall be inspected and accepted, the issuance of Certificate of Completion and Project Closeout shall not occur before all obligations are completed including delivery of digital "as-built" drawings, specifications, software/ firmware versions, and the Operations and Maintenance manual.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- .1 This Section covers items common to more than one section of the Mechanical Divisions 21.
- .2 Refer to Section 23 05 00 and Division 01 for additional general requirements.

1.2 REFERENCE STANDARDS

- .1 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2019, Standard for the Installation of Sprinkler Systems.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for fire suppression components and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Where specified, submit drawings stamped and signed by professional engineer registered or licensed in Ontario, Canada.
 - .2 Indicate on drawings:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
 - .3 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
 - .4 In addition to transmittal letter referred to in Section 01 33 00: use MCAC "Shop Drawing Submittal Title Sheet.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Operation and Maintenance Data: submit operation and maintenance data for incorporation into manual.
 - .1 Operation and maintenance manual approved by, and final copies deposited with, Departmental Representative before final inspection.
 - .2 Operation data to include:
 - .1 Control schematics for systems including environmental controls.

- .2 Description of systems and their controls.
- .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
- .4 Operation instruction for systems and component.
- .5 Description of actions to be taken in event of equipment failure.
- .6 Valves schedule and flow diagram.
- .7 Colour coding chart.
- .3 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .4 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
- .5 Approvals:
 - .1 Submit 2 copies of draft Operation and Maintenance Manual to Departmental Representative for approval. Submission of individual data will not be accepted unless directed by Departmental Representative.
 - .2 Make changes as required and re-submit as directed by Departmental Representative.
- .6 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .7 Site records:
 - .1 Departmental Representative will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.
 - .2 Transfer information biweekly to reproducible, revising reproducible to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.
- .8 As-Built drawings:
 - .1 Prior to start of testing, adjusting and balancing work, finalize production of as-built drawings.
 - .2 Identify each drawing in lower right-hand corner in letters at least 12 mm high as follows: "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW

MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).

- .3 Submit to Departmental Representative for approval and make corrections as directed.
- .4 Perform testing, adjusting and balancing work using as-built drawings.
- .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers.
- .3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.6 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials indoors and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect plumbing components from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.
- .4 Construction Waste Management Plan: Refer to requirements of Section 01 74 21.

PART 2 - PRODUCTS

2.1 NOT USED

- .1 Not used.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections are acceptable for fire suppression components installation in accordance with manufacturer's written instructions.

- .1 Visually inspect substrate in presence of Departmental Representative.
- .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
- .3 Proceed with installation only after unacceptable conditions have been remedied.

3.2 PAINTING REPAIRS AND RESTORATION

- .1 Do painting in accordance with Section 09 91 23.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged.

3.3 PIPING SYSTEM LEAKAGE TESTING

- .1 Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.
- .2 Tests are to be witnessed by Departmental Representative, and, where required, representatives of governing authorities. Give ample notice (minimum 7 working days) of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
- .3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
- .4 Sprinkler System Piping
 - .1 Test system piping in accordance with requirements of NFPA No. 13, and in accordance with any additional requirements of governing authorities.
- .5 Following requirements apply to all type of piping testing:
 - .1 Ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing.
 - .2 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.
 - .3 When testing is carried out below highest level of particular system, increase test pressure by the hydrostatic head of 7 kPa for every 600 mm below high point.
 - .4 Include for temporary piping connections required to properly complete tests.
 - .5 Piping under test pressure is to have zero pressure drop for length of test period.
 - .6 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.
 - .7 Where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions.

- .8 Perform tests in reasonably sized sections so as to minimize number of tests required.
- .9 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.
- .6 Ensure governing authorities are informed well in advance of scheduled tests so they may witness tests as required.

3.4 IDENTIFICATION

- .1 Identify products in accordance with requirements specified in Section 23 05 00.

3.5 SYSTEM CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.6 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 and submit report as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
- .2 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.7 DEMONSTRATION

- .1 Departmental Representative will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.
- .5 Departmental Representative will record these demonstrations on video tape for future reference.

3.8 CLEANING

.1 Progress Cleaning: clean in accordance with Section 01 74 00.

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials,
rubbish, tools and equipment in accordance with Section 01 74 00.

3.9 PROTECTION

.1 Protect equipment and systems openings from dirt, dust, and other
foreign materials with materials appropriate to system.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCES

- .1 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2019, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 45-2019, Standard on Fire Protection for Laboratories Using Chemicals.
- .2 American Society of Mechanical Engineers (ASME)
 - .1 ASME B16.4-2016, Gray Iron Threaded Fittings: Classes 125 and 150.
- .3 ASTM International (ASTM)
 - .1 ASTM A53/A53M-20, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
 - .2 ASTM A135/A135M-19, Standard Specification for Electric-Resistance-Welded Steel Pipe.
 - .3 ASTM A234/A234M-19, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;

1.2 SUBMITTALS

- .1 Submit shop drawings and product data sheets to regulatory authority as required for review and approval, prior to submitting to Departmental Representative. Conform to following requirements:
 - .1 Submit shop drawings and product data sheets for products specified in this Section except pipe and fittings;
 - .2 Submit complete CAD layout drawings indicating source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and zones, all signed and sealed by a qualified professional mechanical engineer registered in jurisdiction of the work as specified below;
 - .3 Submit copies of calculations, including hydraulic calculations, stamped and signed by same engineer who signs layout drawings, and a listing of design data used in preparing calculations, system layout and sizing, including occupancy-hazard design requirements;
 - .4 In addition to submitting shop drawings to regulatory authority as specified above, shop drawings must be approved by Insurer designated by Departmental Representative prior to being submitted to Departmental Representative for review.
- .2 Submit a complete sprinkler system test certificate as specified in Part 3 of this Section.
- .3 Sprinklers are to be identified on drawings and product submittals.

1.3 QUALITY ASSURANCE

- .1 Fire protection sprinkler work is to be performed by a sprinkler company who is a member in good standing of Canadian Automatic Sprinkler Association. Site personnel are to be licensed in jurisdiction of the work and under continuous supervision of a foreman who is experienced fire protection system installer and journeyman pipe fitter licensed in jurisdiction of the work.
- .2 Check and verify dimensions and conditions at site and ensure work can be performed as indicated. Coordinate work with trades at site and accept responsibility for and cost of making adjustments to piping and/or spacing to avoid interference with other building components.
- .3 Verify working condition of existing sprinkler system equipment which has direct interface with project work and is to remain. Replace with new equipment where necessary.
- .4 System components must be ULC listed and labelled.
- .5 Grooved couplings, and fittings, valves and specialties are to be products of a single manufacturer. Grooving tools are to be of same manufacturer as grooved components.
- .6 Castings used for coupling housings, fittings, valve bodies, and ancillary devices, are to be date stamped for quality assurance and traceability.

1.4 DESIGN REQUIREMENTS

- .1 Design fire protection sprinkler work in accordance with NFPA 13, NFPA 45 and local Provincial Standards, and, where required, local building and fire department requirements and standards of Insurer designated by Departmental Representative. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at nearest fire hydrant to obtain criteria to be used in system design. Include hydrant location and flow and pressure test data with system design calculations.
- .2 Include for a qualified mechanical professional engineer registered and licensed in the jurisdiction of the work to design the fire protection sprinkler work.
- .3 Sprinkler/System Occupancy - Hazard Design requirements: In accordance with NFPA 13 occupancy-hazard density requirements, unless otherwise specified.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- .1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
 - .1 Schedule 40 Steel - Grooved Coupling Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53/A53M, Grade B, complete with grooved ends and mechanical

fittings and couplings. Strap type outlet fittings are not acceptable.

- .2 Schedule 40 Steel - Screwed and Welded Joints
 - .1 Schedule 40 mild black carbon steel, ASTM A53/A53M, Grade B. Screwed piping complete with Class 125 cast iron screwed fittings to ASME B16.4. Welded piping complete with factory made seamless carbon steel butt welding fittings to ASTM A234/A234M, Grade WPB, long sweep pattern wherever possible.
- .3 Schedule 10 Steel - Grooved Coupling Joints
 - .1 Schedule 10 mild black carbon steel, ASTM A53/A135M, Grade B, complete with grooved ends and fittings and couplings.
- .4 Schedule 10 Steel - Screwed Joints
 - .1 Schedule 10 mild black carbon steel, ASTM A53/A53M, Grade B, complete with mill or site threaded ends, Class 125 cast iron screwed fittings to ASME B16.4, and screwed joints.
- .5 Light-wall Steel - Grooved Coupling Joints
 - .1 Commercial quality. Light-wall rolled mild carbon steel pipe to ASTM A135/A135M, Grade A, complete with a galvanized exterior, grooved ends, and fittings and couplings.
- .6 Light-wall Steel - Screwed Joints
 - .1 Commercial quality, Light-wall rolled mild carbon steel pipe to ASTM A135/A135M, Grade A, ULC listed, mill or site threaded, complete with galvanized exterior, Class 125 cast iron screwed fittings to ASME B16.4, and screwed joints.

2.2 SPRINKLER HEADS

- .1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.
- .2 Sprinkler body is to be die-cast, with hex-shaped wrench boss integrally cast into sprinkler body to reduce risk of damage during installation. Wrenches are to be provided by sprinkler manufacturer that directly engages wrench boss.
- .3 For locations where corrosive resistant coatings are required, body is to be coated with ULC listed and FM approved anti-corrosion VC-250 coating (silver colouring).
- .4 Where exposed pendent heads occur in areas with suspended ceilings, they are to be complete with chrome plated escutcheon plates. Similarly, sidewall heads with concealed piping are to be complete with chrome plated escutcheon plates.
- .5 Sprinkler heads which are exposed in areas where they may be subject to damage are to be complete with wire guards, chrome plated where in finished areas.
- .6 Escutcheons and guards are to be listed, supplied, and approved for use with sprinkler by sprinkler manufacturer.

- .7 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 74°C heads. Other heads, unless otherwise specified or required, are to be 57°C rated.

PART 3 - EXECUTION

3.1 MONITORING OF SYSTEMS

- .1 Daily monitor and supervise existing sprinkler system serving renovated areas to ensure that each respective system is left in proper operating condition at end of each working day. Include for but not be limited to performing following:
 - .1 Under presence of Departmental Representative, check each morning and evening (start and end of work) of each day, sprinkler system to ensure that it is in proper working condition;
 - .2 If portions of sprinkler system is not in proper working order, provide temporary provisions subject to approval of local fire authority or local governing authority, to ensure that proper sprinkler coverage is provided and/or provide supervisory personnel to monitor areas where sprinkler system is not operational;
 - .3 Document and sign off with Departmental Representative signing off also, each respective daily check condition;
 - .4 Ensure that work to sprinkler system does not affect portion of system serving areas outside of renovation areas.

3.2 DEMOLITION AND REWORKING

- .1 Refer to demolition and re-working requirements identified on drawings.

3.3 PIPING INSTALLATION REQUIREMENTS

- .1 Provide required sprinkler system piping.
- .2 Perform piping work in accordance with requirements of NFPA 13, governing regulations, and "Reviewed" shop drawings.
- .3 Piping, unless otherwise specified, is as follows:
 - .1 For piping inside building and above ground except as noted below - Schedule 40 grooved end black steel with fittings and coupling joints, or, for piping to and including 50 mm diameter, screwed fittings and joints, or, for piping 65 mm diameter and larger, welding fittings and welded joints.
 - .2 For piping downstream of "head end" alarm valve(s) and equipment - Schedule 10 or light-wall black steel pipe with fittings and coupling joints or screwed fittings and joints.
- .4 Exceptions to piping requirements specified above are as follows:
 - .1 Wet zone steel piping, fittings, unions, couplings and flanges for sprinkler work exposed to weather either inside or outside building are to be galvanized.
 - .2 PVC piping is not to be used.

- .3 Ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be electro-galvanized.
- .5 Pipe sizes, pipe routing, sprinkler head quantities and locations, and layout of work shown on drawings are to assist during Bid period. Ensure adequate head coverage, head quantities and pipe sizing. Do not reduce size of sprinkler main or re-route main unless reviewed with and accepted by Departmental Representative.
- .6 Install grooved joints in accordance with manufacturer's installation instructions. Grooved ends are to be clean and free from indentations, projections and roll marks. Gaskets are to be moulded and produced by coupling manufacturer, and verified as suitable for intended service. Have factory-trained representative from mechanical joint manufacturer provide on-site training in proper use of grooving tools and installation of grooved piping products. Have factory-trained representative periodically review product installation and ensure best practices are being followed. Remove and replace any improperly installed products.
- .7 Clean pipe, fittings, couplings, flanges and similar components after erection is complete. Wire brush clean any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibit rust and carefully coat with suitably coloured primer.
- .8 When sprinkler work is complete, test system components and overall system(s) and submit completed test certificate and other documentation in accordance with Chapter 8 of NFPA 13.

3.4 INSTALLATION OF SPRINKLER HEADS

- .1 Provide required sprinkler heads in accordance with following schedule:

APPLICATION	SPRINKLER HEAD TYPE
Rooms/areas with a suspended ceiling	Semi-recessed sprinkler head, chrome plated, chrome plated recessed cup, glass bulb, quick response and have a nominal 12.7 mm orifice or larger as required.
Rooms/areas without a suspended ceiling	Upright sprinkler head, brass, glass bulb, quick response type and have a nominal 12.7 mm orifice or larger as required.

- .2 Sprinkler head on schedule are for application and type indication purposes.
- .3 Coordinate sprinkler head locations with drawings, including architectural reflected ceiling plan drawings, and, where applicable, electrical drawings. Coordinate sprinkler head locations in areas with suspended ceilings with location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on ceiling in accordance with reflected ceiling

plans. In areas with lay-in tile, center sprinkler head both ways in lay-in tile wherever possible. Confirm locations prior to roughing-in.

- .4 Maintain maximum headroom in areas with no ceilings.
- .5 Provide guards for heads where they are subject to damage.
- .6 Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED SECTIONS

- .1 This Section covers items common to more than one section of the Mechanical Divisions 22.
- .2 Refer to Section 23 05 00 and Division 01 for additional general requirements.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for plumbing components and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Where specified, submit drawings stamped and signed by professional engineer registered or licensed in Ontario, Canada.
 - .2 Indicate on drawings:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
 - .3 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
 - .4 In addition to transmittal letter referred to in Section 01 33 00: use MCAC Shop Drawing Submittal Title Sheet.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Operation and Maintenance Data: submit operation and maintenance data for incorporation into manual.
 - .1 Operation and maintenance manual approved by, and final copies deposited with, Departmental Representative before final inspection.
 - .2 Operation data to include:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for systems and component.

- .5 Description of actions to be taken in event of equipment failure.
- .6 Valves schedule and flow diagram.
- .7 Colour coding chart.
- .3 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .4 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
- .5 Approvals:
 - .1 Submit 2 copies of draft Operation and Maintenance Manual to Departmental Representative for approval. Submission of individual data will not be accepted unless directed by Departmental Representative.
 - .2 Make changes as required and re-submit as directed by Departmental Representative.
- .6 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .7 Site records:
 - .1 Departmental Representative will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.
 - .2 Transfer information biweekly to reproducible, revising reproducible to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.
- .8 As-built drawings:
 - .1 Prior to start of testing, adjusting and balancing work, finalize production of as-built drawings.
 - .2 Identify each drawing in lower right-hand corner in letters at least 12 mm high as follows: - AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED (Signature of Contractor) (Date).
 - .3 Submit to Departmental Representative for approval and make corrections as directed.

- .4 Perform testing, adjusting and balancing work using as-built drawings.
- .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .9 Submit copies of as-built drawings for inclusion in final TAB report.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Provide one set of special tools required to service equipment as recommended by manufacturers.
- .3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials indoors and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect plumbing components from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.
- .4 Construction Waste Management Plan: Refer to requirements of Section 01 74 21.

PART 2 - PRODUCTS

2.1 NOT USED

- .1 Not used.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections are acceptable for plumbing components installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.

- .3 Proceed with installation only after unacceptable conditions have been remedied.

3.2 PAINTING REPAIRS AND RESTORATION

- .1 Do painting in accordance with Section 09 91 23.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged.

3.3 PIPING SYSTEM LEAKAGE TESTING

- .1 Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.
- .2 Tests are to be witnessed by Departmental Representative, and, where required, representatives of governing authorities. Give ample notice (minimum 7 working days) of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
- .3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
- .4 Gravity Drainage and Vent 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 smoke test if required by local governing authorities.
- .5 Pumped Drainage Piping
 - .1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for minimum of 2 hours.
- .6 Domestic Water Piping
 - .1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for minimum of 2 hours.
- .7 Standpipe System Piping
 - .1 Test system piping in accordance with requirements of NFPA No. 14, and in accordance with any additional requirements of governing authorities.
- .8 Pure Water Piping
 - .1 When piping has been properly flushed and cleaned, test at 690 kPa for 2 hours with only distilled water or filtered dry compressed air. If distilled water is used, drain system when testing is complete.

- .9 Following requirements apply to all type of piping testing:
 - .1 Ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing.
 - .2 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.
 - .3 When testing is carried out below highest level of particular system, increase test pressure by the hydrostatic head of 7 kPa for every 600 mm below high point.
 - .4 Include for temporary piping connections required to properly complete tests.
 - .5 Piping under test pressure is to have zero pressure drop for length of test period.
 - .6 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.
 - .7 Where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions.
 - .8 Perform tests in reasonably sized sections so as to minimize number of tests required.
 - .9 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.
- .10 Ensure governing authorities are informed well in advance of scheduled tests so they may witness tests as required.

3.4 IDENTIFICATION

- .1 Identify products in accordance with requirements specified in Section 23 05 00.

3.5 SYSTEM CLEANING

- .1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.6 FIELD QUALITY CONTROL

- .1 Site Tests: conduct following tests in accordance with Section 01 45 00 and submit report as described in PART 1 -ACTION AND INFORMATIONAL SUBMITTALS.
- .2 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.

- .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.7 DEMONSTRATION

- .1 Departmental Representative will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.
- .5 Departmental Representative will record these demonstrations on video tape for future reference.

3.8 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 00.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00.

3.9 PROTECTION

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM A126-04(2019), Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - .2 ASTM B62-17, Standard Specification for Composition Bronze or Ounce Metal Castings.
- .2 Canadian Standards Association (CSA)
 - .1 CAN/CSA-B64 Series-11(R2016), Backflow Preventers and Vacuum Breakers.
 - .2 CSA B79-08(R2018), Commercial and Residential Drains and Cleanouts.
- .3 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada 2015 (NPC).

1.2 ADMINISTRATIVE REQUIREMENTS

- .1 Pre-installation Meetings:
 - .1 Convene pre-installation meeting 1 week prior to beginning on-site installation work of this Section, with Departmental Representative to:
 - .1 Verify project requirements.
 - .2 Review installation and substrate conditions.
 - .3 Co-ordination with other building construction subtrades.
 - .4 Review [manufacturer's] written installation instructions and warranty requirements.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for products and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Shop Drawings:
 - .1 Submit shop drawings for products of this Section.
 - .2 Indicate on drawings to indicate materials, dimensions, construction and assembly details, finishes, number of anchors, method of anchorage, accessories for following: soap dispensing system.
- .4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .5 Instructions: submit manufacturer's installation instructions.

- .6 Manufacturers' Field Reports: manufacturers' field reports specified.

1.4 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Operation and Maintenance Data: submit operation and maintenance data for plumbing specialties and accessories for incorporation into manual.
 - .1 Description of plumbing specialties and accessories, giving manufacturers name, type, model, year and capacity.
 - .2 Details of operation, servicing and maintenance.
 - .3 Recommended spare parts list.

1.5 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle materials in accordance with Section 01 61 00
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials in accordance with manufacturer's recommendations in clean, dry, well-ventilated area designated by Departmental Representative.
 - .2 Store and protect materials from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

PART 2 - PRODUCTS

2.1 FLOOR DRAIN TRAP SEAL PRIMERS

- .1 Primer Valve Type
 - .1 Trap primer valve, constructed of brass, adjustable to high or low water pressures and complete with "O" ring seals, 12 mm threaded inlet and outlet connections, and, for priming two traps from the same primer, dual outlet distribution unit.
- .2 Primer Valve Type with Manifold
 - .1 Trap primer valve constructed of brass, adjustable to high or low water pressures and complete with "O" ring seals, 12 mm threaded inlet and outlet connections, complete with required multiple outlet distribution unit for priming required multiple traps, and supply tube as required for specific applications.
- .3 Electronic Type
 - .1 Surface wall mounting, CSA certified, 115 volt, 1-phase, 60 Hz., electronic, automatic trap priming manifolds, each

sized to suit number of drain traps or interceptors serviced, and each complete with:

- .1 Galvanized steel cabinet with door.
- .2 20 mm dia. NPT copper pipe inlet with shut-off valve and water hammer arrestor.
- .3 Solenoid valve, atmospheric vacuum breaker, and discharge manifold with 12 mm dia. compression type copper tube connections on 40 mm centres with quantity to suit number of items primed.
- .4 control panel with circuit breaker, fuse, 24 hour timer, and manual override toggle switch.

2.2 FLOOR DRAINS

- .1 Floor Drains and Trench Drains: to CSA B79.
- .2 Epoxy coated trench drain with stainless steel grate, inside domed strainer, anchor flanges, membrane clamps.

2.3 BACK FLOW PREVENTERS

- .1 Preventers: to CAN/CSA-B64 Series-11, application double check valve assembly, reduced pressure principle type as indicated.

2.4 SHOCK ABSORBERS

- .1 Type 304 stainless steel piping shock absorbers.
- .2 Maximum Working Pressure: 862 kPa.
- .3 Maximum Static Pressure: 1724 kPa.
- .4 Nesting type bellows and casing of sufficient displacement volume to dissipate kinetic energy generated in piping system.
- .5 Sized to suit connecting potable water pipe and equipment to which it is provided.

2.5 VACUUM BREAKERS

- .1 Breakers: to CAN/CSA-B64 Series-11, vacuum breaker laboratory faucet intermediate.

2.6 PRESSURE REGULATORS

- .1 Capacity:
 - .1 Inlet pressure: 1034 kPa.
 - .2 Outlet pressure: 413 kPa.
- .2 Up to NPS 1-1/2 bronze bodies, screwed: to ASTM B62.
- .3 NPS 2 and over, semi-steel bodies, Class 125, flanged: to ASTM A126, Class B.
- .4 Semi-steel spring chambers with bronze trim.

2.7 BACKWATER VALVES

- .1 Galvanized body with bronze seat, revolving bronze flapper and threaded cover.

.2 Access:

- .1 Surface access.
- .2 Access pipe with cover: maximum 300 mm depth.
- .3 Steel housing with gasketed steel cover.
- .4 Concrete access pit with cover, as indicated.

2.8 HOSE BIBBS AND SEDIMENT FAUCETS

- .1 Bronze construction complete with integral back flow preventer, hose thread spout, replaceable composition disc, and chrome plated in finished areas.

2.9 STRAINERS

- .1 860 kPa, Y type with 20 mesh, monel, bronze or stainless steel removable screen.
- .2 NPS 2 and under, bronze body, screwed ends, with brass cap.
- .3 NPS 2 1/2 and over, cast iron body, flanged ends, with bolted cap.

2.10 SOAP DISPENSING SYSTEMS

- .1 Description: complete gravity feed type.
- .2 Piping: NPS 1/2 black steel with standard malleable iron fitting for concealed installations. NPS 1/2 chrome plated brass pipe and fittings for exposed installations. Fit exposed piping with chrome plated solid red brass wall flanges. Make joints with litharge and glycerine.
- .3 Tanks: surface mounted as indicated, satin finished stainless steel, rectangular, with contents gauge on front fitted with chrome plated union shut-off cock and cleanout tee.
- .4 Outlets: mounted as indicated, gravity flow, lather type, stainless steel construction.

PART 3 - EXECUTION

3.1 EXAMINATION

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or are acceptable for plumbing specialties and accessories installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied.

3.2 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheet.

3.3 INSTALLATION - GENERAL

- .1 Install products in accordance with NPC, Ontario provincial codes, and local authority having jurisdiction.
- .2 Install in accordance with manufacturer's instructions and as specified.

3.4 INSTALLATION OF TRAP SEAL PRIMERS

- .1 Provide required accessible trap seal primers to automatically maintain water seal in floor drain traps, whether shown on drawings or not.
- .2 Provide trap primer valves to prime single or multiple (1 to 6) traps. Install trap primer valves in domestic cold water piping to frequently used plumbing fixtures. Where from 2 to 6 traps are to be primed from same primer valve, provide appropriate supply and distribution tube assemblies. Ensure primer valves are accessible.
- .3 Provide 115 volt, electronic, surface wall mounting trap primer assemblies for multiple (4 to 30) traps. Coordinate with work of Division 26, to provide required power feed circuit with panel breaker and wiring in conduit from closest panelboards to power feed primer assembly, in accordance with standards of Division 26. Adjust primer water flow and timing to suit number of traps served.
- .4 Secure trap primer piping to floor drain primer tappings. Do not terminate through tapping in throat of drain.

3.5 INSTALLATION OF SHOCK ABSORBERS

- .1 Provide accessible shock absorbers in domestic water piping.
- .2 Select size of each shock absorber to suit size of domestic water pipe and connected equipment pipe.

3.6 BACK FLOW PREVENTERS

- .1 Install in accordance with CAN/CSA-B64 Series-11, where indicated and elsewhere as required by code.
 - .1 Drains.
 - .2 Backwater Valves.
 - .3 Water Make-up Assembly.
 - .4 Grease Interceptors.
- .2 Pipe discharge to terminate over nearest drain or service sink.

3.7 BACKWATER VALVES

- .1 Install where indicated.

3.8 HOSE BIBBS AND SEDIMENT FAUCETS

- .1 Install at bottom of risers, at low points to drain systems, and as indicated.

3.9 STRAINERS

- .1 Install with sufficient room to remove basket for maintenance.

3.10 START-UP

- .1 General:
 - .1 Perform in accordance with manufacturer instructions and as specified.
- .2 Timing: start-up only after:
 - .1 Pressure tests have been completed.
 - .2 Disinfection procedures have been completed.
 - .3 Certificate of static completion has been issued.
 - .4 Water treatment systems operational.
- .3 Provide continuous supervision during start-up.

3.11 TESTING AND ADJUSTING

- .1 General:
 - .1 Perform in accordance with manufacturer instructions and as specified.
- .2 Timing:
 - .1 After start-up deficiencies rectified.
 - .2 After certificate of completion has been issued by authority having jurisdiction.
- .3 Application tolerances:
 - .1 Pressure at fixtures: +/- 70 kPa.
 - .2 Flow rate at fixtures: +/- 20%.
- .4 Adjustments:
 - .1 Verify that flow rate and pressure meet design criteria.
 - .2 Make adjustments while flow rate or withdrawal is (1) maximum and (2) 25% of maximum and while pressure is (1) maximum and (2) minimum.
- .5 Floor drains:
 - .1 Verify operation of trap seal primer.
 - .2 Prime, using trap primer. Adjust flow rate to suit site conditions.
 - .3 Check operations of flushing features.
 - .4 Check security, accessibility, removability of strainer.
 - .5 Clean out baskets.
- .6 Pressure regulators, PRV assemblies:
 - .1 Adjust settings to suit locations, flow rates, pressure conditions.

- .7 Strainers:
 - .1 Clean out repeatedly until clear.
 - .2 Verify accessibility of cleanout plug and basket.
 - .3 Verify that cleanout plug does not leak.
- .8 Hose bibbs, sediment faucets:
 - .1 Verify that flow and pressure meet design criteria.
 - .2 Check for leaks, replace compression washer if required.
- .9 Soap Dispensing Systems:
 - .1 Verify location and reach.
 - .2 Check for leaks.

3.12 CLOSEOUT ACTIVITIES

- .1 Commissioning Reports: in accordance with Section 01 91 13.
- .2 Training: provide training in accordance with Section 01 91 13: Training of O&M Personnel, supplemented as specified.

3.13 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 00.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00.

3.14 PROTECTION

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by plumbing specialties and accessories installation.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 American Society of Mechanical Engineers International (ASME)
 - .1 ANSI/ASME B16.15-2018, Cast Copper Alloy Threaded Fittings, Classes 125 and 250.
 - .2 ANSI/ASME B16.18-2018, Cast Copper Alloy Solder Joint Pressure Fittings.
 - .3 ANSI/ASME B16.22-2018, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - .4 ANSI/ASME B16.24-2016, Cast Copper Alloy Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500.
- .2 ASTM International (ASTM)
 - .1 ASTM A307-14e1, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .2 ASTM A312/A312M-19, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
 - .3 ASTM A351/A351M-18e1, Standard Specification for Castings, Austenitic, for Pressure Containing Parts.
 - .4 ASTM A403/A403M-20, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
 - .5 ASTM B88M-20, Standard Specification for Seamless Copper Water Tube (Metric).
 - .6 ASTM F1960-19a, Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing.
- .3 American National Standards Institute/American Water Works Association (ANSI)/(AWWA)
 - .1 ANSI/AWWA B300-18, Hypochlorites.
 - .2 ANSI/AWWA C111/A21.11-17, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- .4 Canadian Standards Association (CSA)
 - .1 CSA B137.5-20, Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications.
 - .2 CSA B242-05(R2016), Groove and Shoulder-Type Mechanical Pipe Couplings.
- .5 Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).
 - .1 MSS-SP-67-2017, Butterfly Valves.
 - .2 MSS-SP-70-2011, Grey Iron Gate Valves, Flanged and Threaded Ends.
 - .3 MSS-SP-71-2018, Grey Iron Swing Check Valves, Flanged and Threaded Ends.
 - .4 MSS-SP-80-2019, Bronze Gate, Globe, Angle and Check Valves.

- .6 National Research Council (NRC)
 - .1 National Plumbing Code of Canada (NPC) 2015.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00.
- .2 Product Data
 - .1 Provide manufacturer's printed product literature and datasheets for insulation and adhesives, and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Closeout Submittals:
 - .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00.

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Store and manage hazardous materials in accordance with local governing codes and regulations.
- .2 Place materials defined as hazardous or toxic in designated containers.

PART 2 - PRODUCTS

2.1 PIPING

- .1 Domestic hot, cold and recirculation systems, within building.
 - .1 Above ground:
 - .1 Hard copper - solder joint: Copper tube, hard drawn, type L or K: to ASTM B88M.
 - .2 Copper pressure coupled joint: Type "L" hard drawn seamless copper to ASTM B88.
 - .3 Hard copper - grooved joint: bolted grooved connection type system, suitable and approved for application intended, 50 mm to 200 mm hard copper tubing.
 - .4 PEX Piping to CSA B137.5.
 - .2 Buried or embedded:
 - .1 Copper tube, soft annealed, type K or L: to ASTM B88M, in long lengths and with no buried joints.
 - .2 PEX Piping to CSA B137.5.

2.2 FITTINGS

- .1 Bronze pipe flanges and flanged fittings, Class 150: to ANSI/ASME B16.24.
- .2 Cast bronze threaded fittings, Class 125: to ANSI/ASME B16.15.
- .3 Cast copper, solder type: to ANSI/ASME B16.18.
- .4 Wrought copper and copper alloy, solder type: to ANSI/ASME B16.22.

- .5 Copper pressure coupled joint fittings: Copper fittings with EDPM seals, and pressure type crimped joints made by use of manufacturer recommended tool.
- .6 Hard copper - grooved joint fittings: rigid coupling consisting of ductile iron cast housings, with fluoroelastomer compound gasket of pressure-responsive design, with plated nuts and bolts to secure unit together.
- .7 NPS 2 and larger:
 - .1 ANSI/ASME B16.18 or ANSI/ASME B16.22 roll grooved to CSA B242.
 - .2 PEX fittings to CSA B137.5 and ASTM F1960.
- .8 NPS 1 ½ and smaller:
 - .1 Wrought copper to ANSI/ASME B16.22 or cast copper to ANSI/ASME B16.18 with 306 stainless steel internal components and EPDM seals. Suitable for operating pressure to 1380 kPa.
 - .2 PEX fittings to CSA B137.5.
- .9 Manufacturer Services
 - .1 Include manufacturers factory trained representative to:
 - .2 For special piping applications such as grooved piping, crimping: Train installing contractors on special installation practices and use of special tools for installations.
 - .3 For grooved piping systems: Periodically visit job site to review installation, prepare inspection report, advise installing contractor of deficiencies and re-examine, till corrections are made.

2.3 JOINTS

- .1 Rubber gaskets, latex-free, 1.6 mm thick: to ANSI/AWWA C111/A21.11-17.
- .2 Bolts, nuts, hex head and washers: to ASTM A307, heavy series.
- .3 Solder: lead free for cold water pipe; tin copper alloy 95/5 for other services.
- .4 Teflon tape: for threaded joints.
- .5 Grooved couplings: designed with angle bolt pads to provide rigid joint, complete with EPDM gasket.
- .6 Dielectric connections between dissimilar metals: dielectric fitting, complete with thermoplastic liner.
- .7 NPS 1 ½ and smaller: PEX fittings to CSA B137.5.
- .8 NPS 2 and larger: PEX fittings to CSA B137.5 and ASTM F1960. Elbows, adapters, couplings, plugs, tees, multi-port tees and valves.

2.4 GATE VALVES

- .1 NPS 2 and under, soldered:
 - .1 Rising stem: to MSS-SP-80, Class 125, 860 kPa, bronze body, screw-in bonnet, solid wedge disc, to suit intended applications.
- .2 NPS 2 and under, screwed:
 - .1 Rising stem: to MSS-SP-80, Class 125, 860 kPa, bronze body, screw-in bonnet, solid wedge disc, to suit intended applications.
- .3 NPS 2 1/2 and over, flanged:
 - .1 Rising stem: to MSS-SP-70, Class 125, 860 kPa, flat flange faces, cast-iron body, OS&Y bronze trim, to suit intended applications.
- .4 NPS 2 1/2 and over, (other than mechanical rooms), flanged:
 - .1 Non-rising stem: to MSS-SP-70, Class 125, 860 kPa, flat flange faces, cast-iron body, bronze trim, bolted bonnet, to suit intended applications.

2.5 GLOBE VALVES

- .1 NPS2 and under, soldered:
 - .1 To MSS-SP-80, Class 125, 860 kPa, bronze body, renewable composition disc, screwed over bonnet, to suit intended applications.
 - .2 Lockshield handles: as indicated.
- .2 NPS 2 and under, screwed:
 - .1 To MSS-SP-80, Class 150, 1 MPa, bronze body, screwed over bonnet, renewable composition disc, to suit intended applications.
 - .2 Lockshield handles: as indicated.

2.6 SWING CHECK VALVES

- .1 Horizontal
 - .1 Lead-free, Class 125, bronze, 1380 kPa rated horizontal swing type check valve.
- .2 Vertical
 - .1 Lead-free, 1725 kPa rated, silent type, spring loaded, vertical lift check valve.
- .3 NPS 2 and under, soldered:
 - .1 To MSS-SP-80, bronze body, bronze swing disc, screw in cap, regrindable seat, to suit intended applications.
- .4 NPS 2 and under, screwed:
 - .1 To MSS-SP-80, bronze body, bronze swing disc, screw in cap, regrindable seat, to suit intended applications.

- .5 NPS 2 1/2 and over, flanged:
 - .1 To MSS-SP-71, cast iron body, flat flange faces, renewable regrind seat, bronze disc, bolted cap, to suit intended applications.

2.7 BALL VALVES

- .1 Shut-Off
 - .1 Class 600, 4140 kPa, lead-free, full port ball type valves.
- .2 Drain
 - .1 Lead free, minimum 2070 kPa water rated, 20 mm dia., straight pattern full port bronze ball valves.
 - .2 Threaded outlet suitable for coupling connection of 20 mm dia. hose, and cap and chain.
- .3 NPS 2 and under, screwed:
 - .1 Forged Brass, Bronze body, stainless steel, chrome plated brass ball, PTFE adjustable packing, brass gland and TFE, Bunan, PTFE seat, steel lever handle, to suit intended applications.
- .4 NPS 2 and under, soldered:
 - .1 To ANSI/ASME B16.18.
 - .2 Bronze body, chrome plated brass, stainless steel, ball, PTFE adjustable packing, brass gland and PTFE, Bunan seat, steel lever handle, with NPT to copper adaptors, to suit intended applications.

2.8 BUTTERFLY VALVES

- .1 NPS 2-1/2 and over, lug, wafer, grooved:
 - .1 To MSS-SP-67, Class 200.
 - .2 Cast iron body, ductile iron chrome plated disc, stainless steel stem, EPT liner.
 - .3 Lever operated, NPS 8 and over, gear operated.
- .2 NPS 2-1/2 and over, grooved ends:
 - .1 Class 300 psig CWP, bubble tight shut-off, bronze body EPDM coated ductile iron disc with integrally cast stem.
 - .2 Operator:
 - .1 NPS 4 and under: lever handle.
 - .2 NPS 6 and over: gear operated.

2.9 CHLORINE

- .1 Sodium hypochlorite to AWWA B300.

PART 3 - EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION OF PIPING

- .1 Install in accordance with local authority having jurisdiction, NPC, local governing plumbing code.
- .2 Install pipe work as specified.
- .3 Assemble piping using fittings as specified and as required to intended application.
- .4 Install CWS piping below and away from HWS and HWC and other hot piping so as to maintain temperature of cold water as low as possible.
- .5 Connect to fixtures and equipment in accordance with manufacturer's written instructions unless otherwise indicated.
- .6 Piping, unless otherwise specified, is as follows:
 - .1 For pipe inside building and aboveground in sizes to 100 mm dia: Type "L" hard copper with solder joints or Type "L" hard copper with pressure coupled mechanical joints.
- .7 Slope piping so it can be completely drained.
- .8 Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe or equipment.
- .9 Buried tubing:
 - .1 Lay in well compacted washed sand in accordance with AWWA Class B bedding.
 - .2 Bend tubing without crimping or constriction. Minimize use of fittings.

3.3 INSTALLATION OF VALVES

- .1 Isolate equipment, fixtures and branches with gate, ball, butterfly valves.
- .2 For shut off valves installed on solder joint copper piping up to and including 75 mm diameter, provide ball type valves.
- .3 For flanged joints copper or stainless steel piping larger than 75 mm diameter provide butterfly type valves.
- .4 Balance recirculation system using lockshield globe valves. Mark settings and record on as-built drawings on completion.

3.4 PRESSURE TESTS

- .1 Test pressure: greater of 1 times maximum system operating pressure or 860 kPa.

3.5 FLUSHING AND CLEANING

- .1 Flush and disinfect domestic water piping after leakage testing is complete.
- .2 Isolate new piping from existing piping prior to flushing and disinfecting procedures.
- .3 Flush piping until foreign materials are removed and flushed water is clear. Provide connections and pumps as required. Open and close valves, faucets, hose outlets, and service connections to ensure thorough flushing.
- .4 Flush entire system for 8 h. Ensure outlets flushed for 2 hours. Let stand for 24 hours, then draw one sample off longest run. Submit to testing laboratory to verify that system is clean copper to Provincial, Federal potable water guidelines. Let system flush for additional 2 hours, then draw off another sample for testing.

3.6 PRE-START-UP INSPECTIONS

- .1 Systems to be complete, prior to flushing, testing and start-up.
- .2 Verify that system can be completely drained.
- .3 Ensure that pressure booster systems are operating properly.
- .4 Ensure that air chambers, expansion compensators are installed properly.

3.7 DISINFECTION

- .1 Flush out, disinfect and rinse system to requirements of authority having jurisdiction approval of Departmental Representative.
- .2 Disinfect piping with solution of chlorine in accordance with local governing standards.
- .3 Upon completion, provide laboratory test reports on water quality for Departmental Representative approval.

3.8 START-UP

- .1 Timing: start up after:
 - .1 Pressure tests have been completed.
 - .2 Disinfection procedures have been completed.
 - .3 Certificate of static completion has been issued.
 - .4 Water treatment systems operational.
- .2 Provide continuous supervision during start-up.
- .3 Start-up procedures:
 - .1 Establish circulation and ensure that air is eliminated.
 - .2 Check pressurization to ensure proper operation and to prevent water hammer, flashing and/or cavitation.
 - .3 Commission water conditioning.
 - .4 Bring HWS storage tank up to design temperature slowly.

- .5 Monitor piping HWS and HWC piping systems for freedom of movement, pipe expansion as designed.
- .6 Check control, limit, safety devices for normal and safe operation.
- .4 Rectify start-up deficiencies.

3.9 PERFORMANCE VERIFICATION

- .1 Scheduling:
 - .1 Verify system performance after pressure and leakage tests and disinfection are completed, and Certificate of Completion has been issued by authority having jurisdiction.
- .2 Procedures:
 - .1 Verify that flow rate and pressure meet Design Criteria.
 - .2 TAB HWC in accordance with Section 23 05 93.
 - .3 Adjust pressure regulating valves while withdrawal is maximum and inlet pressure is minimum.
 - .4 Sterilize HWS and HWC systems for Legionella control.
 - .5 Verify performance of temperature controls.
 - .6 Verify compliance with safety and health requirements.
 - .7 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor or re-charge air chambers. Repeat for outlets and flush valves.
 - .8 Confirm water quality consistent with supply standards, and ensure no residuals remain as result of flushing or cleaning.
- .3 Reports:
 - .1 In accordance with Section 01 91 13, and using report forms as specified.
 - .2 Include certificate of water flow and pressure tests conducted on incoming water service, demonstrating adequacy of flow and pressure.

3.10 CLEANING

- .1 Clean in accordance with Section 01 74 00.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 ASTM International (ASTM)
 - .1 ASTM D2235-04(2016), Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
 - .2 ASTM D2564-12(2018), Standard Specification for Solvent Cements for Poly (Vinyl-Chloride) (PVC) Plastic Piping Systems.
- .2 Canadian Standards Association (CSA)
 - .1 CSA-Series B1800-18, Thermoplastic Nonpressure Piping Compendium.
- .3 Green Seal (GS)
 - .1 GS-36-2013, Adhesives for Commercial Use.
- .4 National Research Council Canada (NRC)
 - .1 National Plumbing Code of Canada 2015 (NPC).
- .5 South Coast Air Quality Management District (SCAQMD), California State
 - .1 SCAQMD Rule 1168-Amended 2017, Adhesive and Sealant Applications.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Provide submittals in accordance with Section 01 33 00.
- .2 Product Data:
 - .1 Provide manufacturer's printed product literature and datasheets for piping and adhesives, and include product characteristics, performance criteria, physical size, finish and limitations.

1.3 DELIVERY, STORAGE AND HANDLING

- .1 Deliver, store and handle in accordance with Section 01 61 00.
- .2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .3 Store at temperatures and conditions recommended by manufacturer.

PART 2 - PRODUCTS

2.1 MATERIAL

- .1 Adhesives and Sealants: in accordance with Section 07 92 00.
 - .1 Maximum VOC limit 70, 250 g/L to SCAQMD Rule 1168, GS-36 and in accordance with Section 01 35 21.

2.2 PIPING AND FITTINGS

- .1 For above ground, buried DWV piping to:
 - .1 CSA Series B1800.

2.3 JOINTS

- .1 Solvent weld for PVC: to ASTM D2564.
- .2 Solvent weld for ABS: to ASTM D2235.

PART 3 - EXECUTION

3.1 APPLICATION

- .1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION

- .1 Install in accordance with requirements of local provincial plumbing code, local authority having jurisdiction, and NPC.

3.3 TESTING

- .1 Pressure test covered systems before covering.
- .2 Hydraulically test to verify grades and freedom from obstructions.

3.4 PERFORMANCE VERIFICATION

- .1 Cleanouts:
 - .1 Ensure accessible and that access doors are correctly located.
 - .2 Open, cover with linseed oil and re-seal.
 - .3 Verify cleanout rods can probe as far as the next cleanout, at least.
- .2 Test to ensure traps are fully and permanently primed.
- .3 Storm water drainage:
 - .1 Verify domes are secure.
 - .2 Ensure weirs are correctly sized and installed correctly.
 - .3 Verify provisions for movement of roof system.
- .4 Ensure fixtures are properly anchored, connected to system and effectively vented.
- .5 Affix applicable label (storm, sanitary, vent, pump discharge) with directional arrows every floor or 4.5 m (whichever is less).

3.5 CLEANING

- .1 Clean in accordance with Section 01 74 00.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCES

- .1 ASTM International (ASTM)
 - .1 ASTM B819-19, Standard Specification for Seamless Copper Tube for Medical Gas Systems.
- .2 Canadian Standards Association (CSA)
 - .1 CSA B51-19, Boiler, Pressure Vessel and Pressure Piping Code.

1.2 SUBMITTALS

- .1 Submit shop drawings/product data sheets for products specified in this Section except pipe and fittings. Clearly indicate appropriate Canadian Registration Number (CRN) assigned to each component, on component shop drawing/product data sheet.
- .2 Submit product data sheets for motors, and certified wiring diagrams for equipment requiring power, control and/or alarm wiring connections.
- .3 Submit, prior to work commencing on site, a detailed account of proposed pipe joint brazing procedures including pre- and post-nitrogen purging.
- .4 Submit written certification by equipment manufacturers/suppliers confirming equipment is properly installed, has been tested, and is in proper operating condition, all as specified in Part 3 of this Section.
- .5 Submit manufacturer's start-up reports as specified in Part 3 of this Section.
- .6 Submit 3 identified keys for cabinet/panel lockable doors prior to Substantial Performance of the Work.
- .7 Submit record as-built drawings in accordance with requirements specified in Section 22 05 00.

1.3 DESIGN PRESSURE AND TEMPERATURE REQUIREMENTS

- .1 System design pressures are as follows:
 - .1 Argon:
 - .1 maximum system pressure, 380 kPa.
 - .2 Nitrogen:
 - .1 maximum system pressure, 1400 kPa.
- .2 Design temperature for services will be ambient temperature.

1.4 QUALITY ASSURANCE

- .1 Products and work must comply in all respects with requirements of local governing authorities, and requirements of applicable codes and standards.
- .2 Provide registration, inspection, and/or approval for gas system work, as required, with local governing regulatory authority.

- .3 Laboratory gas systems work must be performed by journeyman plumber/pipefitter/steamfitter tradesmen completely familiar with requirements local codes and standards, and who are qualified and certified (with jurisdictional authority issued Certificate) for silver brazing with nitrogen backing without using flux in accordance with Clause 4.5 in Part 1 of CSA B51. Jurisdictional authority is the authority designated by the province of the work to perform oversight functions cited in Clause 4.5 in Part 1 of CSA B51.

PART 2 - PRODUCTS

2.1 GENERAL RE: PIPING SYSTEM MATERIALS AND COMPONENTS

- .1 Pipe, fittings, and piping system components are factory washed and degreased. Cap pipe. Package fittings and components.
- .2 Piping system components site connected with piping are complete with factory installed, washed, degreased and capped Type "K" hard copper piping stubs with joints silver brazed while component and piping is full of nitrogen.

2.2 PIPE, FITTINGS AND JOINTS

- .1 Aboveground
 - .1 Type "L" or type "K" (as specified in Part 3) hard temper copper tubing to ASTM B819, complete with wrought copper, brass or bronze fittings and silver brazed joints made with brazing alloy conforming to ANSI/AWS Standard A5.8 Classification BcuP-5.

2.3 PIPE ANCHORS

- .1 Welded structural black steel anchors of design, size, and type to securely anchor pipe at point shown.
- .2 Each anchor can withstand 150% axial thrust, and is designed and detailed by third party structural Professional Engineer.
- .3 Submit anchor design and fabrication shop drawings.

2.4 SHUT-OFF VALVES

- .1 Full flow bronze body ball type valves, 4140 kPa rated, ¼ turn on-off from a fully closed to a fully open position, in-line serviceable, blow-out proof, factory pressure tested, and complete with a chrome plated brass or stainless steel ball depending on valve size, a double Teflon seal, a Teflon seat, O-ring packing, lever handle capable of locking in open or closed position, and colour coded permanent identification labels.

2.5 LOCAL EMERGENCY ALARM PANEL ASSEMBLIES

- .1 Wall mounting local emergency alarm panels assemblies incorporating an area alarm panel in one enclosure. Each assembly is to be complete with:
 - .1 Enamelled steel wall mounted box sized to suit components installed, complete with adjustable steel mounting brackets, an anodized aluminium frame.
 - .2 Modular, microprocessor-based, gas specific alarm units with large LED universal (psi, kPa, "Hg, Bar) pressure/vacuum displays, LED trend display, high and low alarms with dry contacts for connection to a master alarm panel, 90 dBA audible alarm with silence button and adjustable alarm reminder, alarm history recall, identified sensors with DISS connection located in back box, and remote monitoring hardware.

2.6 DUPLEX GAS MANIFOLDS

- .1 Factory assembled, pre-wired and tested, duplex, fully automatic, fail-safe design digital manifolds for cylinder arrangement as indicated on drawings, labelled for appropriate gas service and as follows:

SERVICE	MANUFACTURER & MODEL NO.	NO. OF CYLINDERS DELIVERY PRESSURE
argon		345 kPa
nitrogen		1210 kPa

- .2 Changeover from primary supply to secondary supply is to be fully automatic and is not to require manual reset of manifold after cylinder replacement and gas flow and cylinder bank changeover is not to be affected by a power failure. Manifold is to utilize a single high-flow control solenoid valve and accomplish changeover by differential pressure.
- .3 Surface wall mounting, 120 volt, 1-phase, 60 Hz barriered steel cabinet with hinged access door and wall mounting hardware, primed and painted and complete with:
 - .1 24 volt secondary control transformer and DIN rail-mounted user terminal connections.
 - .2 2 primary regulators, 2 pressure transmitters, 2 inlet check valves, 1 normally open brass solenoid valve, 4 union style ball type isolation valves, 2 main line pressure regulators, and 3 externally mounted ASME certified pressure relief valves with union connections.
 - .3 Plugged NPT port for a temporary gas supply connection.
 - .4 Door mounted "Service Ready" LED, "Empty" LED's for each left and right cylinder banks, and LED digital displays of each cylinder bank pressure and main supply pressure.

- .4 Header bars consisting of rigid, silver brazed brass pipe and fittings, labelled for appropriate gas service and complete with wall mounting hardware and gas specific inlet connections with integral check valves.
- .5 600 mm long gas specific cylinder pigtails complete with a Compressed Gas Association (CGA) nut and nipple inlet fitting with reverse flow outlet check valve, and CGA nut and nipple outlet fitting. Pigtail material is as follows:
 - .1 Argon: Semi-rigid copper (no lining).
 - .2 Nitrogen: Teflon lined stainless steel.

2.7 NITROGEN CONTROL PANELS

- .1 Flush wall mounting panel, factory tested and cleaned for nitrogen service, packaged for delivery, and complete with:
 - .1 1.6 mm thick extruded aluminium back box complete with plaster mounting flange, and inlet and outlet 9.5 mm diameter Type "K" copper tubing with brass fittings.
 - .2 2760 kPa rated flexible cross-over tubing complete with quick-connect fittings.
 - .3 Stainless steel front panel with black silk-screened labelling, and panel mounted components as follows:
 - .1 1750 kPa high flow self-relieving, adjustable, lockable pressure regulator.
 - .2 1/4 turn brass ball type inlet supply valve.
 - .3 50 mm diameter, 0 - 2100 kPa inlet and outlet pressure gauges.
 - .4 Cartridge style (Diameter-Index Safety System) DISS nitrogen outlet.

2.8 PRESSURE SWITCHES FOR ALARM SIGNALS

- .1 Factory assembled and set (to suit site requirements) switches as follows:
 - .1 each labelled for intended service.
 - .2 each suitable for pipeline pressure, laboratory gas involved, and alarm function.
 - .3 each complete with a NEMA 4 housing, tamper-proof external adjustment, a gas specific DISS inlet, a 50 mm diameter monitoring gauge, and instructions for field adjustment.

2.9 ALARM PANEL

- .1 Modular, field expandable, 115 volt, solid state, electronic, microprocessor-based flush wall mounting audio-visual alarm panel designed for constant monitoring of piping system pressure or vacuum as applicable, and initiation of an alarm function on any open circuit only. Panel is to be complete with:
 - .1 Minimum 1.0 mm thick steel back box sized to suit gas service modules required and equipped with adjustable mounting brackets to accommodate different wall thicknesses, a 115 volt power connection terminal block, fused 24 volt

- secondary transformer, a motherboard for plug-in connection of modules, and matte finish extruded aluminium or equal trim.
- .2 Power module with green power on LED, and adjustable (2 to 30 minutes) alarm repeater.
 - .3 Microprocessor-based, field adjustable modules, each capable of handling 10 functions, capable of field upgrading to interface with a building automation system or slave alarm, and supplied in quantities to connect alarms as follows:
 - .1 Argon:
 - .1 High Line Pressure.
 - .2 Reserve Manifold in Use.
 - .3 Low Line Pressure.
 - .2 Nitrogen:
 - .1 High Line Pressure.
 - .2 Reserve Manifold in Use.
 - .3 Low Line Pressure.
 - .4 Red alarm LED's which flash and an audible alarm buzzer in excess of 90 dB which sounds when an alarm condition occurs, and an "ALARM MUTE" pushbutton to silence audible alarm, however, panel will remain in alarm state until problem is rectified.
 - .5 "TEST" pushbutton to test all panel functions.
 - .6 Dry contacts for remote monitoring of high and low alarms.
 - .7 Building automation system signal interface panel.

PART 3 - EXECUTION

3.1 GENERAL RE: PIPING INSTALLATION

- .1 Perform pipe joint brazing work and brazing procedures in accordance with.
- .2 Departmental Representative reserves right to cut-out and examine piping joints during course of work or after work is complete, and if interior of cut-out sample and/or fittings are found to be contaminated with oxidation or any other material, piping will be considered unacceptable and must be cleaned or replaced.
- .3 Where low pressure connecting assemblies are used in retractable gas columns, articulating arms, or any other dispensing assembly, DISS body or terminal unit which is used to connect it to copper pipeline must be brazed to piping system.
- .4 Refer to drawing plans and elevations for exact locations of terminal units, zone valve boxes, alarm panels, and other such items.

3.2 INSTALLATION OF LABORATORY GAS SYSTEM PIPING

- .1 Provide required gas system piping. Unless otherwise shown or specified, and piping for services is to be minimum 12 mm diameter.

- .2 Piping aboveground, unless otherwise specified, is to be Type "L" hard copper.
- .3 Provide threaded piping unions at piping connections to source equipment. Do not silver braze unions. Braze a male NPT adaptor on end of pipe, wrap Teflon tape onto adaptor (2 threads back), and screw union as tight as possible by hand, then with proper wrenches for final tightening. Do not over tighten.
- .4 Perform pipe brazing operations.
- .5 Ensure tools used during erection of piping systems are kept clean and free from oil and grease.
- .6 Support piping by means of support materials and anchors of type to suit intended applications.
- .7 Prepare a separate set of as-built white prints on a daily basis. Identify piping system work, including valves, concealed and exposed. Submit record as-built drawings in accordance with requirements in Section 22 05 00.
- .8 Provide DISS identified riser outlet piping connections in ceiling and/or wall spaces for connection to terminal outlets integral with manufactured equipment. Terminal units will be pre-piped by equipment manufacturer to an accessible location. Carefully rough-in piping and coordinate equipment connections, particularly for flush mounted and/or ceiling mounted equipment.
- .9 Provide identified piping connections to ceiling columns and/or headwalls, and/or other locations as indicated.
- .10 Provide a full size branch tee with shut-off valve for each gas source downstream of main isolation valve.

3.3 INSTALLATION OF VALVES

- .1 Provide shut-off/isolation valves where shown or required by local governing codes or standards. Shut-off valves, unless otherwise specified, are to be ball type.
- .2 Provide check valves where shown or required by local governing codes or standards.
- .3 Locate valves in positions for easy access and operation.

3.4 INSTALLATION OF AREA ALARM BOXES

- .1 Provide area alarm assemblies. Provide a service isolation valve in piping immediately upstream of each zone valve and on same floor.
- .2 Accurately install boxes with reference to wall finish, and confirm exact locations prior to roughing-in.

3.5 INSTALLATION OF DUPLEX GAS MANIFOLDS

- .1 Provide duplex gas manifold assemblies.
- .2 Surface wall mount control panel.
- .3 Rigidly secure each manifold in place and connect to control panel. Surface wall mount dual line pressure regulator and

connect to control panel. Connect control panel outlet to system piping.

- .4 Pipe manifold relief valves to atmosphere using piping sized one size larger than outlet port of relief valve. Terminate vent piping in a "turned down" elbow arrangement with bronze insect screen permanently secured over pipe opening. Confirm exact termination points prior to roughing-in.

3.6 INSTALLATION OF NITROGEN CONTROL PANELS

- .1 Provide nitrogen control panels and flush wall mount. Confirm exact locations prior to roughing-in.
- .2 Connect with Type "K" copper inlet and outlet piping. Test operation and adjust as required.

3.7 INSTALLATION OF PRESSURE/VACUUM SWITCHES

- .1 Provide pressure or vacuum switches, as applicable, and all required connection hardware for medical gas pressure or vacuum alarms. Install in piping tees in accessible locations.
- .2 Adjust each switch in accordance with manufacturer's/supplier's instructions to suit site and system conditions.

3.8 INSTALLATION OF ALARM PANELS

- .1 Provide wall mounted gas pressure/vacuum alarm panels. Confirm exact panel locations prior to roughing-in.
- .2 Provide required hardware and connect each panel with required piping as applicable.
- .3 Carefully check panel pressure/vacuum readings and make any required adjustments.
- .4 When installation is complete, test each panel function, and make any adjustments and corrections necessary.

3.9 PIPING SYSTEM CLEANING AND LEAKAGE TESTING

- .1 Flush out, disinfect and rinse system to requirements of authority having jurisdiction approval of Departmental Representative.
- .2 Disinfect piping with in accordance with local governing standards.
- .3 Refer to additional requirements in Section 22 05 00.

3.10 POWER AND CONTROL WIRING

- .1 Line voltage power wiring to equipment, unless otherwise specified, will be done as part of electrical work.
- .2 Control and alarm wiring, unless otherwise specified, is to be installed in conduit as part of medical gas system work in accordance with electrical work wiring requirements, and manufacturer's/supplier's certified wiring schematics.

- .3 Generally, power wiring (provided as part of work of Division 26) and control and alarm wiring (provided as part of work of this Division and Division 25) is to be as follows:

EQUIPMENT	LINE VOLTAGE POWER WIRING	CONTROL AND/ OR ALARM WIRING
duplex manifolds	115 volt to cabinet	alarm wiring from cabinet to master alarm panel
local alarm panels	115 volt to panel	
combo zone valve and area alarm units	115 volt to panel	

3.11 EQUIPMENT START-UP AND CERTIFICATION

- .1 When installation of gas system equipment from source of supply up to but not including outlets is complete, and piping leakage testing is complete, arrange for equipment manufacturers/suppliers to visit site for length of time necessary to:
- .1 Check installation of equipment and recommend any adjustments required to be performed immediately.
 - .2 Start-up equipment, test operation, recommend any adjustments required to be performed immediately, check and verify safeties, operational sequences, controls and alarms to ensure they are operating properly, and ensure equipment performs as intended.
 - .3 Obtain letter(s) from system manufacturer(s)/supplier(s) certifying above requirements have been successfully completed, have letter(s) signed by system manufacturer(s)/supplier(s), and submit to Department Representative.

3.12 GAS SYSTEM CERTIFICATION

- .1 When equipment start-up and certification is complete, notify Department Representative that systems are ready for gas system certification.
- .2 Arrange for system installer to be part of certification team.
- .3 Perform gas system certification in accordance with requirements of local governing authorities and codes.

3.13 IDENTIFICATION AND LABELLING

- .1 Identify piping with labelling in accordance with local governing codes and standards.
- .2 Provide identification nameplate on equipment.
- .3 Review nomenclature, sizing, colours, and other identification requirements with Departmental Representative.
- .4 Refer to additional requirements specified in Section 23 05 00.

3.14 SYSTEM TRAINING

- .1 Include for 2 site training sessions for a minimum of 6 people for 8 hours per session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

PART 1 - GENERAL

1.1 SUBMITTALS

- .1 Submit shop drawings/product data sheets for products specified in this Section.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS AND JOINTS

- .1 Tempered and annealed borosilicate glass pipe, fittings, and accessories with bolted stainless steel compression type couplings.
- .2 Cleanouts
 - .1 For horizontal piping, glass TY pipe fitting with removable, air-tight cleanout access cover.
 - .2 For vertical piping, chemically strengthened glass ("Barrett" type) cleanout tee fitting with removable, air-tight access cover.

2.2 FLOOR DRAINS

- .1 Drains as indicated, or as per drawing schedule, each complete with epoxy coated (inside and outside) body, clamp and strainer, combination invertible membrane clamp, and a trap primer connection.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION REQUIREMENTS

- .1 Provide required acid and corrosive resistant drainage and vent piping.
- .2 Piping is to be borosilicate glass.
- .3 Unless otherwise specified, slope horizontal drainage piping above ground in sizes to and including 75 mm diameter 25 mm in 1.2 m, and pipe 100 mm diameter and larger 25 mm in 2.4 m.
- .4 Unless otherwise specified, slope horizontal branches of vent piping down to fixture or pipe to which they connect with a minimum pitch of 25 mm in 1.2 m.
- .5 Ensure piping is installed in accordance with manufacturer's instructions, particularly with respect to piping joints, and piping hangers and supports.

3.2 INSTALLATION OF CLEANOUTS

- .1 Provide cleanouts in acid and corrosive resistant drainage piping in locations as follows:
 - .1 At or as close as practical to the foot of each stack.
 - .2 At maximum 15 m intervals in horizontal pipe 100 mm diameter and smaller.

- .3 At maximum 30 m intervals in horizontal pipe larger than 100 mm diameter.
- .4 Wherever else shown on drawings.
- .2 Cleanouts are to be same diameter as pipe in piping to 100 mm diameter and not less than 100 mm diameter in piping larger than 100 mm diameter.
- .3 Where cleanouts are concealed behind walls or partitions, install cleanouts near floor and so cover is within 25 mm of finished face of the wall or partition.

3.3 INSTALLATION OF FLOOR DRAINS

- .1 Provide floor drains.
- .2 Equip each drain with an acid-resistant trap, and connect each drain with trap seal primer tubing.
- .3 Confirm locations prior to roughing-in.
- .4 Temporarily plug and cover floor drains during construction procedures. Remove plugs and covers during final clean-up work and when requested by Departmental Representative, demonstrate free and clear operation of each drain.

3.4 PRESSURE TESTS

- .1 Piping test pressure: in accordance with manufacturer recommended maximum system operating pressure.

3.5 FLUSHING AND CLEANING

- .1 Flush and disinfect piping after leakage testing is complete.
- .2 Flush piping until foreign materials are removed and flushed water is clear.

END OF SECTION

PART 1 - GENERAL

1.1 GENERAL

- .1 This Section covers items common to more than one section of the Mechanical Divisions 21, 22, 23 and 25.
- .2 "Provide" shall mean "supply, install and connect".
- .3 Provide new materials, equipment and plant of proven design and quality, and of current models with published ratings for which replacement parts are readily available.
- .4 Refer to Division 01 for additional general requirements.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME B31.1-2020, Power Piping.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB-24.3-92, Identification of Piping Systems.
- .3 Canadian Standards Association (CSA)
 - .1 CSA C390:10(R2019), Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors.
- .4 National Building Code of Canada (NBC)- 2015.
- .5 Ontario Building Code (OBC) - 2012 with amendments in effect up to January 1, 2020.

1.3 HALOCARBONS

- .1 Comply with Federal Halocarbon Regulations 2003 under the Canadian Environmental Protection Act 1999, EPAM and PWGSC Ontario Region Halocarbon Information Sheet dated March 2010.

1.4 EQUIPMENT LIST

- .1 Complete list of equipment to be used on this project by adding manufacturer's name and model number. Submit for approval within one week of Award of Contract.
- .2 Complete the following list of equipment with manufacturer's name and model number:
 - .1 Airflow Control Valves: Maker and model number.
 - .2 Hydronic Duct Heating & Cooling Coils: Maker and model number.
 - .3 Control and instrumentation: Maker and model number.
- .3 Ensure that the equipment to be used will meet the performance specifications and will fit the spaces allocated.
- .4 Submit for approval within one week after Award of Contract.

1.5 CUTTING AND REMEDIAL WORK

- .1 Cutting and remedial work is specified in Section 01 73 00.

- .2 Assume full responsibility for laying out mechanical work and for any damage caused by incorrectly located equipment and mechanical services.
- .3 Set sleeves and mark openings in concrete forms and in masonry before placing of concrete and erection of masonry.

1.6 CO-ORDINATION

- .1 Locate distribution systems, equipment and materials to provide minimum interference and maximum useable space.
- .2 Where interference occurs, Departmental Representative shall approve relocation of equipment and materials.

1.7 DRAWINGS

- .1 Working drawings, except where dimensioned, indicate general mechanical layouts only. Do not scale.
- .2 Existing equipment and services shown on the drawings:
 - .1 The information shown on the drawings is incomplete and is for reference only. Some of the existing equipment, ducts, pipes and other services are not shown on the drawings.
 - .2 Examine existing conditions, determine conditions affecting the work, and verify sizes and location of existing equipment, ducts, pipes and any other services.
 - .3 Unless the discrepancies are noted and reported to the Departmental Representative prior to close of the bid, relocate existing equipment and reroute existing ducts, pipes and any other services required for the installation of new work at no extra cost to the Contract.
- .3 If required by Departmental Representative, provide field drawings to show relative positions of various services. Obtain approval before beginning work.

1.8 SHOP DRAWINGS AND PRODUCT DATA SHEETS

- .1 Submit shop drawings and product data sheets for major equipment listed in each section.
- .2 Submit within two (2) weeks to permit Project Schedules to be met.
- .3 Show materials; sizes, dimensions, performance ratings, curves and operating characteristics, compliance with codes and standards, wiring, controls, piping diagrams, installation instructions, fabrication, assembly and installation details.
- .4 For additional requirements pertaining to shop drawings and product data refer to Section 01 33 00.

1.9 OPERATION AND MAINTENANCE DATA

- .1 Supply operating and maintenance instructions complete with names and addresses of spare parts suppliers in accordance with requirements of Section 01 78 00.

1.10 EQUIPMENT DESIGN AND INSTALLATION

- .1 Uniformity:
 - .1 For equipment or material of same type or classification, use product of one manufacturer.
- .2 Installation:
 - .1 Install equipment to manufacturer's recommendations with adequate and easy access for inspection, servicing and lubrication.
 - .2 Install equipment to permit maintenance and disassembly with minimum disturbance to connecting piping and duct systems and without interference with building structure or equipment.
 - .3 Provide screwdriver stops on supplies to plumbing fixtures.
 - .4 Provide support brackets, bases, and all necessary fastenings.

1.11 ELECTRIC MOTORS AND CONTROLS

- .1 Electrical equipment shall bear CSA label. Obtain inspection labels required by Provincial authority having jurisdiction.
- .2 Use high efficiency motors. Minimum acceptable motor efficiency levels shall be based on the latest table of motor efficiency levels in accordance with CSA C390.
- .3 Unless otherwise specified or indicated, motors $\frac{1}{2}$ HP and larger shall be 3 phase.
- .4 Refer to Electrical Division 26 regarding specifications of power wiring (i.e. wiring carrying the full load current), conduits, starters, disconnect switches, etc., for mechanical equipment specified in Mechanical Divisions. Unless noted and specified in Electrical Divisions to be provided by Electrical Divisions, all field installed power wiring, conduit, starters, disconnect switches, etc., shall be provided by Mechanical Divisions.
- .5 Provide motors, control wiring and controls together with associated relays, signaling devices, thermostats, control transformers, firestats, pressure switches, electric-pneumatic switches, required to form a complete control system for the equipment specified in Mechanical Divisions.

1.12 EQUIPMENT SUPPORTS

- .1 Unless noted otherwise, fabricate equipment supports from structural grade steel. Submit structural calculations with shop drawings.
- .2 Mount base mounted equipment on chamfered edge concrete housekeeping pads, minimum of 100 mm high and 50 mm larger than equipment dimensions all around.

1.13 PIPING INSTALLATION

- .1 Conform to requirements of ASME B31.1.
- .2 Provide dielectric couplings where piping of dissimilar metals is joined.
- .3 Provide easily accessible unions close to equipment, to permit easy removal of equipment with minimum disturbance to piping systems.

- .4 Valves:
 - .1 Provide easy access for servicing and operation. Install access doors where concealed.
 - .2 Install with stems above horizontal.
- .5 Drainage:
 - .1 Provide easily accessible drain valves at low points to permit complete drainage of piping systems.
 - .2 Extend equipment drain piping to discharge into floor or hub drain.
 - .3 Provide drain piping from drain pan of air handling units, full size of outlet connection and equip with deep-seal trap.
- .6 Expansion and Contraction:
 - .1 Make adequate provision for expansion and contraction of piping systems.
 - .2 Use expansion joints and compensators, flexible connections, pipe loops and offsets as indicated and required.
 - .3 Support piping to prevent any stress or strain from occurring at connections to equipment.
 - .4 Install and guide expansion joints in accordance with manufacturer's recommendations.
 - .5 Provide steel anchors welded to piping, fastened to building structure or embedded in concrete pier so that forces acting on anchor points are restrained without causing damage to structure or systems.
 - .6 Base design axial traverse on temperature difference between -18°C ambient and corresponding fluid temperature plus a twenty five percent (25%) safety factor.

1.14 PIPE HANGERS AND SUPPORTS

- .1 Fabricate hangers, supports and sway braces in accordance with ASME B31.1.
- .2 Provide adjustable clevis type hangers on all sizes of pipe except where roller type hangers are required.
- .3 Minimum 150 mm hanger rod length.
- .4 Provide hangers on piping with heated or cooled contents as follows:
 - .1 Rigid hangers when rod length is 300 mm or more, pipe expansion to hanger rod length ratio is less than 1:24 and hanger is supported from top of structural steel.
 - .2 Swing hangers when rod length is 300 mm or more, pipe expansion to hanger rod length ratio is less than 1:6 and hanger is supported from top of structural steel.
 - .3 Roller hangers when rod length is less than 300 mm or pipe expansion to hanger rod length ratio is more than 1:6 or hanger is not supported from top of structural steel.
- .5 On uninsulated copper piping, ensure steel hangers in contact with copper piping are copper plated. Copper pipe shall not contact steel, iron or cinder materials. Covered 12 mm diameter copper pipe may be supported on copper straps.

1.15 SLEEVES, ESCUTCHEONS AND PLATES

- .1 Escutcheons and plates:
 - .1 Provide on pipes passing through finished walls, partitions, floors and ceilings.
 - .2 Use chrome or nickel-plated brass, solid type, with set screws for ceiling or wall mounting. For equipment rooms, use cast-iron type.

1.16 TESTS

- .1 Give written 48 hours notice of date when tests will be made.
- .2 Conduct tests in presence of Departmental Representative and representatives of agencies having jurisdiction.
- .3 Bear all costs in connection with all tests.
- .4 Obtain acceptance certificates from authorities having jurisdiction. Work shall not be considered complete until certificates are delivered to the Departmental Representative.
- .5 Piping pressure tests:
 - .1 Fill water piping with water and test at 1-1/2 times system operating pressure or at 860 kPa, whichever is greater.
 - .2 Maintain test pressures without loss for four hour period.
 - .3 Test natural gas systems with nitrogen gas at 690 kPa for 24 hour period without loss.
 - .4 Repair leaks and defects. Retest until approved by Departmental Representative.
- .6 Flushing and cleaning:
 - .1 After pressure tests are completed and approved, prior to start-up and placing into operation, flush and clean out piping systems.
 - .2 For water and oil systems fill with solution of water and approved non-foaming, phosphate free detergent. Circulate solution throughout piping systems.
 - .3 Flush and drain systems until free of dirt, sludge, oil, grease and other foreign material. Clean strainers.
 - .4 Refill water systems with clean water.
 - .5 Use compressed air to remove moisture from interior surfaces of fuel oil piping systems before filling with oil.
- .7 Testing plumbing systems:
 - .1 Conform to requirements of National Building Code, Ontario Plumbing Code, and Municipal regulations.
 - .2 Test in presence of Departmental Representative and Municipal Plumbing Inspector.
- .8 Testing and balancing of heating, ventilating, and air-conditioning systems:
 - .1 Use qualified personnel approved by the Departmental Representative to test and balance systems and keep records of operating results.

- .2 After systems balanced and tests concluded, submit test and balance report showing relevant operating data of equipment and systems.
- .3 Report shall certify compliance with requirements of drawings and specifications.

1.17 PAINTING

- .1 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.
- .2 Prime and touch up marred finished paintwork to match original.
- .3 Restore to new condition, finishes which have been damaged too extensively to be merely primed and touched up.

1.18 DRAIN VALVES

- .1 Minimum NPS 3/4 unless otherwise specified: bronze, with hose end male thread and complete with cap and chain.

1.19 IDENTIFICATION

- .1 Existing identification systems:
 - .1 Apply existing identification system to new work.
 - .2 Where existing identification system does not cover for new work, use identification system specified this section.
 - .3 Before starting work, obtain written approval of identification system from Departmental Representative.
- .2 Identification of piping systems:
 - .1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB-24.3 except where specified otherwise.
 - .2 Pictograms:
 - .1 Where required, to Workplace Hazardous Materials Information System (WHMIS) regulations.
 - .3 Legend:
 - .1 Block capitals to sizes and colours listed in CAN/CGSB-24.3.
 - .4 Arrows showing direction of flow:
 - .1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.
 - .2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.
 - .3 Use double-headed arrows where flow is reversible.
 - .5 Extent of background colour marking:
 - .1 To full circumference of pipe or insulation.
 - .2 Length to accommodate pictogram, full length of legend and arrows.
 - .6 Materials for background color marking, legend, arrows:
 - .1 Pipes and tubing 20 mm and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.

- .2 All other pipes: Pressure sensitive plastic-coated cloth with protective vinyl over coating, waterproof contact adhesive undercoating, suitable for ambient of 100% RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.
- .7 Colours and Legends:
 - .1 Where not listed, obtain direction from Departmental Representative.
 - .2 Colors for legends, arrows: To following table:

Background color:	Yellow	Legend, arrows:	BLACK
	Green		WHITE
	Red		WHITE
- .3 Identification ductwork systems:
 - .1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.
 - .2 Colours: black, or co-ordinated with base colour to ensure strong contrast.
- .4 Valve tags: brass tags with 12 mm stamped identification data filled with black paint.
- .5 Location of identification on piping and ductwork systems:
 - .1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: At not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.
 - .2 Adjacent to each change in direction.
 - .3 At least once in each small room through which piping or ductwork passes.
 - .4 On both sides of visual obstruction or where run is difficult to follow.
 - .5 On both sides of separations such as walls, floors, partitions.
 - .6 Where system is installed in pipe chases, ceiling spaces, galleries, other confined spaces, at entry and exit points, and at each access opening.
 - .7 At beginning and end points of each run and at each piece of equipment in run.
 - .8 At point immediately upstream of major manually operated or automatically controlled valves, dampers, etc.

1.20 INSTRUCTION OF OPERATING STAFF

- .1 Furnish competent instructors to fully instruct operating staff in care, adjustment and operation of mechanical systems. Use factory trained instructors.
- .2 Instruct during regular work hours before systems accepted and turned over to operating staff for regular operation.

- .3 Where significant changes or modifications in equipment are made under terms of guarantee, instruct operating staff about changes or modifications.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION NAMEPLATES

- .1 Nameplates: Lamicoid, minimum 3 mm thick, 2-ply, laminated coloured plastic plates.
- .2 Nameplate sizes as follows:

NAMEPLATE SIZES			
Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	6 mm high letters

- .3 Labels:
- .1 Embossed plastic labels with 6 mm high letters, unless specified otherwise. Labels adhesives are to be heavy duty strength and water-resistant, to maintain adhesion to surfaces. Apply clear coat of lacquer over installed labels.
- .4 Identification in English. Review nomenclature on nameplates and signs with Departmental Representative, prior to manufacture. Review with Departmental Representative, requirements for special sized nameplates other than size listed above.
- .5 Use maximum 25 letters per nameplate. Provide one nameplate for each piece of equipment.
- .6 Identify equipment with typically with Size 3 unless otherwise specified, nameplates with numbering and nomenclature, as reviewed with Departmental Representative. Increase nameplate size as required to accommodate required nomenclature.
- .7 Nameplates to completely identify equipment and its use with no abbreviations.
- .8 Wording is generally in accordance with drawings and includes equipment service and building area/zone served.
- .9 Supply stainless steel screws for securing nameplates in place.
- .10 For nameplates for equipment suspended above floor level, or generally not within easy viewing from floor level, increase in size making it easier to read from floor level.

2.2 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

- .1 Perform equipment installation in accordance with local governing authority seismic requirements, and NBC and OBC seismic requirements, applicable for building designation.
- .2 Provide labour, materials, and equipment required and necessary to seismically restrain equipment and equipment bases including concrete pads, and guarantee function of materials and equipment supplied.
- .3 Isolation product manufacturer seismic restraint engineer to verify that seismic restraints and combination isolator/restraints intended for use on project are fit for intended purpose and are in accordance with applicable local building code requirements for Place of Work.
- .4 Test and adjust installation in accordance with product manufacturer instructions.
- .5 Certify installation is in accordance with local governing authority requirements. Obtain required certificates of approvals.

2.3 FIRESTOPPING AND SMOKE SEAL MATERIALS

- .1 Asbestos-free, elastomeric materials and intumescent materials, tested, listed and labelled by ULC in accordance with CAN/ULC S115, and CAN/ULC S101 for installation in ULC designated firestopping, and smoke seal systems to provide a positive fire, water and smoke seal and a fire resistance rating (flame, hose stream and temperature) no less than fire rating for surrounding construction.
- .2 Firestopping and smoke seal material system to be specifically ULC certified with designated reference number for its specific installation. As part of shop drawing submission, submit copies of firestopping drawings with ULC certificate and system number for each specific installation.
- .3 Smoke and fire seal materials and manufacturers must be specifically approved for each application of penetrated surfaces, and as confirmed with Departmental Representative as approved by FM Global and listed in FM Global Approval Guide. As part of shop drawing submission, submit copies of firestopping drawings with FM Global Approval Guide.
- .4 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports, and anchoring devices in accordance with firestopping manufacturer's recommendations and ULC tested assembly. Coordinate material requirements with trades supplying abutting areas of materials.
- .5 Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- .6 Supply products of a single manufacturer for use on work of this Division.
- .7 Installer to be manufacturer trained and certified on specific product. Submit copy of certificate with shop drawings.
- .8 Include for manufacturer's authorized representative to inspect and verify each installation and application. Submit test report signed

and verified by system installer authorized representative and manufacturer's representative.

- .9 Acceptable certification to also include certification by Underwriters Laboratories of Northbrook IL, using tests conforming to CAN/ULC-S115 and given cUL listing published by UL in their "Products Certified for Canada (cUL) Directory".
- .10 Refer to additional requirements of Section 07 84 00.

PART 3 - EXECUTION

- .1 Not used.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

- .1 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
 - .1 ASHRAE Handbook: HVAC Applications, Chapter 37 - Testing, Adjusting and Balancing, Chapter 48 - Sound and Vibration Control-2019.
- .2 Associated Air Balance Council (AABC)
 - .1 AABC National Standards for Total System Balance - 7th Edition, 2016.
- .3 National Environmental Balancing Bureau (NEBB)
 - .1 NEBB Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems, 9th Edition, 2019.
- .4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - .1 SMACNA HVAC Air Duct Leakage Test Manual-2nd Edition, 2012.
 - .2 SMACNA HVAC Systems Testing, Adjusting and Balancing-3rd Edition, 2002.

1.2 GENERAL

- .1 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do all other work as specified in this section.
- .2 Standard: TAB to be to most stringent of TAB standards of AABC, NEBB, SMACNA and ASHRAE.
- .3 Perform TAB of all systems, equipment, components, controls specified in Mechanical Divisions.
- .4 Engage independent TAB agency to perform TAB Work.

1.3 QUALIFICATIONS OF TAB PERSONNEL

- .1 Within 90 days of Award of Contract, submit names of all personnel proposed to perform TAB, to Departmental Representative for approval.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 Qualifications: personnel performing TAB to be current member in good standing of AABC, NEBB, or National Building Comfort Testing Association (NBCTA).
- .4 Quality Assurance: perform TAB under direction of supervisor qualified by AABC, NEBB, or NBCTA.

1.4 PURPOSE OF TAB

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads.

- .2 Adjust and regulate equipment and systems so as to meet specified performance requirements and to achieve specified interaction with all other related systems under all normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.5 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards to be to satisfaction of authority having jurisdiction.

1.6 CO-ORDINATION

- .1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule so as to ensure completion before acceptance of project.
- .2 Coordinate TAB activities with controls contractor, fume hood tester and during fume hood testing;
- .3 Perform TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.7 PRE-TAB REVIEW

- .1 Review contract documents before project construction is started and confirm in writing to Departmental Representative adequacy of provisions for TAB and all other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Departmental Representative in writing all proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of all TAB devices, equipment, accessories, measurement ports and fittings.

1.8 START-UP

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in Mechanical Divisions.

1.9 OPERATION OF SYSTEMS DURING TAB

- .1 Operate systems for length of time required for TAB and as required by Departmental Representative for verification of TAB reports.

1.10 START OF TAB

- .1 Notify Departmental Representative seven (7) days prior to start of TAB.
- .2 Start TAB only when building is essentially completed, including:
 - .1 Installation of ceilings, doors, windows, other construction affecting TAB.
 - .2 Application of weather-stripping, sealing, caulking.

- .3 All pressure, leakage, and other tests specified by Divisions 23 and Division 25.
- .4 All provisions for TAB installed and operational.
- .5 Start-up, verification for proper, normal and safe operation of all mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - .1 Proper thermal overload protection in place for electrical equipment.
 - .2 Air systems:
 - .1 Filters in place, clean.
 - .2 Duct systems clean.
 - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - .4 Correct fan rotation.
 - .5 Fire, smoke, volume control dampers installed and open.
 - .6 Coil fins combed, clean.
 - .7 Access doors, installed, closed.
 - .8 All outlets installed, volume control dampers open.
 - .3 Liquid systems:
 - .1 Flushed, filled, vented.
 - .2 Correct pump rotation.
 - .3 Strainers in place, baskets clean.
 - .4 Isolating and balancing valves installed, open.
 - .5 Calibrated balancing valves installed, at factory settings.
 - .6 Chemical treatment systems complete, operational.

1.11 APPLICATION TOLERANCES

- .1 Perform TAB to following tolerances of design values:
 - .1 Hydronic systems: plus or minus ten percent (10%).
 - .2 All other HVAC systems: plus or minus five percent (5%).

1.12 ACCURACY TOLERANCES

- .1 Measured values to be accurate to within plus or minus two percent (2%) of actual values.

1.13 INSTRUMENTS

- .1 Prior to TAB, submit to Departmental Representative list of instruments to be used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within three (3) months of TAB. Provide certificate of calibration to Departmental Representative.

1.14 SUBMITTALS

- .1 Submit, prior to commencement of TAB:
 - .1 Proposed methodology and procedures for performing TAB if different from referenced standard.
 - .2 Proposed check lists and report forms.

1.15 PRELIMINARY TAB REPORT

- .1 Submit for checking and approval of Departmental Representative, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - .1 Details of instruments used.
 - .2 Details of TAB procedures employed.
 - .3 Calculations procedures.
 - .4 Summaries.

1.16 TAB REPORT

- .1 Format to be in accordance with referenced standard.
- .2 TAB report to show all results in SI units and to include:
 - .1 Project record drawings.
 - .2 System schematics.
- .3 Submit two (2) unless otherwise specified in Division 01, hard copies of TAB Report to Departmental Representative for verification and approval, in English in D-ring binders, complete with index tabs. Submit one electronic pdf format copy.

1.17 VERIFICATION

- .1 All reported results subject to verification by Departmental Representative.
- .2 Provide manpower and instrumentation to verify up to thirty percent (30%) of all reported results.
- .3 Number and location of verified results to be at discretion of Departmental Representative.
- .4 Bear costs to repeat TAB as required to satisfaction of Departmental Representative.

1.18 SETTINGS

- .1 After TAB is completed to satisfaction of Departmental Representative, replace drive guards, close all access doors, lock all devices in set positions, ensure sensors are at required settings.
- .2 Permanently mark all settings to allow restoration at any time during life of facility. Markings not to be eradicated or covered in any way.

1.19 COMPLETION OF TAB

- .1 TAB to be considered complete only when final TAB Report received and approved by Departmental Representative.

1.20 AIR SYSTEMS

- .1 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
- .2 Locations of equipment measurements: To include, but not be limited to, following as appropriate:
 - .1 Inlet and outlet of each damper, filter, coil, humidifier, fan, other equipment causing changes in conditions.
 - .2 At each controller, controlled device.
- .3 Locations of systems measurements to include, but not be limited to, following as appropriate: Each main duct, main branch, sub-branch, run-out (or grille, register or diffuser).

1.21 HYDRONIC SYSTEMS

- .1 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: Flow rate, static pressure, pressure drop (or loss), temperature, specific gravity, density, RPM, electrical power voltage, noise, vibration.
- .2 Locations of equipment measurement: To include, but not be limited to, following as appropriate:
 - .1 Inlet and outlet of each heat exchanger (primary and secondary sides), boiler, chiller, coil, humidifier, cooling tower, condenser, pump, PRV, control valve, other equipment causing changes in conditions.
 - .2 At each controller, controlled device.
- .3 Locations of systems measurements to include, but not be limited to, following as appropriate: Supply and return of each primary and secondary loop (main, main branch, branch, sub-branch of all hydronic systems, inlet connection of make-up water.

1.22 OTHER SYSTEMS

- .1 Plumbing systems:
 - .1 Flush valves: adjust to suit project pressure conditions.
 - .2 Pressure booster systems: test for capacity and pressures under all conditions and at all times.

1.23 OTHER TAB REQUIREMENTS

- .1 Refer to other mechanical specification sections for additional requirements.

1.24 POST- OCCUPANCY TAB

- .1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, in occupied areas.

PART 2 - PRODUCTS

.1 Not Used.

PART 3 - EXECUTION

.1 Not Used.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Safety Professionals (ASSP)
 - .1 ANSI/ASSP Z9.5-2012, Laboratory Ventilation.
- .2 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 110-2016, Method of Testing Performance of Laboratory Fume Hoods.
- .3 Public Works and Government Services Canada (PWGSC)
 - .1 PWGSC MD15128-2008, Laboratory Fume Hoods.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00.

1.3 CLOSEOUT SUBMITTALS

- .1 Submit in accordance with Section 01 78 00.
- .2 Record Documentation:
 - .1 Submit list of materials used in fume hood work.

1.4 QUALITY ASSURANCE

- .1 Test Agency: fume hood tests to be performed by qualified independent testing agency with proven experience in Work of this Section and in accordance with PWGSC MD15128.
- .2 Test Agency Qualifications:
 - .1 Minimum 3 years' experience in testing of fume hoods.
 - .2 Attendance at laboratory HVAC design course, by US Eagleson Institute or equivalent.
 - .3 Attendance at ASHRAE 110 Testing Workshop, by US Eagleson Institute or equivalent.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- .1 Test equipment to ANSI/ASSP Z9.5 and PWGSC MD 15128.
- .2 Data logger:
 - .1 Speed: 10 Hz or better.
 - .2 Memory: sufficient to allow data collection for duration of test.
- .3 In-duct flow sensor to measure flow response:
 - .1 Speed: 10 Hz.
 - .2 Range: 95 L/s to 950 L/s.
 - .3 Accuracy: $\pm 5\%$.

- .4 Thermal anemometer:
 - .1 Mounting: on stand with probe fixed at each traverse grid location.
 - .2 Include: averaging function over twenty second period for each location or output recorded for 20 seconds minimum at a rate of one reading/second on data logger.
- .5 Accuracy:
 - .1 Below 0.50 m/s: ± 0.025 m/s.
 - .2 0.50 m/s and over: $\pm 5\%$.
- .6 Detector for tracer gas containment:
 - .1 Type: continuous reading.
 - .2 Minimum Detectable Level (MDL): 0.01 ppm.
 - .3 Accuracy: concentrations below 0.1 ppm: $\pm 25\%$; concentrations above 0.1 ppm: $\pm 10\%$.

PART 3 - EXECUTION

3.1 AS INSTALLED (AI) AND INTEGRATED SYSTEMS TESTS

- .1 Perform AI and integrated systems tests as follows:
 - .1 After entire laboratory HVAC and exhaust systems have been tested and balanced (TAB), and TAB and Performance Verification (PV) reports have been submitted and accepted.
 - .2 HVAC and exhaust systems are in full operation.
 - .3 Room temperatures are maintained between 22 degrees C and 24.5 degrees C., recorded and submitted with fume hood test documentation.
 - .4 At specified laboratory space pressurization.
 - .5 Under deviation of space pressurization due to laboratory door opening and closing, change of laboratory operating modes, upset conditions, and other causes of change in laboratory air pressure.
 - .6 As part of commissioning of integrated HVAC and exhaust systems and laboratory space pressurization tests included in commissioning process.
- .2 After installation, test each fume hood to ASHRAE 110 and PWGSC MD15128 at design sash position of 700 mm (28") to ensure compliance with design criteria in PWGSC MD15128.
- .3 Design sash position for Fume Hood testing shall be 700 mm (28").

3.2 "AI" TESTS FOR VAV FUME HOODS

- .1 Cross draft tests:
 - .1 Test air currents external to fume hood to PWGSC MD15128.
 - .2 Ensure velocity of cross draft does not exceed 50% of average face velocity.

- .3 Record measurements as follows:
 - .1 Using thermal anemometer take readings 1.5 m above floor, 500 mm from sash, at centre, and left and right posts of fume hood.
 - .2 Take readings at 1 reading/second, recorded to obtain average, and maximum and minimum values over a duration of 20 seconds at each location.
 - .3 Ensure that project authority reduces excessive values to less than 50% of average face velocity before proceeding with further fume hood testing.
- .2 Visualization (smoke) tests:
 - .1 Extent of tests and performance criteria: to PWGSC MD15128.
- .3 Face velocity and flow response test pass ratings: to PWGSC MD15128 and ASHRAE 110.
 - .1 VAV face velocity and flow response tests:
 - .1 Average face velocity at design sash position: 0.5 m/s
 - .2 Average face velocity with sash at 66% of design sash position: 0.5 m/s \pm 0.025 m/s
 - .1 Variation allowed for individual readings: \pm 20%
 - .3 Average face velocity with sash at 33% of design sash position: 0.5 m/s \pm 0.025 m/s.
 - .1 Variation allowed for individual readings: \pm 20%
 - .4 Response time: time to reach 90% of the average steady state value: within 5 seconds of initial sash movement
 - .5 Test for VAV minimum flow with sash closed: to ANSI/ASSP Z9.5 capable of maintaining 375 air changes per hour.
- .4 Tracer Gas tests:
 - .1 Performance criteria: to PWGSC MD15128.
 - .2 Conduct tests at target average face velocity.
 - .3 Use approved tracer gas.
 - .4 Perform tests with probe at height of 560 mm above work surface.
 - .5 Leakage with sash at normal operating position:
 - .1 Average leakage: 0.05 ppm maximum.
 - .2 Peak reading: 0.25 ppm.
 - .6 Leakage with sash in fully open position:
 - .1 Average leakage: 0.05 ppm maximum.
 - .2 Peak reading: 0.25 ppm.
 - .7 Peripheral scan:
 - .1 Record significant peak readings and their locations.
 - .2 Record 30 second rolling averages.
 - .3 Maximum 0.25 ppm for any 30 second rolling average.
 - .4 Include readings in test report.

- .8 Sash Movement Effect (SME), to determine potential for escape after movement of sash to ASHRAE 110 procedures:
 - .1 Maximum 45 second rolling average: 0.05 ppm.
- .5 Conduct VAV Response Tests, Stability Tests and SME simultaneously for VAV fume hoods.

3.3 FUME HOOD MONITOR AND ALARM TESTS

- .1 Fume Hood Monitor:
 - .1 Provide 3 point calibration.
 - .2 Ensure each monitor initiates alarms (audible, visual, and BMS) when unsafe velocity conditions occur.
 - .3 Ensure monitor readings are displayed in metres per second, to 2 decimal places.
- .2 Fume Hood Monitor/Alarm testing:
 - .1 Monitor accuracy test: ensure monitor is accurate within 5% of average face velocity.
 - .2 Alarm enunciation test: ensure alarm occurs beyond $\pm 20\%$ of design flow set point.
 - .3 Alarm response enunciation test: ensure alarm delay is 10 seconds maximum.

3.4 FUME HOOD STATIC PRESSURE TEST

- .1 With sash at design position and face velocity at target setting, fume hood static pressure: less than 62 Pa.

3.5 NOISE LEVEL TEST

- .1 With sash at design position and face velocity at target setting, noise level at working position in front of fume hood: less than 70 dBA.

3.6 VERIFICATION LABELS

- .1 Affix label to front of fume hood indicating verification, name of testing agency, and date.

3.7 COMMISSIONING - INTEGRATED SYSTEMS TESTS

- .1 Do commissioning tests in accordance with Section 01 91 13.
- .2 Fume hood testing to commence only after laboratory HVAC systems are fully commissioned, including calibration of airflow controls, calibration of automatic temperature controls, balance of air supply, completion of duct traverse on each fume hood exhaust duct, and completion of an air balance of the total exhaust flow.
- .3 Test fume hoods in conjunction with complete laboratory integrated HVAC and exhaust systems commissioning testing including, room air flow patterns, temperature, humidity, pressurization, noise, and vibration.

3.8 REPORTS

- .1 Ensure test reports are signed by testing agency before submitting to Departmental Representative.

3.9 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 11.
 - .1 Leave Work area clean at end of each day.
 - .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11.

3.10 PROTECTION

- .1 Protect adjacent materials from work associated with testing and maintenance of fume hoods.

END OF SECTION

PART 1 - GENERAL

1.1 MINIMUM STANDARDS

- .1 Conform to or exceed Provincial Codes, Local Municipal By-Laws, all codes of utility authorities having jurisdiction.

1.2 REFERENCES

- .1 ASTM International (ASTM)
 - .1 ASTM B209M-14, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - .2 ASTM C547-19, Standard Specification for Mineral Fiber Pipe Insulation.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 51.53-95, Poly (Vinyl Chloride) Jacketing Sheet, for Insulated Pipes, Vessels and Round Ducts.
- .3 Thermal Insulation Association of Canada (TIAC)
 - .1 Mechanical Insulation Best Practices Guide.
- .4 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S702.1-14(R2019), Standard for Mineral Fibre Thermal Insulation for Buildings, Part 1: Material Specification.
 - .2 CAN/ULC-S702.2-15, Standard for Mineral Fiber Thermal Insulation for Buildings, Part 2: Installation.

1.3 PRODUCT DATA SHEETS

- .1 Submit product data sheets and installation instructions in accordance with Section 01 33 00 and 01 78 00.

PART 2 - PRODUCTS

2.1 THERMAL INSULATION AND JACKETING

- .1 Insulation Materials to ASTM C547 and CAN/ULC-S702.1, and in accordance with TIAC - Mechanical Insulation Best Practices Guide.
- .2 Insulate heating and cooling piping with 25 mm thick rigid mineral fibre sleeving and factory applied all service jacket.
- .3 Fastenings: use self-adhesive tape rated <25 for flame spread, and <50 for smoke development.
- .4 Provide canvas cover over insulated piping in exposed areas. Canvas cover to be compact, firm, ULC listed heavy plain weave, cotton fabric at 220 g/m². Provide two coats of diluted fire retardant lagging adhesive over canvas covering.
- .5 Provide polyvinyl chloride (PVC) cover over insulated piping in exposed areas:
 - .1 One-piece moulded type and sheet to CAN/CGSB-51.53 with pre-formed shapes as required.
 - .2 Colors to match adjacent finish paint
 - .3 Minimum service temperatures: -20°C.

- .4 Maximum service temperature: 65°C.
- .5 Moisture vapour transmission: 0.02 perm.
- .6 Fastenings:
 - .1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - .2 Tacks.
 - .3 Pressure sensitive vinyl tape of matching colour.
- .6 Provide aluminum cover over insulated piping in exposed areas:
 - .1 To ASTM B209M.
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: smooth.
 - .4 Joining: longitudinal and circumferential slip joints with fifty 50 mm laps.
 - .5 Fittings: One half 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
 - .6 Metal jacket banding and mechanical seals: stainless steel, nineteen 19 mm wide, one half 0.5 mm thick at three hundred 300 mm spacing.
- .7 Provide weatherproofing for all outdoor pipe insulation. Apply two 3 mm thick coats of asphalt or vinyl mastic with glass reinforcing fibre between coats, lapping joints a minimum of 305 mm.
- .8 Make good all existing insulation where previously damaged by others or damaged by work under this Contract.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install work generally in accordance with TIAC Mechanical Insulation Best Practices Guide, and CAN/ULC-S702.2, with exceptions to conform to manufacturer instructions and recommendations, and requirements specified in this Section.

END OF SECTION

PART 1 - GENERAL

1.1 MINIMUM STANDARDS

- .1 Conform to or exceed:
 - .1 CSA Standards.
 - .2 ASHRAE Standards.
 - .3 SMACNA Standards.
 - .4 Provincial Codes, Local Municipal By-Laws, all codes of utility authorities having jurisdiction.

1.2 REFERENCES

- .1 American National Standards Institute (ANSI)/American Society of Safety Professionals (ASSP)
 - .1 ANSI/ASSP Z9.5-2012, Laboratory Ventilation.
- .2 Sheet Metal & Air Conditioning Contractors' National Association (SMACNA)
 - .1 ANSI/SMACNA 006-2006, HVAC Duct Construction Standards, Metal and Flexible.
 - .2 ANSI/SMACNA 016-2012, HVAC Air Duct Leakage Test Manual.
 - .3 ASHRAE/SMACNA 126-2020, Method of Testing HVAC Air Ducts (ANSI/SMACNA Approved).
- .3 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 130-2016, Laboratory Methods of Testing Air Terminal Units (ANSI Approved).
- .4 ASTM International (ASTM)
 - .1 ASTM A653/A653M-2020, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanealed) by the Hot-Dip Process.
 - .2 ASTM B209M-14, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - .3 ASTM C612-14(2019), Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .4 ASTM E119-20, Standard Test Methods for Fire Tests of Building Construction and Materials.
 - .5 ASTM F38-18, Standard Test Methods for Creep Relaxation of a Gasket Material.
- .5 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 51-GP-52Ma-89, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .6 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-2018-REV1, Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S110-13(R2018), Standard Methods of Test for Air Ducts.
 - .3 CAN/ULC-S112-2010(R2016), Standard Method of Fire Test of Fire Damper Assemblies.

- .4 CAN/ULC-S702.1-14(R2019), Standard for Mineral Fibre Thermal Insulation for Buildings, Part 1: Material Specification.
- .7 National Fire Protection Association (NFPA)
 - .1 NFPA 90A-2018, Standard for Installation of Air Conditioning and Ventilating Systems.

1.3 SHOP DRAWINGS AND PRODUCT DATA SHEETS

- .1 Submit shop drawings and product data sheets in accordance with Sections 01 33 00, 01 78 00 and 23 05 00 for products of this Section.

PART 2 - PRODUCTS

2.1 LOW PRESSURE DUCTWORK

- .1 Material: forming steel FS Type A steel with Z275 designation zinc coating to ASTM A653/A653M, minimum 30% recycled content.
- .2 Gauge and construction of ducts and fittings shall be in accordance with ANSI/SMACNA 006 for rectangular ducts for positive and negative static pressure up to 500 Pa with leakage rate of 5% maximum.
- .3 Seal classification: to SMACNA seal class C with transverse joints and connections made airtight with sealant.
- .4 Hangers:
 - .1 Ducts up to size 900 mm shall be supported with 25 mm x 1.6 mm thick galvanized strap hangers spaced at not over 3 m centres.
 - .2 Ducts over 900 mm shall be supported with 10 mm steel rods and 50 x 50 x 6 mm angles. Maximum spacing of hangers to be 2.5 m.
 - .3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel deck or use powder actuated fasteners.
- .5 Radius of duct elbow shall be at least equal to the width of the elbow. Use square elbow with double thickness turning vanes when space is limited.
- .6 Provide balancing dampers at all branch ducts and as indicated. Each damper shall be fitted with locking type quadrant operator.
- .7 Duct leakage: in accordance with ANSI/SMACNA 016.
- .8 Applications: supply air ducting downstream of VAV boxes, all exhaust air ducting, and all return air ducting.

2.2 MEDIUM PRESSURE RECTANGULAR DUCTWORK

- .1 Material: lock-forming quality steel with Z275 designation zinc coating to ASTM A653/A653M, minimum 30% recycled content.
- .2 Gauge and construction of ducts and fittings shall be in accordance with ANSI/SMACNA 006 for rectangular duct for a positive static pressure up to 1.5 kPa with leakage rate of 1.5% maximum.
- .3 Seal classification: to SMACNA seal class A with longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant.

- .4 Hangers:
 - .1 Ducts up to size 900 mm shall be supported with 25 mm x 1.6 mm thick galvanized strap hangers spaced at not over 3 m centres.
 - .2 Ducts over 900 mm shall be supported with 10 mm steel rods and 50 x 50 x 6 mm angles. Maximum spacing of hangers to be 2.5 m.
 - .3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel deck or use powder actuated fasteners.
- .5 Radius of duct elbow shall be at least equal to the width of the elbow. Use square elbow with double thickness turning vanes when space is limited.
- .6 Provide opposed blade volume dampers with lockable quadrant operators at all branch ducts and as indicated.
- .7 Provide twenty five 25 mm test plugs with chain and cap, where required and indicated to accommodate testing and balancing instruments.
- .8 Duct Leakage: in accordance with ANSI/SMACNA 016.
- .9 Applications: supply air ducting upstream of VAV boxes.

2.3 MEDIUM PRESSURE RIGID ROUND DUCTS

- .1 Material: lock-forming quality steel with Z275 designation zinc coating to ASTM A653/A653M, minimum 30% recycled content.
- .2 Gauge and construction of ducts and fittings shall be in accordance with ANSI/SMACNA 006 for round ducts for a positive static pressure up to 2.5 kPa with leakage rate of 1.5% maximum.
- .3 Round ducts, fittings and specialties shall be fabricated by one manufacturer. Use conical tees at branch takeoffs. Do not use straight 90° tee.
- .4 Seal classification: spiral wound round ducting up to 900 mm to SMACNA seal class A with transverse joints, duct wall penetrations and connections made airtight with sealant.
- .5 Hangers:
 - .1 Ducts with diameter up through 450 mm shall be supported with 40 x 1.6 mm thick galvanized steel straps and 40 x 1.6 mm thick hanger rings spaced at not over 3 m centres.
 - .2 Ducts with diameter from 475 mm through 900 mm shall be supported with 40 x 3 mm thick galvanized steel straps and 40 x 3 mm thick hanger rings spaced at not over 3 m centres.
 - .3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel deck or use powder actuated fasteners.
- .6 Provide round butterfly dampers with locking quadrants at all branch ducts and as indicated.
- .7 Duct Leakage: in accordance with ANSI/SMACNA 016.
- .8 Applications: all rigid round ducts unless noted otherwise.

2.4 FLEXIBLE DUCTWORK

- .1 Factory fabricated Class 1 air duct to CAN/ULC-S110. Flame spread rating not to exceed 25 and smoke developed rating not to exceed 50.
- .2 Duct must withstand 2.5 kPa internal pressure.
- .3 Material: spiral wound flexible aluminum.
- .4 Support flexible ducts at 1.2 m centres. Do not lay ducts across any lighting fixtures or hot surfaces.
- .5 Maximum length of flexible duct connections: 4 m.
- .6 Make connections between flexible duct and terminal devices airtight with duct tape.

2.5 LABORATORY EXHAUST DUCT

- .1 Laboratory exhaust ductwork (LXD) in accordance with following requirements:
 - .1 Prefabricated flanged duct sections constructed of minimum 1 mm thick (18 gauge) type 316 stainless steel.
 - .2 Duct shall be constructed as shown on the contract documents in round or rectangular configuration.
 - .3 The duct assembly and joints shall be third party tested in accordance with ASHRAE/SMACNA 126 to meet a minimum 2.5 kPa positive pressure or 2.5 kPa negative pressure to achieve Seal Class A.
 - .4 Access doors shall be provided when noted on the contract documents to maintain pressure.
 - .5 Ductwork shall be tested to ensure flanged connections are structurally sound by way of third party testing to support 4 times the load of the duct weight.
 - .6 Gasket material shall be supplied with the LXD system, be chemically inert and resist creep relaxation to 25% when tested in accordance with ASTM F38.
 - .7 Where noted on drawings provide a two-hour fire resistance. To gain the specified fire resistance rating, external insulation ductwork materials are acceptable for use.
 - .8 Two-hour rated, "0" clearance, fire resistive assemblies shall be tested in accordance with ASTM E119 requirements.
 - .9 The fire resistant duct assembly shall not exceed a flame spread rating of 0 when tested to CAN/ULC-S102.
 - .10 The fire resistant duct assembly shall not exceed a smoke development rating of 0 when tested to CAN/ULC-S102.
 - .11 Through-penetration firestopping materials:
 - .12 When the ventilation duct passes through a fire rated floor or wall assembly, the through openings shall be firestopped in accordance with the cUL/ULC listings.

2.6 DUCT SEALANTS AND TAPES

- .1 Sealant: oil resistant, polymer type flame resistant duct sealant. Temperature range of -30°C to +93°C.
- .2 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm wide.

2.7 DUCT ACCESS DOORS

- .1 Provide for access to fire or other dampers and for service or inspection, and for cleanouts where required, panel type access doors, 300 x 300 mm unless otherwise stated, complete with two sash locks.

2.8 BALANCING DAMPERS

- .1 Approved units of thicknesses and type of construction in accordance with ANSI/SMACNA 006.
- .2 Splitter dampers: where indicated with control rod with locking device on exterior of duct. Damper to be single thickness one gauge heavier than duct.
- .3 Single blade butterfly dampers: where indicated with locking quadrant.
 - .1 Round butterfly dampers to be 1.6 mm thick in medium pressure ducts and 0.8 mm in low pressure ducts.
 - .2 Rectangular butterfly dampers to thicknesses indicated in ANSI/SMACNA 006.
- .4 Multi-leaf opposed blade dampers: designed to SMACNA details with locking quadrant.

2.9 LABORATORY AIRFLOW CONTROL VALVE

- .1 Provide low pressure drop laboratory airflow control valves with vortex airflow measurement, high speed electric actuation and integral access panel for all associated devices as shown on drawings. Control valve shall utilize a venturi section into which a single line damper slides to create a smoothly varying, annular orifice. Valve shall be constructed such that the venturi body's shape logarithmically necks down to the orifice area and then logarithmically re-expands to full valve inlet size to ensure a static regain with minimum pressure loss. Valve shall have an Equal Percentage flow characteristic to provide accurate control at low flow values. Venturi valve to be capable of vortex airflow measurement (true airflow measurement). High accuracy Damper Control Valves complying with the required performance and construction will be accepted. VAV boxes are not acceptable.
- .2 Airflow control valves and single blade-type dampers, in order to meet ANSI/ASSP Z9.5 guidelines, to be fabricated with access doors upstream and downstream of the airflow control valve to allow visual inspection of the valve internals.
- .3 Airflow control valves and blade dampers to be provided with pilot-positioners in order to detect linkage or actuator failure. Pilot positioners to be wired to controllers to provide alarms in the event that proper valve position is not obtained.
- .4 Fume Hood Airflow Valve (FHV) type for fume hood exhaust shall be constructed of 304 stainless steel. Both the valve body and the single blade dampers be 304 stainless steel. Shaft and pivot assemblies on which the dampers and spring assemblies must slide freely shall be made of titanium. Valve body material shall be 304 stainless steel; 0.81 mm thick for body and 1.3 mm thick for blades. Valve shaft material shall be 316 stainless steel.

- .5 Single blade type airflow control dampers shall be constructed of 304 stainless steel. Bearings and shafts shall be constructed of 316 stainless steel.
- .6 All airflow control valves to be provided with pressure switches to indicate low pressure in the ductwork. The pressure switch must be provided on both supply and exhaust valves. The pressure switch must be able to operate below 37 pa (0.15" WC) on the supply and makeup air valves without nuisance alarms.
- .7 Airflow control valves shall include airflow sensors to create a closed loop control to insure the venturi valve is controlling to the required airflow volume. Airflow sensors shall meet criteria of this specification.
- .8 Offset Airflow Valve (OSV), Supply Airflow Valve (SAV) and General Exhaust Airflow Valves (GEV) consists of airflow control valve with integrated high performance closed loop feedback controller, vortex airflow sensor and high speed electric actuator. Valve body material shall be galvanized steel; 0.81 mm thick for body and 1.3 mm thick for blades. All bearing surfaces shall be made of a composite Teflon or Teflon Infused (versus coated) aluminum. The valve shaft, pivot arm, shaft support brackets, and internal mounting hardware shall be 316 L stainless steel.
- .9 Fume Hood Exhaust Airflow Valves consists of airflow control valve with vortex airflow sensor and high speed electric actuator. The airflow valve shall be complete with a digital vortex type airflow sensing device providing true airflow feedback for the system.
- .10 Airflow control valves shall be a linear type and shall operate with a minimum turndown ratio of 8 to 1. Accuracy of the airflow valve shall be 5% of reading in the 8 to 1 range of the damper.
- .11 The airflow control valve shall respond within one second of a change in duct static pressure when provided with factory controls.
- .12 The airflow control valve shall be capable of being mounted in any position (360° mounting plane) in ductwork without the need for recalibration. It shall not be required to specify mounting plane when ordering valve.
- .13 Airflow measuring devices shall be of the Vortex Shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume.
- .14 Airflow Control Valve shall have an integral closed-loop feedback controller. Airflow measurement through the vortex airflow sensor shall send the digital signal to the controller which modulates the high speed electric actuator to maintain desired airflow setpoint. The airflow setpoint shall have the capability of being provided through analog input, digital input, and communications over BACnet internal program memory. Analog output signal shall be provided for airflow and alarm outputs must be provided to indicate abnormal airflow conditions.
- .15 The airflow control valve shall not exceed the NC levels shown in equipment schedule and no straight duct run downstream and upstream will be required.

- .16 Airflow control valves shall be of a low pressure drop design for energy efficiency. Valves shall not require greater pressure drop than listed at "Max CFM" on project valve schedule or 70 pa (0.3"), whichever is less.
- .17 In order to ensure the minimum operating pressure meets the specification every valve must be provided with a Minimum Operating Pressure curve as tested in accordance with ASHRAE 130.

2.10 FIRE DAMPERS

- .1 Listed and bear label of ULC, and shall meet requirements of PWGSC/PSPC Fire Protection Engineer, CAN/ULC-S112, and authorities having jurisdiction.
- .2 Factory fabricated for fire rating requirement to maintain integrity of membrane being pierced.
- .3 Fire dampers shall be single-blade, multi-blade or curtain type, sized to maintain full flow cross section as indicated.
- .4 Complete with frame and 40 x 40 x 3 mm steel angle on full perimeter of frame on both sides of barrier being pierced.
- .5 Provide at each fire damper an access door for access to fusible links.
- .6 Follow NFPA 90A and manufacturer's installation instructions including the installation of drywall filler pieces when installed in a gypsum board wall.

2.11 GRILLES, REGISTERS AND DIFFUSERS

- .1 General:
 - .1 Sizes indicated are nominal. Provide correct standard product nearest to nominal.
 - .2 Construction: steel with baked enamel to match existing.
- .2 Supply grilles and registers: double deflection with airfoil shape vertical face and horizontal rear bars, opposed blade dampers with concealed manual operator and gaskets.
- .3 Return and exhaust grilles and registers:
 - .1 For lay-in 'T'-bar ceiling installation: 12 x 12 x 12 mm egg crate with removable key-operated volume damper.
 - .2 For surface-mount installation: single deflection, air foil shape, horizontal bar type with 45° deflection, opposed blade damper with concealed operator and rubber sealing strips.
- .4 Square or circular diffusers:
 - .1 For lay-in 'T'-bar ceiling installation: square type, size and capacity indicated for neck diameter indicated, having adjustable pattern and volume control dampers with flow straightening devices and blank-off quadrants. Diffuser face to be 600 x 600 mm unless otherwise noted.
 - .2 For surface-mount installation: circular or square type to match existing, size and capacity indicated for neck diameter indicated, having adjustable pattern and volume control dampers with flow-straightening devices and blank-off quadrants.

- .3 Square diffusers for multi-zone VAV terminal system at perimeter of the building will be perforated face high capacity modular core directional diffusers. Perforated faceplate will be hinged for easy access to the four louvered air pattern controllers to give adjustable 1, 2, 3, or 4 way air diffusion patterns.
- .4 Diffusers shall be aluminum face and core and shall have custom dimensions to suit the existing ceiling grid. Paint finish and colour shall match existing ceiling grid.

2.12 AUTOMATIC CONTROLS

- .1 For requirements, refer to Section 25 10 10.

2.13 THERMAL INSULATION AND JACKETING

- .1 Insulate all supply air ducting, all outside air ducting, all exhaust air ducting from fan to exhaust louvre, all return air ducting in Mechanical rooms.
- .2 Material:
 - .1 On exposed rectangular ducting: 25 mm thick rigid mineral glass fibre board to ASTM C612 and vapour barrier jacket to CAN/CGSB 51-GP-52Ma.
 - .2 On concealed rectangular ducting: 25 mm thick glass fibre blanket to CAN/ULC-S702.1 and vapour barrier jacket to CAN/CGSB 51-GP-52Ma and vapour barrier jacket to CGSB 51-GP-52Ma.
 - .3 On round ducting: 25 mm thick glass fiber blanket to CAN/ULC-S702.1 and vapour barrier jacket to CAN/CGSB 51-GP-52Ma.
- .3 Fastenings on rectangular ducts:
 - .1 Use 50% coverage of insulation adhesive. Flame spread 15, smoke development 0.
 - .2 If duct is over 635 mm wide, provide weld pins in addition to insulation adhesive. Place weld pins at not more than 200 mm centres, and not less than 2 rows per side.
- .4 Fastenings on round ducts: Use 100% coverage of insulation adhesive of flame spread 15, smoke development 0, and 100 mm wide self-adhesive tape rated under 25 for flame spread and under 50 for smoke development.
- .5 Vapour barriers: Use quick-setting adhesive for joints and lap sealing of vapour barriers. Flame spread 10, smoke development 0.
- .6 Vapour barriers and insulation to be complete over the full length of duct or surface, without penetration for hangers, standing duct seams and without interruption at sleeves.
- .7 Provide canvas cover over all insulated ducts in exposed areas. Canvas cover to be compact, firm, ULC listed heavy plain weave, cotton fabric at 272 g/m². Provide two coats of diluted fire retardant lagging adhesive over canvas covering.
- .8 Provide weatherproofing for all outdoor duct insulation. Apply two 3 mm thick coats of asphalt or vinyl mastic to external type duct insulation, with a glass reinforcing fibre between coats lapping

joints a minimum of 305 mm. Secure 10 mm thick plywood over all horizontal ducts exposed to weather, and cover plywood with sheet metal. Turn over all edges.

- .9 Provide weatherproofing for all outdoor duct insulation. Aluminum:
 - .1 To ASTM B209M with moisture barrier.
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: Smooth.
 - .4 Jacket banding and mechanical seals: 19 mm wide, 0.5 mm thick stainless steel.
 - .1 Stainless steel, type: 304.

PART 3 - EXECUTION

3.1 EXISTING AND REUSED CONTROLS

- .1 Recalibrate and test existing and reused control devices shown on the drawings.
- .2 Report any inoperative control device to Departmental Representative immediately and obtain Departmental Representative's instructions.

3.2 INSTALLATION

- .1 Install material and equipment in accordance with referenced standards and manufacturer's written instructions.
- .2 Make good all existing insulation where previously damaged by others or damaged by work under this contract.

END OF SECTION

PART 1 - GENERAL

1.1 GENERAL

- .1 The "provide" in this Division shall be interpreted as "supply, install, and connect".
- .2 Energy Monitoring and Control System (BAS) shall include Direct Digital Control (DDC) of mechanical systems as specified for this project.
- .3 Building Automation System (BAS) shall include the BAS as specified for this project.

1.2 DESCRIPTION OF SYSTEM

- .1 Extend the existing Networked DDC Control System to meet the requirements specified for this project. The new and extended DDC products and services shall be fully compatible with the existing TAC (Andover) Controls system. The extended Control System shall consist of but is not limited to the following:
 - .1 Laboratory Airflow Control System (LAFCS) as specified;
 - .2 Software required to implement a complete and operational system.
 - .3 Input and output control devices including sensors, actuators, conduit and wiring, as required to provide the operations specified.

1.3 QUALITY ASSURANCE

- .1 The System Manufacturer shall match base building Building Automation System (BAS).
- .2 The System Manufacturer must have maintained a local office within 400 kilometers of job site for at least 5 years with technical staff to provide technical information, routine and emergency maintenance on the system and all system components, and to provide training instructions to O&M staff.
- .3 The System Manufacturer must have proven record of successful experience on projects of similar type and size.
- .4 Submit the following information for review by Departmental Representative:
 - .1 Location of local office.
 - .2 Names and phone numbers of technical staff.
 - .3 Specification sheets for Master Control Units, Local Control Units and Terminal Control Units.
 - .4 Data communication network performance information including network protocols to be used, data rate, maximum number of nodes per Local Area Network (LAN).

1.4 CO-ORDINATION

- .1 Co-ordinate work with Mechanical and Electrical Trades. Unless noted otherwise, provide all interface devices, control wiring, and controls as required to provide the control operation specified.

- .2 Unless noted in Division 26, provide line voltage and low voltage control wiring for equipment specified in Division 25. Refer to Division 26 for power wiring, starters, disconnect switches, etc., to be provided for mechanical equipment.
- .3 Provide all necessary power and dedicated circuits as required from local 120 volt branch circuits panel board for all Master Control Units. Install tamper locks on breakers of circuit panel.
- .4 Unless noted otherwise, provide all other installation work required for the complete installation of BAS, including all interface devices, control and power wiring, controls and controlled devices.

1.5 LOCKABLE PANELS

- .1 Provide lockable panels with key lock handle operators and hinged doors.
- .2 Panels located in climate controlled environments to be NEMA 2 or 12 rating. Panels located in non-climate controlled environments to be NEMA 3R or 4 rating. Panels exposed to corrosive environments to be NEMA 4X rating.
- .3 Equip all panels for Master Control Units with standard keyed-alike cabinet locks, keyed to same key.

1.6 NAMEPLATES

- .1 Provide nameplates on all control items listed or shown in the submittal and approved control diagrams.
- .2 Identify all panels and items mounted on panel face by laminated plastic nameplates 3 mm thick. Lettering shall be accurately aligned and engraved into the white core. Size of nameplates shall be 20 mm by 100 mm minimum. Lettering shall be minimum 5 mm high normal black lettering.
- .3 Identify field sensors and controlled devices by plastic encased cards attached to the device by chain.
- .4 Warning signage: provide each motor starter under remote automatic control (DO point on I/O Point Schedules) with signage warning of automatic starting under control of BAS. (i.e. "Caution - this equipment is under automatic remote control of BAS").

1.7 SHOP DRAWINGS

- .1 Submit shop drawings and product data in accordance with Section 23 05 00. Submit control shop drawings within 15 days of Award of Contract.
- .2 Shop drawings shall include:
 - .1 Description of software programs included.
 - .2 Specification sheets for each piece of equipment or control devices to be provided.
 - .3 Equipment and DDC Controllers location drawings.
 - .4 Mechanical control schematics.
 - .5 Sequence of operation for each mechanical system.
 - .6 DDC control point schedules.

1.8 INSTALLATION AND COMPLETION TESTS

- .1 Installation and Calibration:
 - .1 Set control points and calibrate sensors immediately after installing controls.
- .2 Completion Tests:
 - .1 After installation of each part of the system and completion of mechanical and electrical hood-up, perform tests to confirm correct installation and operation of equipment.
 - .2 Check and calibrate each AI using a calibrated digital thermometer, humidistat, velometer or transducer.
 - .3 Check each DI to insure proper settings and switching contacts.
 - .4 Check each AO to insure proper operation of valves and dampers. Verify tight closing, input and output signals.
 - .5 Check each DO to insure proper operation and lag time.
 - .6 Check all operating software.
 - .7 Check all application software. Provide samples of all logs and commands.
 - .8 Debug all software.
 - .9 Fine tuning and adjusting all control devices and make modifications as required to provide a fully operational BAS.
 - .10 Submit test report with checklist showing all input/output control points and all software programs.
- .3 All reported results are subject to verification by the Departmental Representative.

1.9 SYSTEM STARTUP VERIFICATION TESTING

- .1 Provide technical personnel and instrumentation to conduct startup verification and testing.
- .2 Verification:
 - .1 Perform point-by-point verification of entire system.
 - .2 Verify the calibration of all AI devices individually.
 - .3 Verify the calibration of all DI devices individually.
 - .4 Verify all AO devices are functional, start and span are correct, direction and normal positions are correct.
 - .5 Verify that all DO devices operate properly and that the normal positions are correct.
 - .6 Verify the system sequences of operation. Simulate all modes of operation.
 - .7 Verify the stability of all DDC loops and optimum start/stop routines.
 - .8 Check each alarm separately.
 - .9 Verify interlocks and conditional control response.
 - .10 Simulate alarm conditions to check the initiating value of variable and interlock action.
- .3 Complete and submit System Startup Verification Forms. Each item on the verification forms shall be signed off as verified (yes), or not

verified (no) and actual date of verification. Forms to be signed by testing technician.

1.10 OPERATION AND MAINTENANCE MANUAL

- .1 The manual shall be custom designed for this project and contain only information relevant to this project.
- .2 The manual shall provide full and complete coverage of the following subjects:
 - .1 Operational Requirements: This document shall describe, in concise English terms, all the functional and operational requirements for the system and its functions that have been implemented.
 - .2 System Operation: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm, and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.
 - .3 Maintenance: Documentation of all maintenance procedures for each and all system component including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module.
 - .4 Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as Test Procedures. A provision for the measurement or observation of results, based on the previously published Test Specification, forms the Test Reports.
 - .5 Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system.

1.11 TRAINING

- .1 Provide the services of competent instructors who will provide instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach.

1.12 WARRANTY AND MAINTENANCE

- .1 Provide all services; materials and equipment necessary for the maintenance of the Automatic Control Systems for a period of 12 months concurrent with the warranty period.
- .2 Provide three minor inspections or as required by the manufacturer and one major inspection per year, and all service for the required maintenance. Major inspection shall be scheduled in April or November. A major inspection shall involve a point by point check and/or calibration. Provide dated database log to indicate executed point to point system check.

- .3 Emergency Service: Departmental Representative will initiate service calls when there is indication that the Automatic Control System is not functioning properly. Provide qualified personnel available during the contract period to provide service to the "critical" overall control system components whenever required at no additional cost Contract. Furnish the Departmental Representative with a telephone number where the service personnel can be reached at all times. The service technician shall be on the job ready to service the control system within 4 hours after receiving a request for service. The work shall be performed continuously until the control system is back in reliable operating condition. This service shall be provided on a 24 hours basis 7 days a week.
- .4 Upon completion of each inspection or emergency service, submit fully detailed report in writing to Departmental Representative.

PART 2 - PRODUCTS

2.1 BAS DATA COMMUNICATION NETWORK

- .1 The Control Manufacturer shall design, supply, install and connect a data communication network to link all Terminal Control Units, Local Control Units, Master Control Units, and Operator Workstation.
- .2 Local (field) Control Units (LCUs): Stand-alone such as: LAFCS, LCM and HPFC fully user programmable DDC Controllers that reside on BAS-BUS.

2.2 OWS SOFTWARE

- .1 Provide to existing OWS, the software programs recommended by system manufacturer to update existing software, to permit command entry, information management, alarm management and database management functions for the new laboratory airflow control system, Laboratory Air Contaminant Concentration System and High Plume Exhaust Fan System.
- .2 Workstation operating system shall be multitasking and Windows 10 based.
- .3 Workstation software shall include but not be limited to the following functions:
 - .1 Operator's commands and programming.
 - .2 Access control.
 - .3 Graphics software.
 - .4 Alarm management.
 - .5 Reports and logs.
 - .6 Database back-up and download.
- .4 Refer to the specification for additional requirements of each function.

2.3 OPERATOR'S COMMANDS AND PROGRAMMING

- .1 Provide software to enable non-programmer operator to perform global supervision tasks such as to view, and edit if applicable, the status of any object and property in the system.

- .2 Operator shall be able to terminate automatic software control, initiate DO and AO manual commands, and return DO and AO manual commands to automatic software controls.
- .3 Provide programming software at OWS to allow operator to create, edit, and download custom application programs to support MCUs and LCUs. On-line programming/configuration shall not interfere with normal system operation and control.

2.4 ACCESS CONTROL

- .1 A minimum of 4 levels of access shall be supported:
 - .1 Level 0 No Password = Data Access and Display.
 - .2 Level 1 = Operator Overrides.
 - .3 Level 2 = Level 1 + Database Modification and Generation.
 - .4 Level 3 = Level 3 + Password Assignment: Addition / Modification.
- .2 User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line. Default setting shall be 3 minutes.

2.5 GRAPHICS SOFTWARE

- .1 Provide OWS with upgraded graphics software necessary to permit the operator to create, modify, delete, file, and recall all graphics. Operators shall be able to start and stop equipment or change set points from graphical displays.
- .2 Utilize the graphics software to generate the custom Building Outline Drawings, Equipment and Sensors Location Diagrams, and Control Schematic Diagrams for this project.
- .3 Operator shall be able to build graphic displays that include on-line point data from multiple MCU panels. Data shall be updated every 10 seconds or less.
- .4 Windowing: the windowing environment of the OWS shall allow the user to simultaneously view several graphics at the same time.

2.6 ALARM MANAGEMENT

- .1 Provide the software to notify the operator of the occurrence of an alarm condition. All alarm messages shall be displayed and printed. Alarm messages shall include as a minimum: location of alarm, time of occurrence, and type of alarm. Each point shall have its own message. Assignment of messages to a point shall be an operator editable function.

2.7 LAB CONTROL SYSTEM SPECIFICATION

- .1 Refer to Section 25 50 00.

2.8 TEMPERATURE SENSORS AND TRANSMITTERS

- .1 General: temperature sensors shall be RTD platinum type, unless otherwise noted.
- .2 Temperature sensors shall be of the following types:
 - .1 Space RTD - suitable for wall mounting, with protective guard.

- .2 Duct point RTD - suitable for insertion into air ducts at any angle, insertion length of 460 mm unless otherwise as noted on schedule or drawings.
- .3 Mixed Air Averaging RTD: continuous filament with probe length of 6000 mm minimum. Maximum 6 mm cross section area per sensor. Probe to be bent, at field installation time, to a minimum radius of 100 mm at any point along the probe length without degradation in performance.
- .3 Provide each sensor with a temperature transmitter having the following minimum specifications:
 - .1 Output signal of 4-20 mA into maximum of 500 ohm load.
 - .2 Combined nonlinearity, repeatability and hysteresis effects not to exceed $\pm 0.5\%$ of full scale output.
 - .3 Integral, zero and span adjustments.
 - .4 Temperature effect of $\pm 1.0\%$ full scale or less.
- .4 Range of sensors to suit application and to be submitted with shop drawings.

2.9 HUMIDITY SENSORS AND TRANSMITTERS

- .1 Provide humidity sensors with the following minimum specifications:
 - .1 Operating range: 10-90% RH.
 - .2 Operating temperature: 0°C to 60°C.
 - .3 Accuracy: $\pm 2\%$ RH at 25°C.
 - .4 Response time: 60 seconds from 90% to 10% RH.
- .2 Provide transmitters for all supplied relative humidity sensors with the following minimum specifications:
 - .1 Output signal of 4-20 mA or 0 to 10 VDC.
 - .2 Maximum output linearity error of $\pm 1.0\%$ of full scale output.
 - .3 Integral zero and span adjustments.
 - .4 Temperature effect of $\pm 1.0\%$ full scale or less.
 - .5 Drift: not to exceed 1% over 12 months.

2.10 AIR SYSTEM STATIC PRESSURE SENSORS AND TRANSMITTERS

- .1 Sensors shall meet the following:
 - .1 Multipoint element with self-averaging manifold.
 - .2 Maximum pressure loss: 160 Pa at 10 m/s. (air stream manifold).
 - .3 Accuracy: $\pm 1\%$ of actual duct static pressure.
- .2 Provide each sensor with a transmitter to meet the following requirements:
 - .1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.
 - .2 Calibrated span: not to exceed 150% of duct static pressure at maximum flow.
 - .3 Accuracy: $\pm 1.0\%$ of full scale.
 - .4 Repeatability: within 0.5% of output.
 - .5 Linearity: within 1.5% of span.
 - .6 Deadband or hysteresis: 0.1% of span.

- .7 External exposed zero and span adjustment.
- .8 Range: 0 to 125 Pa static pressure downstream of VAV boxes and 0 to 373 Pa static pressure upstream of VAV boxes, unless otherwise noted.

2.11 AIR SYSTEM VELOCITY SENSOR/TRANSMITTER

- .1 Sensors shall meet the following requirements:
 - .1 Multipoint static and total pressure sensing element with self-averaging manifold, and with integral air equalizer and straightener section.
 - .2 Maximum pressure loss: 37 Pa at 10 m/s.
 - .3 Accuracy: +1% of actual duct velocity.
- .2 Provide each sensor with a transmitter to meet the following requirements:
 - .1 Output signal: 4 - 20 mA or 0 - 10VDC linear into 500 ohm maximum load.
 - .2 Calibrated span: not to exceed 25% of duct static pressure at maximum flow.
 - .3 Accuracy: $\pm 0.4\%$ of span.
 - .4 Repeatability: within 0.1% of output.
 - .5 Linearity: within 0.5% of span.
 - .6 Deadband or hysteresis: 0.1% of span.
 - .7 External exposed zero and span adjustment.
 - .8 Air velocity range: 1 m/s to 10 m/s at 15°C.

2.12 PRESSURE/CURRENT TRANSMITTERS

- .1 Provide pressure-to-current transmitters having the following minimum specifications:
 - .1 Internal materials of the transducer suitable for continuous contact with industrial standard instrument air, compressed air, water or steam as applicable.
 - .2 Output signal of 4-20 mA into a maximum of 500 ohm load.
 - .3 Output variations of less than 0.2% full scale for supply voltage variations of $\pm 10\%$.
 - .4 Combined nonlinearity, repeatability and hysteresis effects not to exceed $\pm 0.5\%$ of full scale output over entire range.
 - .5 Integral zero and span adjustment.
 - .6 Temperature effect of $\pm 1.5\%$ full scale/50°C or less.
 - .7 Output short circuit and open circuit protection.
 - .8 Over-pressure input protection to a minimum of twice rated input.
 - .9 Pressure ranges to suit application.

2.13 DIFFERENTIAL PRESSURE TRANSMITTERS

- .1 Provide differential pressure transmitters having the following minimum specifications:
 - .1 Internal materials to be suitable for continuous contact with the process material measured including compressed air, water, glycol, or steam as applicable.
 - .2 Output signal of 4-20 mA into maximum of 500 ohm load.
 - .3 Output variation of less than 0.2% full scale for supply voltage variations of $\pm 10\%$.
 - .4 Combined nonlinearity repeatability and hysteresis effects not to exceed $\pm 0.5\%$ of full scale output over entire range.
 - .5 External exposed integral zero and span adjustment.
 - .6 Temperature effect of $\pm 1.5\%$ full scale/ 50°C or less.
 - .7 Output short circuit and open circuit protection.
 - .8 Over-pressure input protection to a minimum of twice rated input.
 - .9 Differential Pressure ranges to suit application.

2.14 PRESSURE SWITCHES

- .1 Provide pressure or differential pressure switches for ranges as indicated on point schedule.
- .2 Pressure sensing elements shall be bourdon tube, bellows or diaphragm type.
- .3 Adjustable setpoint and differential.
- .4 Pressure switches shall be snap action type rated at 120 volts, 15 amps AC or 24 volts DC.
- .5 Sensor assembly shall operate automatically and reset automatically when condition returns to normal.

2.15 TEMPERATURE SWITCHES

- .1 Provide High/Low temperature switches for ranges as indicated on point schedule.
- .2 Temperature sensing element shall be liquid, vapour or bimetallic type.
- .3 Adjustable setpoint and differential.
- .4 Snap action type rated at 120 Volts, 15 amps or 24 V DC as required.
- .5 Sensors shall operate automatically and reset automatically. Sensors used for freeze detection or fire detection shall be manually reset type.
- .6 Temperature switches shall be of the following types:
 - .1 General Purpose Duct type - suitable for insertion into air ducts, insertion length of 457 mm.
 - .2 Thermowell type - with compression fitting for 20 mm NPT well mounting, length of 100 mm. Immersion wells shall be stainless steel.

- .3 Freeze detection type - continuous element with insertion length of 6000 mm minimum, suitable for duct mounting to detect the coldest temperature in any 30 mm section.
- .7 Temperature accuracy shall be $\pm 1^{\circ}\text{C}$.

2.16 CURRENT/PNEUMATIC TRANSDUCERS

- .1 Provide current to pneumatic transducers having the following minimum specifications:
 - .1 Input range of 4-20 mA or 0 to 10 VDC as suitable for interfacing with the FID digital-to-analog converter output subsystem.
 - .2 Directly proportioned output range of 20-104 kPa.
 - .3 Dustproof housing or panel mounted.
 - .4 Internal materials of the converter suitable for continuous contact with industrial standard instrument air.
 - .5 Combined nonlinearity, repeatability and hysteresis effects not to exceed +2% of full scale over the entire range.
 - .6 Integral zero and span adjustment.
 - .7 Temperature effect of +2.0% full scale or less.
 - .8 Maximum regulated supply pressure of 138 kPa or less.
 - .9 Provide air gauge on outlet.
 - .10 Air consumption: 0.008 scfm at 103 KPa supply.

2.17 CONTROL RELAYS

- .1 Contacts rated at 5 amps at 120 V AC.
- .2 Relays to be plug in type with termination base.

2.18 CURRENT TRANSDUCER

- .1 Provide current transducers with range to match load being metered.
- .2 Current transducers shall measure line current and produce a proportional signal in one of the following ranges.
 - .1 4-20 mA dc.
 - .2 0-1 V dc.
 - .3 0-10 V dc.
 - .4 0-20 V dc.

2.19 CURRENT SENSING RELAY

- .1 Provide adjustable current-operated solid-state relays with integral zero leakage LED for switching AC or DC circuits.
- .2 The contacts shall close when the current level sensed by the internal current transformer exceeds the trip point set by the multi-turn adjustment.
- .3 Range of monitored AC current to suit application and to be submitted with shop drawings.

2.20 CONTROL DAMPERS

- .1 Construction: Blades shall not exceed 200 mm wide or 1250 mm long. Modular maximum size 1250 mm wide x 1500 mm high. Multiple sections to have stiffening mullions and jack shafts.
- .2 Materials:
 - .1 Frame: 2.3 mm (13 gauge) galvanized sheet steel.
 - .2 Blades: two sheets 0.5 mm (22 gauge) or 1.6 mm (16 gauge) galvanized steel.
 - .3 Bearings: oil impregnated sintered bronze. Provide additional thrust bearings for vertical blades.
 - .4 Linkage and shafts: zinc plated steel.
 - .5 Seals: Replaceable neoprene seals or stain-less steel spring on sides, top and bottom of frame and along all blade edges and blade ends.
- .3 Performance:
 - .1 50 L/s/m² maximum allowable leakage against 1000 Pa static pressure.
 - .2 Temperature range: minus 50°C to 100°C.

2.21 DAMPER OPERATORS ELECTRONIC

- .1 Provide direct coupled type electronic proportional damper operators where indicted or required.
- .2 Spring return for "fail-safe" in Normally Open or Normally Closed position where required.
- .3 Size operators to control dampers against maximum pressure or dynamic closing pressure whichever is greater.
- .4 For modulating services, provide feedback circuit to indicate actuator position.
- .5 Power Requirements 12 VA maximum at 24 V AC.
- .6 Input signal: 2 to 10 VDC or 4 to 20 mA.

2.22 EXISTING CONTROLS

- .1 Unless noted otherwise or approved by the Departmental Representative in writing, provide all new control devices required for a complete and working BAS System.
- .2 Submit written requests to disconnect any controls and to obtain equipment down time. Only after receiving these requests shall such work be allowed to proceed.
- .3 Be responsible for repair costs due negligence or abuse of existing equipment, or failure in reporting defective controls within 30 days of Award of Contract.
- .4 Shop drawings shall show all signal levels, pressures, etc., where tying into existing control equipment.
- .5 Where existing controls are not to be reused or not required, they shall be removed and placed in storage for future disposition as directed by Departmental Representative.

2.23 CONDUIT AND WIRE

- .1 Use type FT6 plenum rated cable for low voltage BAS wiring in ceiling return plenum. Support FT6 cables in ceiling return plenum using cable straps and clamps screwed on to ceiling slab. Spacing to be 2 m maximum. Do not use ceiling suspension wires for fastening cables. Exact routings shall suit site conditions and shall be to the approval of the Departmental Representative.
- .2 Use EMT conduit for wiring in mechanical, electrical, janitor rooms or equipment rooms.
- .3 Unless noted otherwise, install network cable within building in EMT conduit and install network cable between buildings in buried PVC conduit. Provide conduits with spare capacity not less than 50%.
- .4 Field wiring for each digital input and output shall be No. 20 AWG, stranded twisted pair. For multi-conductor wire having four or more conductors, wire size shall be not less than No. 22 AWG solid copper. Analog input shall be wired with shielded No. 20 AWG, stranded twisted pair, copper wire. Analog output shall be wired with 3 shielded No. 20 AWG stranded twisted copper wires.
- .5 Where conduits pass through fire rated walls or floors, provide schedule 40 steel sleeves filled with fire stopping material and approved sealant around conduits to maintain fire rating integrity.

2.24 RESPONSIBILITY FOR QUANTITIES

- .1 Provide correct lengths or sizes of conduit or correct types of wire or the correct number of DDC panels. No additional charges for these materials is acceptable.

2.25 WIRING IDENTIFICATION

- .1 Provide numbered tape markings on all branch control wiring, and pneumatic tubing.
- .2 At all junction boxes, splitters, cabinets and outlet boxes, maintain identification system.
- .3 Use colour coded wires in communication cables, matched throughout system.
- .4 Identify all power sources at each panel location.

2.26 CONDUIT IDENTIFICATION

- .1 Colour code all Control System conduits.
- .2 Coding to be located on all conduits and cables exposed after completion of construction in all locations including suspended accessible ceilings, tunnels and shafts.
- .3 Coding to be plastic tape or paint at all points where conduit or cable enters wall, ceiling, or floor, and at 15000 mm intervals.
- .4 Coding to be 25 mm wide, and fluorescent orange. Confirm colour with the Departmental Representative at commencement of the project.

2.27 MANUFACTURER'S AND CSA LABELS

- .1 Manufacturers' nameplates and CSA labels to be visible and legible after equipment is installed.

PART 3 - EXECUTION

3.1 GENERAL

- .1 All equipment shall be installed in according to manufacturers' published instructions.
- .2 Provide programming for the system and adhere to the sequence of operation specified.
- .3 Coordinate with work of Division 26 to provide required power feeds to BAS devices.

3.2 BUILDING AUTOMATION SYSTEM (BAS) NETWORK ARCHITECTURE

- .1 Building Automation System (BAS) Network Architecture as shown on the Mechanical Drawings.

3.3 DDC INPUT/OUTPUT POINT SCHEDULE

- .1 DDC Input/Output Point Schedule, as shown on the Mechanical Drawings.
- .2 Naming convention: PWGSC Standardized Identifiers and Expansions of Building Names, System Names and Point Names shall be used for identification. Identifiers shall be not more than 10 alphanumeric characters, and Expansions shall not more than 40 characters.
- .3 The Application Programs shall be assigned with the specified DDC points as indicated on the DDC Input/Output Schedule. In addition, the Application Program shall be assigned with the following point types:
 - .1 Alarm Program with: all space temperature AI points, all supply air temperature AI points, all supply air and return air humidity AI points, all air filter pressure drop AI points, all supply air static pressure AI points, all AI points of heating water supply and return temperature, all AI points of chilled water supply and return temperature, all DI points of fans and pumps.
 - .2 Auto Start/Stop Program with: all DO points of fans and pumps.
 - .3 Run Time Total Program with: all DO points.
 - .4 Heavy Equipment Delay Program with: all DO points of motors of 15 kw and larger.
 - .5 PID Control Program with: all AO points of control valves (except terminal heating control valves and radiation control valves) and control dampers (except terminal zone control dampers).
 - .6 Analog/PI Total Program with all AI or PI points of water meters and energy meters.
- .4 All DI or DO points assigned with "alarm" and "run time total" programs shall be provided with "critical" and "maintenance" alarms. All AI or AO points assigned with "alarm" program shall be provided with "critical" and "cautionary" alarms.

3.4 INSTALLATION OF SENSORS

- .1 Install sensors in accordance with the manufacturer's recommendations.
- .2 Sensors used in mixing plenums shall be the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- .3 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m of cross section area.
- .4 All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.
- .5 Outdoor air temperature sensors shall be installed on north wall, complete with sun shield at designated location.
- .6 Building static pressure sensors: Pipe the low pressure port of the differential air static pressure sensor to the static pressure port located on the outside of the building through a high volume accumulator. Pipe the high pressure port to a location behind a thermostat cover.
- .7 Supply duct static pressure sensor: Pipe the high pressure tap of the differential air static pressure sensor to the duct using a pitot tube. Pipe the low pressure port to a tee in the high pressure tap tubing of the corresponding building static pressure sensor.

3.5 INSTALLATION OF ACTUATORS

- .1 Install actuators in accordance with the manufacturer's recommendations.
- .2 Electronic dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low leakage dampers with seals, the actuator shall be mounted with a minimum 5 degree available for tightening the damper seals.
- .3 Electronic Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

END OF SECTION

PART 1 - GENERAL

1.1 REFERENCE STANDARD

- .1 American National Standards Institute (ANSI)/American Society of Safety Professionals (ASSP)
 - .1 ANSI/ASSP Z9.5-2012, Laboratory Ventilation.

1.2 GENERAL

- .1 Conform to Section 23 05 93 with the following additions:
 - .1 Provide all materials, products, equipment and services for the specified integrated laboratory air flow and control systems.
 - .2 Integrated laboratory room air control system shall respond to full scale air flow change commands within less than 1 second.
 - .3 Integrated Laboratory Air Control System shall include sash position sensors, fume hood monitors, laboratory control panels, make-up air laboratory airflow control valves, supply air laboratory airflow control valves, exhaust air laboratory airflow control valves plus on-site start-up and commissioning to result in a completely operational system.
 - .4 All control components except for pneumatic actuators shall be strictly electronic.
 - .5 All local (field) control panels inside the building shall be NEMA 1, wall mounted enamelled steel barriered enclosures sized to suit the application with 20% spare capacity, sub-panel, numbered terminal strips, hinged door and latch.

1.3 CALIBRATION OF LABORATORY AIRFLOW CONTROL VALVES

- .1 Each laboratory airflow control valves shall be factory calibrated to the job specific air flows as indicated on the drawings. Valve shall be electronically calibrated/characterized at the factory by certified NIST traceable air stations. The valve's characterization shall be determined at eight unique air flows including a test of the valve's pressure independence at three different static pressures. Air flow checks shall be performed and recorded for each air valve.
- .2 Field adjustments shall not be required other than minor changes as required by testing adjusting and balancing work. Accuracy and performance shall be guaranteed as specified regardless of field conditions such as duct entry and exit configurations.
- .3 Each valve shall be individually marked with valve specific factory calibration data. As a minimum, it should include valve tag number, serial number, model number, eight point valve characterization information, and quality control inspection numbers. All information shall be stored on computer CD in ASCII format for future retrieval and for hard copy printout to be included with as-built documentation.

1.4 FUNCTIONAL PERFORMANCE TESTS

- .1 Use qualified personnel directed by the Departmental Representative to conduct functional performance tests of Laboratory Air Control Systems. The test shall verify system operation including, but not

limited to, hood exhaust volume tracking, temperature control, room supply/exhaust differential, speed of response, accuracy, pressure independence and stability. Tests shall be performed with supply and exhaust valve pressure drops varying from 150 to 750 Pa.

- .2 If the results of the system testing show any deviation from the minimum specified performance and operating characteristics, tests shall be repeated after corrective measures are carried out, and this process shall continue until acceptable performance is achieved.

PART 2 - MATERIALS

2.1 SASH POSITION SENSOR (SPS)

- .1 SPS shall consist of a precision 10 turn spring return potentiometer mechanically coupled to a constant tension spring reel. A stainless steel, vinyl coated cable shall be attached to the spring reel. It shall measure the height of a vertically moving fume hood sash.
- .2 SPS shall be type-tested for 200,000 full height sash movements without failure in order to be used in these critical applications.
- .3 All SPS's shall not have their output signal influenced by heat sources such as hot plates, Bunsen burners or combustion resting in the hood, or by cold sources such as dry ice either inside or outside the hood. All SPS's shall be installed and wired by the fume hood manufacturer to provide an accurate signal proportional to fume hood sash opening without binding or other operational difficulties.

2.2 FUME HOOD MONITOR (FHM)

- .1 FHM shall receive the sash opening signals from the SPS, compute the total open sash area and compare this to the calibrated, adjustable changeover setpoint.
- .2 FHM control system shall consist of a sash position sensor, a fume hood airflow valve (FHAV), an air flow controller, and alarm annunciator and include an occupancy space detector (OSD). The OSD shall reduce the face velocity to a nominal 0.3 m/s when no presence is sensed in front of the hood.
- .3 Adjustable changeover setpoint shall initiate a change from high to low flow (and vice versa) through a variable speed exhaust fan to achieve the desired variable face velocity profile.
- .4 FHM shall respond to maintain the desired flow state as dictated by the sash changeover setpoint. System shall achieve either calibrated flow volume to within 10% in less than one second with less than 5% overshoot or undershoot regardless of the turndown range of the system.
- .5 Sash changeover setpoint shall be adjustable at the FHM via trimpot adjustments.
- .6 FHM shall illuminate one of two GREEN pilot lights to indicate high and low flow respectively.
- .7 Each FHC shall contain a visual and audible LOSS OF FACE VELOCITY alarm to indicate a low face velocity condition. Muting of the alarm shall only silence the audible portion, while the visual alarm shall

be maintained unless the low flow condition has been removed. Alarm shall be triggered by:

- .1 A differential pressure switch located in fume hood exhaust duct that senses an air flow of approximately 20% below setpoint.
- .2 An alarm wire being disconnected.
- .8 Provide a push button switch to mute audible alarms. The mute mode shall automatically reset when the alarm condition ceases.
- .9 The FHM shall consist of a colour LCD screen no smaller than 51 mm x 70 mm, have four push buttons and a six line display to indicate operation of the hood. By pushing the SYSTEM push button, the FHM shall command the following modes of operation with the indicated fully programmable displays:
 - .1 In STANDARD or NORMAL Mode of Operation the FHM shall display the following:

- Line 1: STANDARD
- Line 2: Face velocity in m/s or fpm
- Line 3: NORMAL (Normal hood operation)
- Line 4: Clock, local time in hh:mm
- Line 5 & 6: Text: "FUME HOOD OPERATIONAL"

STANDBY Mode of Operation

- Line 1: STANDBY
- Line 2: Face velocity in m/s or fpm
- Line 3: NORMAL (Normal hood operation)
- Line 4: Clock, local time in hh:mm
- Line 5 & 6: Push "STANDBY" to revert to NORMAL OPERATIONAL STATUS

STANDARD Mode of Operation (Minimum Exhaust):

- Line 1: STANDARD
- Line 2: Face velocity in m/s or fpm
- Line 3: NORMAL (Normal hood operation)
- Line 4: Clock, local time in hh:mm
- Line 5 & 6: Text: "FUME HOOD OPERATIONAL"

SHUTDOWN Mode of Operation

- Line 1: Text: "SHUTDOWN"
- Line 2: Text: "NO EXHAUST"
- Line 3: Text: "NORMAL"
- Line 4: Clock, local time in hh:mm
- Line 5 & 6: Text: "DO NOT USE HOOD"

LOW EXHAUST SUCTION PRESSURE ALARM

- Line 1: Text: "WARNING"
- Line 2: Text: "UNSAFE"

Line 3: Text: "LOW DUCT PRESSURE"
Line 4: Clock, local time in hh:mm
Line 5 & 6: Text: "CLOSE SASH; CHECK DUCT PRESSURE"

PURGE EXHAUST

Line 1: Text: "WARNING"
Line 2: Text: "PURGE EXHAUST"
Line 3: Text: "EMERGENCY"
Line 4: Clock, local time in hh:mm
Line 5 & 6: Text: "CALL FOR SERVICE"

SASH POSITION ALARM

Line 1: Text: "WARNING"
Line 2: Face velocity in m/s or fpm
Line 3: Text: "Excess sash opening"
Line 4: Clock, local time in hh:mm
Line 5 & 6: Text: "LOWER SASH BELOW 450 MM"

INSUFFICIENT EXHAUST

Line 1: Text: "WARNING"
Line 2: Text: "DANGER"
Line 3: Text: "INSUFFICIENT EXHAUST"
Line 4: Clock, local time in hh:mm
Line 5 & 6: Text: "LOWER SASH BELOW 450 MM"

2.3 LABORATORY AIRFLOW CONTROL VALVES

- .1 Refer to section 23 30 00;
- .2 Airflow control valves and blade dampers must be provided with pilot-positioners in order to detect linkage or actuator failure. Pilot positioners must be wired to controllers to provide alarms in the event that proper valve position is not obtained.
- .3 Valve shall be pressure independent over a differential pressure range of 150 Pa to 750 Pa across the valve. Integral pressure independent assembly shall respond and maintain specific air flow within one second of a change in duct static pressure.
- .4 Valve air flow accuracy shall be $\pm 5\%$ of reading (not full scale) regardless of inlet or exit duct configuration over an air flow turndown range of no less than 8 to 1. No entrance or exit duct diameter restrictions shall limit the specified speed of response, accuracy or pressure independence.
- .5 Install laboratory airflow control valves horizontally, unless specified otherwise.
- .6 Laboratory airflow control valves shall use electronic based closed loop position feedback and control to regulate air volume linearly proportional to a 0 to 10 Volt electronic control signal. Valve shall generate a 0 to 10 Volt feedback signal linearly proportional to air flow for internal volume control, monitoring, or air flow tracking

control. Signal shall be factory calibrated to a stated L/s per volt scale factor using NIST traceable instrumentation directly from the control arm or shaft position.

- .7 Valve shall achieve 90% of its commanded volume within one second of being commanded to its new volume set point (regardless of system stability) with less than a 5% undershoot or overshoot.
- .8 A static pressure switch pre-mounted to each laboratory airflow control valves shall sense and alarm an air flow of approximately 20% below the setpoint. The switch shall operate by measuring the pressure drop across the variable orifice venturi.

2.4 LABORATORY CONTROL PANEL (LCP)

- .1 Provide a LCP to control the air flow balance of the laboratory room. Provide one LCP per laboratory pressurization zone.
- .2 LCP shall be of electronic design and shall accept 0 to 10 volt input signals proportional to air flows.
- .3 LCP shall be a fully distributed micro-processor based controller with multiple inputs and outputs to control OAVs (Offset Airflow Valve), SAVs (Supply Airflow Valve) and GEXs (General Exhaust Airflow Valve) as well receive airflow feedback from Fume Hood Airflow Valve (FHAV) with 0 to 10 volt signals linearly proportional to the desired minimum and purge ventilation levels while maintaining constant room pressurization levels under all operating conditions.
- .4 The LCP shall perform the sequence of operations as specified in Part 3 of this Section.
- .5 Provide integral field adjustable trimpots for all required calibration and scaling adjustments.
- .6 LCP shall maintain a specified constant adjustable off set between the sum of the room's total exhaust and the make-up/supply air volumes for "leaky" labs without air locks. This offset shall be independent of the exhaust volume magnitude and represent the volume of air that will infiltrate the room from the corridor or other areas.
- .7 LCP shall generate 0 to 10 volt analog signals linearly proportional to all air flow sources, sash sensors, and flow alarms (0 or 12 V alarm). These signals shall be available for direct connection to the facility's BAS. As a minimum, the following signals (points shall be available:
 - .1 Laboratory net air flow differential alarm (Digital Contact).
- .8 LCP shall also accept direct input signals from the facility's BAS System. As a minimum, the following inputs shall be available:
 - .1 Exhaust fan air flows (0 - 10 VDC).

2.5 DIFFERENTIAL PRESSURE SENSOR (PS)

- .1 PS shall be position insensitive even at pressure near 2.5 Pa.
- .2 PS shall provide an output of 0 - 10 VDC for a full scale pressure input of 0 - 250 Pa positive or negative.
- .3 PS shall have integral filters at both ports.

- .4 Accuracy including non-linearity and hysteresis shall be + 1% of range.
- .5 Maximum drift due to temperature not to exceed $\pm 0.05\%$ per degree C.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Unless noted otherwise this section shall be responsible for supply and installation of all materials specified under this Section including all pneumatic piping and control wiring.
- .2 The 138 kPa compressed air, shall be clean and dry instrument quality.

3.2 SEQUENCE OF OPERATION

- .1 Fume Hood Monitor (FHM):
 - .1 Fume hood monitor controller (FHM) shall modulate the fume hood exhaust valve from a sash position sensor(s) to maintain a constant face velocity regardless of sash position above a set minimum flow. Minimum flows to be as per ANSI/ASSP Z9.5.
 - .2 The FHM shall calculate the amount of exhaust air required to maintain a constant face velocity regardless of the sash position above a minimum flow setting and the mechanically latched sash working height, and control the air flow at that level.
 - .3 The occupancy space detector (OSD) shall constantly monitor a defined area in front of the hood. When the presence of a person has been detected in front of the hood, the FHM shall control the face velocity at the specified level, normally 0.5 m/s. When the OSD has detected that the person has left the detection zone, the FHM shall control the face velocity at a reduced value, typically 0.3 m/s. When the person has returned to the detection zone, the FHM shall re-establish the specified face velocity within less than 1.5 seconds.
 - .4 Pushing the EMERGENCY push button will initiate the purge exhaust mode and display all above information on the display.
 - .5 EMERGENCY modes of operation will command the exhaust valve to its maximum setting and energize an audible annunciator. Activating the MUTE push button will silence the audible alarm.
 - .6 Should the fume hood sash be opened beyond the standard operating height of 450 mm, unless otherwise specified each FHM shall audible and visually alarm.
- .2 Laboratory Control Panel (LCP):
 - .1 The LCP shall sum the total exhaust flow from every exhaust device and control the supply air at a constant shortfall to the total exhaust to maintain a directed air flow into the lab for a negatively pressurized room. This pressurization level shall be maintained constant under all operating conditions.

- .2 The LCP shall maintain the following ventilation levels:
 - .1 Minimum 6 Air Changes per Hour (ADJ), when the air is measured to be "clean", area is occupied and there is no additional demand for make-up air from exhaust devices or supply air for cooling. The ventilation level cannot drop below this number under any conditions;
 - .2 A higher ventilation level when so commanded by maximum exhaust from all exhaust devices in the room including fume hoods, BSC's, any snorkels and/or chemical storage cabinets. In this case, the amount of supply air shall not exceed the total exhaust air flow, less the room pressurization flow;
 - .3 A maximum purge ventilation level, when so commanded by a purge push button or some other purge command;
 - .4 A supply air flow in excess of that required for ventilation in reheat systems, to meet the cooling/heating demand.
 - .5 Under all of the above conditions, the room pressurization level shall remain constant.
- .3 OFFSET SUPPLY AIR (OSV):
 - .1 Provide OSV to provide a supply air flow, usually into the corridors, to make up the sum of all the offsets of the labs that face the common area.

3.3 START-UP, CALIBRATION COMMISSIONING AND OTHER SERVICES

- .1 Factory-trained and authorized personnel in the regular employ of the laboratory system integrator shall provide start-up, calibration, and commissioning services. These services shall include the setting of fume hood face velocities, fume hood air flows, and the setting of exhaust and supply air flows, specified.
- .2 This supplier shall include for a second trip to the jobsite, not longer than 3 months after the project has been completed and handed over to the Departmental Representative, to instruct the building management personnel in the proper care and maintenance of the systems.
- .3 This supplier shall include for a third trip to the jobsite, not longer than 3 months after the completion of the project, to instruct the users in the correct operation of the system.
- .4 Not longer than 3 months after the completion of the project, submit a preventative maintenance service proposal to the Departmental Representative to check the operation and calibration of the systems and perform the recommended maintenance at the beginning of the second year of operation.

3.4 FAIL-SAFE OPERATION

- .1 In the event of a compressed air or local power failure, or a break in the wiring carrying the control signals, EAV valves and exhaust fans shall revert to their maximum air flow positions. Under these abnormal conditions, EAV valves and exhaust fans shall maintain maximum specified air flows, independent of duct pressure fluctuations.

- .2 In the event of a compressed air or local power failure, or a break in the wiring carrying the control signals, all MAV and SAV valves shall revert to their minimum air flow positions. Under these abnormal conditions, each valve shall maintain specified minimum air flows, independent of duct pressure fluctuations.
- .3 The maximum and minimum air flows under loss of power or compressed air conditions, shall be as follows, unless specified otherwise:

Airflow Control Valve Size	Minimum Air Flow	Maximum Air Flow
150 mm	15 L/s	118 L/s
250 mm	29 L/s	425 L/s
300 mm	78 L/s	660 L/s
2x250 mm	58 L/s	850 L/s
2x300 mm	156 L/s	1320 L/s
3x300 mm	235 L/s	1980 L/s
4x300 mm	312 L/s	2640 L/s

3.5 DDC SYSTEM TIE-INS

- .1 Provide the following tie-in signals and/or dry contacts for wiring to the DDC system:
 - .1 Dry Contact for Alarm form LCP.
 - .2 Override wiring to 2 speed motor starter from LCP.
 - .3 Other system wiring and interconnections.
- .2 Wire the SPS to the FHM and to the hood termination junction box and terminate all wiring.

END OF SECTION