

Appendix E: DIVISION 26 - ELECTRICAL REQUIREMENTS

E66 Electrical General Requirements

E66.1 Description

- (a) Labour, Products, equipment and services necessary for electrical general requirements Work in accordance with the Contract Documents.
- (b) In general, the following summarizes Electrical Scope of Work and General Requirements. Details of Contract requirements to be in accordance with Contract Documents.
 - (i) Electrical distribution connection to Manitoba Hydro transformers.
 - (ii) New grounding system in accordance with Contract Documents.
 - (iii) New snow-melting and heat tracing system in accordance with Contract Documents.
 - (iv) New lighting replacements in accordance with Contract Documents.
 - (v) New panelboards in accordance with Contract Documents.
 - (vi) Confirm exact location and characteristics of new and existing electrical systems on Site and adjust to suit Site requirements. Advise City of Winnipeg of discrepancies. Test and commission standalone and interfaced systems to ensure proper operation. Correct deficiencies.
 - (vii) Coordinate with City of Winnipeg for demolition and construction Work to avoid disruption of transit operation.
 - (viii) Trace, verify and record existing circuits to existing electrical equipment and provide typed revised panelboard schedules.
 - (ix) Equipment not indicated on Contract Drawings shall remain unless noted otherwise. Remove and reinstall electrical equipment, conduit, wire, and light fixtures, required to be moved because of interference due to installation of new equipment. Coordinate with other trades.
 - (x) Confirm exact locations of new and existing electrical systems on Site. Advise City of Winnipeg of discrepancies.
 - (xi) Cut, patch and make good holes made due to electrical system installation.
 - (xii) Prior to and during construction, coordinate with other Divisions to avoid interference of equipment and services. Ensure no services are affected by demolition Work. If services are affected by demolition Work, notify City of Winnipeg immediately.
 - (xiii) Complete inspection, start-up, testing and commissioning of installed equipment in accordance with manufacturer's recommendations and Contract Documents.
 - (xiv) Correct and complete all construction deficiencies before scheduling commissioning.
 - (xv) Provide services of manufacturer's technical representative for commissioning at no additional cost to City of Winnipeg.

E66.2 References

- (a) Use the standard version listed in the technical Sections unless replaced by updated amendment or revision.
 - (i) CSA C22.2 No. 94, Special Purpose Enclosures.
 - (ii) CSA Z462, Workplace Electrical Safety.
 - (iii) IEEE 1584, Guide for Performing Arc Flash Hazard Calculations.
 - (iv) NEMA, National Electrical Manufacturers Association.
 - (v) Canadian Electrical Code.
- (b) Quality Assurance
 - (i) Manufacturer to show minimum of thirty (30) years' experience in manufacturing mineral insulated (MI) heating cables.

- (ii) Manufacturer will be ISO-9001 registered.
- (iii) Manufacturer to provide products consistent with UL 515, CSA 22.2 No 130-03 and IEEE 515.1 requirements.
- (iv) System installer shall have a complete understanding of product and product literature from manufacturer or authorized representative prior to installation. Electrical connections shall be performed by a licensed electrician.
- (v) The system (heating cable, connection kits, and controller) shall be UL Listed and CSA Certified for snow melting.

E66.3 As-Built Drawings

- (a) Submit As-Built Drawings indicating the following:
 - (i) Accurately maintained, dimensioned record of cable, conduit, bus duct and equipment locations in the pedestrian tunnels, bridge deck and surrounding areas. Show deviations and changes in Work from Contract Drawings.
 - (ii) Actual locations of conduits and ducts, piping, maintenance holes, and similar items located below or outside of structure.
 - (iii) On each As-Built Drawing in lower right hand corner in letters minimum 13 mm high as follows: AS-BUILT: THIS DRAWING HAS BEEN REVISED TO SHOW ELECTRICAL SYSTEMS AS INSTALLED followed by signature of the Contractor and date.

E66.4 Environmental Conditions

- (a) Outdoor equipment, whether permanent or temporary for the execution of the Work, supplied under this Contract to be suitable for its intended use with the outdoor temperature and humidity experienced in the Winnipeg area.

E66.5 Design For Ease of Maintenance

- (a) Equipment to be designed and constructed so that adjustment, replacement, repairs or regular upkeep can be easily carried out by maintenance personnel with minimum additional training and with tools normally available. The design to incorporate, where possible, the concept of modular removal and replacement of malfunctioning components.
- (b) Design of the equipment to provide maximum accessibility to equipment and components to facilitate preventative maintenance checks, services and repair actions. Test points and test procedures, with values and tolerance range, to be provided to facilitate diagnosis of malfunctioning components and for check-out after repair and replacement.

E66.6 Site Conditions

- (a) Protect, support and maintain existing active services as required for execution of the Work without disturbing the existing site conditions.

E66.7 Fabrication

- (a) If CSA certified equipment is unavailable, obtain special approval for equipment from CSA.
- (b) Provide equipment suitable for its intended use within range of temperature typical in the Winnipeg area
- (c) Factory assemble control panels and other components, except for shipping splits.
- (d) Fabricate steel supports, plates and hardware as required. Hot-dip galvanize prefabricated supports such as channels, brackets, hangers, and slotted angles. Do not field weld, but bolt or clamp. Touch-up cut sections with cold galvanizing zinc coating.

- (e) Do not manufacture or install electrical equipment or systems until Shop Drawing reviewed and acceptance by City of Winnipeg and/or authorities having jurisdiction.

E66.8 FINISHES

- (a) Prepare and clean surfaces of electrical Products requiring painting in accordance with SSPC-SP1 for oil, grease, dirt and other contaminants and SSPC-SP3 for rust.
- (b) Apply one coat of primer.
- (c) Apply 2 coats of finish paint. Colour of manufacturer's standard ASA 61 grey exterior and interior, except as specified otherwise. Paint all electrical equipment in accordance with EEMAC standard.
- (d) Apply paint in accordance with manufacturer's instructions regarding application methods, coating thicknesses, equipment, temperature and humidity conditions.
 - (i) Provide verification of finish standards that the finish system complies with EEMAC and industry test standards. Provide specific verification that 1000 hour (min) salt spray and humidity tests have been met.
- (e) Clean and touch-up surfaces scratched or marred during shipment and installation, to match paint finish.
- (f) Clean, prime and paint exposed hangers, racks and fasteners to prevent rust.

E66.9 EXAMINATION

- (a) Verify condition and dimensions of previously installed Work this Section depends upon. Report defects to City of Winnipeg. Commencement of Work means acceptance of existing conditions.
- (b) Verify equipment access and coordinate with equipment supplier to ensure equipment can be physically transported to installation location.
- (c) Quantities or lengths indicated in Contract Documents are approximate and do not gauge or limit Work. No adjustment to Contract Price allowed to complete the Work.
- (d) Include for changes or additions to routing of conduits to accommodate structural, mechanical and architectural conditions.

E66.10 EXISTING EQUIPMENT

- (a) Electrical equipment requiring temporary or permanent relocation or power due to construction is the Contractor's responsibility.
 - (i) All new and existing electrical equipment to be connected to or disconnected from existing distribution system (for example, panelboards, control panels, etc.) by City of Winnipeg forces. Contractor to coordinate Work schedule with City of Winnipeg minimum 4 weeks in advance.
- (b) Provide additional items and accessories or connections obviously required to provide complete working system for relocated equipment, but omitted from Specifications or not shown on Contract Drawings.
- (c) Assume existing conduits in Work area contain live circuits.
- (d) Trace conduits and circuits feeding existing equipment in Work area obstructing and interfering with Work. Maintain circuits live, if required, and in use.
- (e) Contractor shall coordinate with City of Winnipeg, Work related to electrical equipment requiring temporary or permanent relocation or power due to construction.
- (f) Unless "only" suffixes "supply, install and connect" or variation of those words, it means "supply, install and connect".

E66.11 INSTALLATION

- (a) Coordinate installation of electrical equipment with equipment of other trades. Notify other trades in advance of openings, anchors, hangers or other provisions necessary for electrical installation.
- (b) Identify embedded, concealed or recessed equipment before construction. In spaces above ceilings, coordinate electrical installation with other trades, such as ductwork and piping.
- (c) Install wiring and connections to equipment supplied by other trades, such as wiring and interlocks of equipment and control devices specified in other Divisions.
- (d) Protect electrical equipment from the elements and damage by construction activities in area.
- (e) Perform electrical Work in accordance with OBC, CEC, and CSA. Perform changes or alterations required by authorized inspectors of authorities having jurisdiction such as Manitoba Hydro.
- (f) After completion of part of Work, notify City of Winnipeg to make final inspection. Make tests of such portions and promptly make any changes necessary, to the acceptance of City of Winnipeg. Place Work in service at such time and in such order as City of Winnipeg may direct.
- (g) Do not reduce requirements of standards established by Contract Documents by applying codes referred to in this Division.
- (h) Assemble, install, connect and adjust for complete operation of electrical equipment.
- (i) Install electrical equipment in locations shown on Contract Drawings. Such locations are subject to change to suit conditions as Work progresses. Before installing equipment, obtain instructions from City of Winnipeg for exact locations, make such changes without extra cost to City of Winnipeg.
- (j) Existing and new conduits, outlets, or other electrical equipment shown on Contract Drawings are not necessarily exact locations or quantities. Make allowances for additional Work of removing or installing additional conduits, outlets, as required, to accommodate Work.
- (k) No change to Contract Price will be allowed for relocation of equipment incorrectly installed because of failure to check and coordinate details, Contract Drawings and interferences, prior to installation.

E66.12 CONDUIT AND CABLE INSTALLATION

- (a) Assume existing conduits in Work area(s) contain live circuits. Coordinate Work on existing equipment with City of Winnipeg.
- (b) Relocate temporary or permanent electrical equipment and conduits as required.
- (c) Install high raised concrete curb at floor openings for new bus ducts and conduits through floor slabs as shown on Contract Drawings.

E66.13 LOAD BALANCING

- (a) Measure phase current to panelboards with normal loads operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record current readings. Submit recorded data to City of Winnipeg for review.
- (b) Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment. Measure phase voltages to reflect utility voltage fluctuations and set accordingly.

E66.14 CARE, OPERATION AND START-UP

- (a) Instruct City of Winnipeg's staff in operation, care, and maintenance at times arranged by City of Winnipeg and detailed in other Sections at no additional cost to City of Winnipeg.
- (b) Provide services of Contractor's staff to supervise startup of installation, check, adjust, balance and calibrate components at no additional cost to City of Winnipeg.
- (c) Provide these services for such period and for as many visits as necessary to put installation in working order and to ensure City of Winnipeg staff is conversant with all aspects of its care and operation at no additional cost to City of Winnipeg.

E66.15 CLEANING

- (a) Where equipment shows corrosion, or damage to finish of panels, panelboards fixtures or devices, touch-up surfaces to the acceptance of City of Winnipeg.

E66.16 MAINTENANCE

- (a) Carry out regular scheduled maintenance of equipment and systems following Substantial Performance until Contract Completion.

E67 **Wires and Cables**

E67.1 Description

- (a) Labour, Products, equipment and services necessary for wires and cables 0 - 1000 V Work in accordance with the Contract Documents.

E67.2 REFERENCES

- (a) ANSI/NETA ATS-2017, Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- (b) ASTM B3, Standard Specification for Soft or Annealed Copper Wire.
- (c) ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- (d) ASTM D1047, Standard Specification for Poly(Vinyl Chloride) Jacket for Wire and Cable.
- (e) CSA, Canadian Standards Association.
- (f) CSA C22.2 No. 0.3, Test Methods for Electrical Wires and Cables.
- (g) CSA C22.2 No. 38, Thermoset-Insulated Wires and Cables.
- (h) CSA C22.2 No. 49, Flexible Cords and Cables.
- (i) CSA C22.2 No. 75, Thermoplastic Insulated Wires and Cables.
- (j) CSA C22.2 No. 124, Mineral-Insulated Cable.
- (k) CSA C22.2 No.131, Type TECK 90 Cable.
- (l) NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail System.
- (m) CEC, Canadian Electrical Code.
- (n) UL, Underwriters' Laboratories.
- (o) ULC, Underwriters Laboratories of Canada.

E67.3 SUBMITTALS

- (a) Submit the following Shop Drawing(s):
- (b) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists.
- (c) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
- (d) Product transportation, storage, handling, and installation requirements.
- (e) Cables used on Contract.
- (f) Cable terminations used on Contract.
- (g) Cable supports used on Contract.

E67.4 Quality Assurance Submittal(s):

- (a) Submit manufacturer's qualifications.
- (b) If requested by City of Winnipeg, or if necessary to meet Site condition requirements, submit alternate cable routing information for review prior to proceeding with the Work.

E67.5 Commissioning Submittal(s):

- (a) Submit Test Procedures.
- (b) Submit Certificate of Readiness.

- (c) Submit Test Reports.
- (d) Submit Closeout Report.

E67.6 Regulatory requirements

- (a) Furnish Products listed and classified by CSA and UL as suitable for application.

E67.7 Delivery, Storage, and Handling

- (a) Ship cables from manufacturer with ends temporarily sealed against moisture ingress.
- (b) Store cables in clean, dry location.
- (c) Uncoil cable by rolling or rotating supply reel (available from manufacturer) to ease handling and prevent possible snarling and kinking. Do not pull from coil periphery or centre.
- (d) Take precautions necessary to prevent damage to cables from contact with sharp objects, including pulling over foreign objects or sheaves.

E67.8 Site Conditions

- (a) Verify field measurements and conditions as required by Contract Documents.
- (b) Cable routing on Contract Drawings is approximate unless fully dimensioned. Route cable as required to suit Site conditions and as reviewed by City of Winnipeg.
- (c) Where cable routing is not shown and destination only is indicated, determine exact routing and lengths required to suit Site conditions and as reviewed by City of Winnipeg.

E67.9 Coordination

- (a) Coordinate Work specified in this Section with Work provided under other electrical Sections and Work of other trades.
- (b) Determine required separation between cable and other Work.
- (c) Determine cable routing to avoid interference with other Work.
- (d) Provide core drilling where required prior to commencing Work.
- (e) Coordinate alternate cable routing with City of Winnipeg prior to proceeding with the Work.

E67.10 Manufacturers

- (a) Electro Cables Inc.
- (b) General Cable, a company of the Prysmian Group.
- (c) Nexans Canada Inc.
- (d) RSCC Wire and Cable LLC.

E67.11 Low voltage cables

- (a) Minimum 600 V insulation.
- (b) Conductors: No. 12 AWG (3.31 mm²) through to No. 8 AWG (8.38 mm²) stranded copper wire. Nylon jacketed and thermoplastic insulated T90 and TWU90 unless indicated otherwise in Contract Documents.
- (c) Copper conductors: Size #6 and larger, RW90 and RWU90 as indicated on Contract Drawings with 600 V (for 208 V feeder) and 1000 V (for 600 V feeder) rated thermosetting cross-linked polyethylene (XLPE) insulation.
- (d) Wires and cables free of splices between terminations. If physical constraints of installation prevent this, details of splicing are subject to approval by City of Winnipeg.
- (e) Colour coding as follows:

- (i) 3 Conductors, 3 phase: Red, black, and blue.
- (ii) 4 Conductors, 3 phase: Red, black, blue, and white.
- (f) Ground: Green.

E67.12 Examination

- (a) Verify cable end factory temporary seals remain intact, insulation has not been exposed to air, and no moisture has entered cable insulation.
- (b) Verify completion of Work by other trades likely to damage cable.

E67.13 WIRING METHODS

- (a) Use wiring methods indicated on Contract Drawings, manufacturer's instructions, and as specified herein.
- (b) When cables are cut in field, seal exposed end using standard sealing compound and PVC tape in accordance with cable manufacturer's recommendation.

E67.14 Installation of Wires and Cables

- (c) Carefully pull in all wires in any one conduit at same time directly from reels or coil in accordance with cable manufacturer's recommendations. Avoid damage to conductors or insulation.
- (d) Joints are not permitted in conductors between boxes or outlets. Ensure neutral conductors are unbroken throughout their length and feeders are continuous without splices throughout their entire length unless splices permitted by City of Winnipeg.
- (e) Use proper crimping tool on pressure-applied specific connectors at conductor joints.
- (f) Designate wire and cable circuits at distribution panelboards and switchboards by correct specified fibre tag.
- (g) Use terminal lugs on conductors No. 10 AWG (5.26 mm²) or larger where they are terminated for connection to switchboard or other equipment. Apply lugs with manufacturer's recommended tools.
- (h) Carefully unroll cable from reels and coil and run cable as complete from one outlet or junction box to next.
- (i) Seal space between cables and sleeves or wall or floor opening with UL-listed firestop putty, sealant, compound, or pillow, after wires and cables have been installed.
- (j) If necessary to splice cable, make splice in junction box sized to suit cable thickness in accordance with CEC. Keep the number of splices in any run of cable to a minimum consistent with available coil length and installation conditions.
 - (i) If City of Winnipeg determines that an excessive number of splices have been made in a run of cable, remove, replace, and splice cable as directed by, and at no additional cost to, City of Winnipeg.
- (k) Support cables on clips at maximum spacing of 1 m. Make bends in cable with manufacturer's recommended tools to the following minimum radii measured inside bend.

SHEATH DIAMETER (OD)	MINIMUM BENDING RADIUS
Above 19 mm and including 38 mm	12 x sheath diameter
Above 38 mm	15 x sheath diameter

- (l) Straighten cable runs to form a neat and uniform appearance. Route cables, where possible, parallel to or at right angles to walls, ceilings, and floors. Where this is not possible, seek permission from City of Winnipeg.

- (m) Carry conductors of branch circuits or feeders in same multi-conductor cable, unless otherwise noted or reviewed by City of Winnipeg.
- (n) Identify at both ends utilizing permanent markers.
- (o) Install wiring as follows:
 - (i) In conduit systems.
 - (ii) In underground ducts.
- (p) Where wire size has been increased to compensate voltage drop, make reductions to wire size only at terminal lugs. In accordance with CEC, do not reduce wire size below rated circuit ampacity.

E67.15 FIELD QUALITY CONTROL AND COMMISSIONING

- (q) Inspect cable for physical damage and proper connection.
- (r) Verify continuity of each conductor.
- (s) Obtain cable manufacturers' certification that installation is in accordance with their requirements. Pay all applicable fees.
- (t) Test conductors for continuity, short circuits, and grounds. Ensure resistance to ground is not less than 50 megohms.
- (u) Pre-acceptance tests:
 - (i) After installing cable, but before splicing and terminating, perform insulation-resistance test on each conductor with respect to ground and adjacent conductors.
 - (ii) Check insulation resistance after each splice to ensure cable system is safe and ready for termination.
 - (iii) During testing ensure terminations and accessory equipment are disconnected.
- (v) Acceptance tests:
 - (i) Verify wiring terminations and cable torque measurements to ensure interconnections are in accordance with Contract Documents.
- (w) If cable fails to meet any of the test criteria, remove and replace entire length of cable at no additional cost to City of Winnipeg.

E68 **Grounding and Bonding**

E68.1 Description

- (a) Labour, Products, equipment, testing and services necessary for grounding and bonding Work in accordance with the Contract Documents.

E68.2 References

- (a) CAN/CSA-B72-M, Installation Code for Lightning Protection Systems.
- (b) CSA C22.2 No. 31, Switchgear Assemblies.
- (c) CEC, Canadian Electrical Code.

E68.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Technical data, supplemented by bulletins, component illustrations, detailed views, technical description of items and parts list.
 - (ii) Ground electrode, ground electrode boxes, ground connector, lightning rod, stand-off insulator, resistor elements and ground conductor.

E68.4 Quality Assurance Submittal(s):

- (a) Submit test results of grounding system continuity and resistance.

E68.5 Commissioning Submittal(s):

- (a) Submit Test Procedures.
- (b) Submit Certificate of Readiness.
- (c) Submit Test Reports.
- (d) Submit Closeout Report.

E68.6 Manufacturers

- (a) Thomas and Betts.
- (b) Burndy.
- (c) Dossert.
- (d) Hubbell.
- (e) Erico.

E68.7 MATERIALS

- (a) Ground rods: 19 mm diameter x 3050 mm long, copper bonded with minimum 10 mil copper coating.
- (b) Grounding conductors: Green insulated up to size No. 1 AWG or bare conductors for larger sizes unless indicated otherwise on the Contract Drawings.
- (c) Grounding and bonding conductors: In accordance with CEC.

E68.8 Electrical Safety Grounding

- (a) Supply means for permanent and effective electrical grounding of exposed non-current-carrying metal parts, assemblies housing electrical current carrying components (switchgear and transformer), as required by the CEC and Contract Drawings.
- (b) Additional grounding requirements of the electrical equipment in accordance with CSA C22.2. No. 31-18 and Occupational Health and Safety Act and Regulations for Construction Projects.

- (c) All electrical distribution and control equipment doors to have flexible ground bonding braid to extend ground from equipment ground bus bar and not rely on hinge.
- (d) Supply effective grounding of exposed non-current-carrying metal structures like doors, frames, supports etc. Doors and moving parts to have flexible ground bonding braid extended from the ground bus bar and not rely on hinge

E68.9 Installation

- (a) Provide ground rods, grounding conductors, bonding and tap connections in exterior and interior for complete grounding system in accordance with Contract Drawings.
- (b) Bond metallic conduits, boxes, and non-current-carrying metal parts of equipment together to form continuous grounded system.
- (c) Minimum burial depth for underground or buried ground loops and interconnections 450 mm.
- (d) Install grounding conductors without damage, do not dislodge or displace during construction Work. Install conductors with enough slack to prevent breaking stresses.
- (e) Install ground connections within boxes in locations accessible for inspection.
- (f) Install separate ground conductor in all conduits sized to CEC unless noted otherwise.
- (g) Terminate neutral return conductors from 600 V/208 V distribution sections on neutral bus.
- (h) Bond transformer XO to ground grid or ground rod.

E68.10 Handholes

- (a) Ground/bond handholes in as follows:
 - (i) Install ground bus and grounding electrodes.
 - (ii) Provide ground copper wire No. 6 AWG in concrete encasement and terminated on ground bus in each maintenance hole throughout duct bank system.

E68.11 Field Quality Control and Commissioning

- (a) Conduct grounding system continuity and resistance tests using 62% or “fall of potential” method. Submit ground continuity and resistance test results to City of Winnipeg for review.

E69 Hangers and Supports

E69.1 Description

- (a) Labour, Products, equipment and services necessary for hangers and supports Work in accordance with the Contract Documents.

E69.2 References

- (a) ANSI/MSS SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- (b) ANSI/MSS SP-69, Pipe Hangers and Supports - Selection and Application.
- (c) ANSI/UL-2196, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
- (d) ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron & Steel Products.
- (e) ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- (f) ASTM A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- (g) ASTM A536, Standard Specification for Ductile Iron Castings.
- (h) ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts.
- (i) ASTM B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- (j) CSA C22.1, Canadian Electrical Code, Part 1, Safety Standards for Electrical Installations.
- (k) NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems.
- (l) CEC, Canadian Electrical Code.
- (m) UL, Underwriters' Laboratories.
- (n) cUL, Tested to Canadian Standards by Underwriters' Laboratories.

E69.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - (iii) Product transportation, storage, handling, and installation requirements.

E69.4 Manufacturers

- (a) Unistrut Corporation.
- (b) Hilti Corporation.

E69.5 Anchors

- (a) Fastening devices in various types of structures to be sized by the Contractor for specific loading applications and installed in accordance with manufacturer's recommendations.
- (b) Anchor bodies and expansion elements to be stainless steel in accordance with ASTM A240/A240M.
- (c) Precast concrete panel:

- (i) Medium to light-duty applications: Sleeve anchor, Grade 304 stainless steel, HLC by Hilti Corporation.
 - (ii) Heavy-duty applications: Heavy-duty expansion anchor, Grade 316 stainless steel, HSL-3 by Hilti Corporation.
- (d) Concrete structure:
- (i) Non-Seismic applications: Expansion anchor, stainless steel, KWIK Bolt 3 by Hilti Corporation.
 - (ii) Seismic application: Expansion anchor, stainless steel, KWIK Bolt-TZ by Hilti Corporation.
 - (iii) Concrete block wall:
 - (iv) Medium to light-duty applications: Sleeve anchor, Grade 304 stainless steel, HLC by Hilti Corporation.
- (e) Concrete:
- (i) Drop in anchor: Expansion type internally threaded and flush mounted; Grade 303 stainless steel (HDI) or carbon steel plated with a zinc finish (HDI-L), by Hilti Corporation.

E69.1 Steel Beam Clamps

- (a) Ductile iron, electro-galvanized, BC-EG by Hilti Corporation, cUL listed, and in accordance with ASTM A536 and ANSI/MSS SP-58.

E69.2 Wire Harness

- (a) Supply strapping for control wire and cable installation within equipment.

E69.3 Touch-up paint

- (a) Inorganic zinc rich primer, in accordance with manufacturer's recommendations.

E69.4 Installation

- (a) Install mounting channels for support of conduits, lighting fixtures, boxes, cabinets, and other electrical devices and equipment.
- (b) Fasten mounting channels at maximum 100 mm from each end and install clamps for mounting conduits and cables on channels.
- (c) Secure equipment to concrete structure with expansion anchors or drop-in anchors.
- (d) Secure equipment to hollow masonry walls with sleeve anchors.
- (e) Precast concrete panel: Obtain approval from City of Winnipeg before drilling precast concrete panels.
- (f) Steel beams and columns: Obtain approval from City of Winnipeg before drilling through steel and bolt.
- (g) Fasten exposed conduit or cables to structures or support system using straps, as follows:
 - (i) One-hole steel straps to secure surface conduits and cables smaller than 50 mm dia.
 - (ii) Two-hole steel straps for conduits and cables 50 mm and larger in diameter.
 - (iii) Beam clamps to secure conduit to exposed steel work.
- (h) Suspended support systems:
 - (i) Support individual cable or conduit runs with minimum 6 mm dia threaded rods and spring clips.

- (ii) Support two or more cables or conduits on channels supported by minimum 6 mm dia threaded rod hangers where direct fastening to building construction is impractical.
- (i) For surface mounting of two or more conduits, use channels at maximum 1500 mm o.c. spacing.
- (j) Install metal brackets, frames, hangers, clamps, and other supports where indicated on Contract Drawings or as required to support conduit and cable runs.
- (k) Install threaded rods and brackets for raceway risers where there is no wall support.
- (l) Install beam clamps in accordance with ANSI/MSS SP-69.
- (m) Do not use wire lashing or perforated straps to support or secure raceways or cables.
- (n) Install fastenings and supports as required for each type of equipment, cables and conduits, and in accordance with manufacturer's recommendations.
- (o) Touch up abrasions, cuts and welds of galvanized material with touch up paint and remove sharp edges.

E70 Junction and Splitter Boxes

E70.1 Description

- (a) Labour, Products, equipment and services necessary for splitter boxes, junction boxes, pull boxes and cabinets Work in accordance with the Contract Documents.

E70.2 References

- (a) ANSI/ASA 61, Gray Powder Coating.
- (b) CSA C22.2 No. 0, General Requirements – Canadian Electrical Code, Part II.
- (c) CSA C22.2 No. 0.4, Bonding of Electrical Equipment.
- (d) CSA C22.2 No. 26, Wireways, Auxiliary, Gutters and Associated Fittings.
- (e) CSA C22.2 No. 40, Cutout, Junction and Pull Boxes.
- (f) CSA C22.2 No. 85-M, Rigid PVC Boxes and Fittings.
- (g) CSA C22.2 No. 94-M, Special Purpose Enclosures.
- (h) NEMA, National Electrical Manufacturers Association.
- (i) CEC, Canadian Electrical Code.

E70.3 Submittals

- (j) Submit the following Shop Drawing(s):
 - (i) Technical data supplemented by bulletins, component illustrations, detailed views, technical descriptions of items and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standard, characteristics, limitations and troubleshooting protocol.
 - (iii) Product transportation, storage, handling and installation requirements.
 - (iv) Mounting details, methods and dimensions.
 - (v) Enclosure type and size.
 - (vi) Internal layout of identified components.
 - (vii) Front panel layout of identified components.
 - (viii) Electrical wiring diagram with internal and external connections.
 - (ix) Bill of material listing all components.
 - (x) Electrical schematic with description of operations, complete with terminal numbers and field connections.

E70.4 Manufacturers

- (a) Hammond.
- (b) Hubbell.
- (c) Appleton.
- (d) Eurobex.
- (e) Thomas & Betts.

E70.5 Junction boxes

- (a) Rigid Galvanized Steel Threaded Conduit:
 - (i) Enclosures shall be fabricated from minimum 1.9 mm thick galvanized sheet steel, powder coated in accordance with ANSI/ASA 61, grey epoxy textured powder electrostatically applied inside and out and suitable for surface or flush mounting. Enclosure shall be complete with screw on cover, a neoprene gasket for a water-

tight seal and a 1.9 mm thick inner plate. Enclosures shall be minimum size of 150 mm x 150 mm x 100 mm. Type NEMA-3R.

- (ii) Round junction boxes shall be fabricated from malleable iron, high tensile strength and ductility, high corrosion resistance and high impact and shock resistant. Junction boxes shall be suitable for exposed or concealed installations, cast ferrous alloy cover, neoprene gasket, 4 tapped holes, 2 external mounting tabs, 4 tapped conduit entries for rigid galvanized steel threaded conduit and 2 close-up plugs (hub size as required). Type NEMA-4 or stainless steel NEMA-4X, as indicated on Contract Drawings.
- (b) Rigid PVC Conduit:
- (i) Enclosures shall be fabricated of the same PVC material and provided by the same manufacturer as PVC conduit.
- (c) Liquid-tight Flexible Conduit:
- (i) Enclosures shall be fabricated from minimum 1.9 mm thick sheet steel, powder coated in accordance with ANSI/ASA 61, grey epoxy textured powder electrostatically applied inside and out and suitable for surface or flush mounting. Enclosure shall be complete with screw on cover, a neoprene gasket for a water-tight seal and a 1.9 mm thick inner plate. Enclosures shall be minimum size of 150 mm x 150 mm x 100 mm. Type NEMA-4 or stainless steel NEMA-4X, as indicated on Contract Drawings.
 - (ii) Round junction boxes shall be fabricated from malleable iron, high tensile strength and ductility, high corrosion resistance and high impact and shock resistant. Junction box shall be suitable for exposed or concealed installations, cast ferrous alloy cover, neoprene gasket, 4 tapped holes, 2 external mounting tabs, 4 tapped conduit entries for rigid galvanized steel threaded conduit and 2 close-up plugs (hub size as required). Type NEMA.

E70.6 Splitter boxes, CSA certified and as follows, unless indicated otherwise:

- (a) Enclosures shall be fabricated from minimum 1.9 mm thick sheet steel, powder coated in accordance with ANSI/ASA 61, grey epoxy textured powder electrostatically applied inside and out and suitable for surface mounting. Enclosure shall have mounting holes, conduit knockouts, bracket hinges, padlocking provision, drip hood and interior panel. Splitter boxes shall be rated for minimum 600 volts, amperage as indicated on Contract Drawings and lugs to match. NEMA rating as indicated on Contract Drawings.
- (b) Fire resistant backing: Fibre cement and galvanized sheet steel composite panel, 9.5 mm thick, 3DF2 by DuraSystem Barriers Inc.

E70.7 Installation

- (a) Install junction and splitter boxes in locations indicated on Contract Drawings to suit Site conditions.
- (b) Before proceeding with installation, ensure junction/splitter boxes, conduits and other electrical equipment clear mechanical, architectural and other installations.
- (c) Install junction and splitter boxes in accordance with the CEC.
- (d) Set boxes and fittings square with adjacent ceiling, floor, wall or beam line and support independently of conduits entering same. Keep unused knockouts flush and tight. Unused nailing or other holes in boxes not permitted.
- (e) Locate boxes to be freely accessible. Locate boxes above suspended ceilings within reach of openings for fluorescent fixtures. Install access panels where boxes inaccessible.
- (f) Conduit bends shall not exceed the equivalent of four 90° bends between pull boxes or maintenance holes in accordance with CEC.

- (g) City of Winnipeg reserves right to alter location of any electrical installation by 1.5 metres, without increase to Contract Price, prior to outlet installation.
- (h) Install correct identification for boxes.

E71 Conduits

E71.1 Description

- (a) Labour, Products, equipment and services necessary for conduits Work in accordance with the Contract Documents.

E71.2 References

- (a) ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- (b) ASTM E136, Standard Test Method for Behaviour of Materials in a Vertical Tube Furnace 750°C.
- (c) CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
- (d) CE12-1000, PVC Coated Rigid Metal Conduit.
- (e) CEC 12-1200 thru 12-1220, Rigid RTRC (Fiberglass) Conduit.
- (f) CSA C22.2 No. 211.2, Rigid PVC (Unplasticized) Conduit.
- (g) CSA C22.2 No. 45, Rigid Metal Conduit.
- (h) CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
- (i) CSA C22.2 No. 83, Electrical Metallic Tubing.
- (j) CSA C22.2 No. 85, Rigid PVC Boxes and Fittings.
- (k) NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems.
- (l) CEC, Canadian Electrical Code.

E71.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - (iii) Product transportation, storage, handling and installation requirements. Indicate application conditions and limitations of use of Product as stipulated by product testing agency specified under regulatory requirements.
 - (iv) All conduits used on Contract.
 - (v) All conduits terminations used on Contract.
 - (vi) All conduits supports used on Contract.

E71.4 Commissioning Submittal(s):

- (a) Submit Test Procedures.
- (b) Submit Certificate of Readiness.
- (c) Submit Test Reports.
- (d) Submit Closeout Report.

E71.5 Manufacturers

- (a) PVC conduit: IPEX or Royal Pipe Systems.
- (b) Metallic conduit: Columbia MBF/Allied Tubing or Wheatland Tube.

E71.6 Materials - Rigid Galvanized Steel (RGS) Conduit:

- (a) Material: Hot-dip galvanized steel tubing. Metallic rigid conduit other than hot-dip galvanized rigid steel is unacceptable.
- (b) Applications: Indoor, outdoor, wet and dry locations, concealed or exposed to all atmospheric conditions.
- (c) Fittings: Use threaded hubs (bullet hubs) for connections to threadless junction boxes, enclosures and equipment. Threaded hubs shall be of rugged steel/malleable iron construction, electro-zinc plated, complete with nylon insulated throat. Couplings shall be threaded of rugged steel/malleable iron construction and electro-zinc plated and shall allow conduit coupling without rotating either pipe. Straps shall be steel/malleable iron construction with hot-dipped galvanized finish. Expansion/contraction fitting shall be telescopic sleeve type with bonding jumper and made of steel/malleable iron construction with hot-dipped galvanized finish. Conduit bodies shall be steel/malleable iron with zinc electroplate finish.
- (d) Conduit shall be threaded at both ends.

E71.7 Materials – Flexible Metal Conduit:

- (a) Material: Flexible steel armour.
- (b) Restrictions: Not permitted in hazardous classified locations, embedded in concrete or aggregate, in wet locations, exposed to oil or gasoline. It shall not be subject to physical damage and limited to less than 1 m in public areas.
- (c) Applications: Exposed or concealed work, limited to maximum 1 m unless noted otherwise and shall be approved by City of Winnipeg.
- (d) Fittings: Rugged steel/malleable iron construction, electro-zinc plated, nylon insulated throat complete with bushing and locknut.

E71.8 Materials – Liquid-Tight Flexible Conduit:

- (a) Material: Corrosion resistant galvanized steel flexible inner core extruded with flexible durable PVC jacket. PVC jacket shall be resistant to sunlight, oils, acids and vapors while providing protection from moisture.
- (b) Restrictions: Not permitted in hazardous classified locations, embedded in concrete, aggregate or cinder fill.
- (c) Applications: Indoor, outdoor, concealed, wet and dry locations.
- (d) Fittings: Compression metallic convolution type suitable for liquid-tight conduit where exposed to moisture, made from steel/malleable iron and electro-zinc plated and chromate coated for corrosion protection, complete with body, gland, locknut, ground cone, sealing gasket and insulator.

E71.9 Materials – Rigid PVC Conduit:

- (a) Material: Shall be Schedule-40, sunlight resistant, FT-4 rating, fire resistant, impact and chemical resistant, non-corrosive and non-magnetic.
- (b) Restrictions: Not permitted in hazardous classified locations. It shall not be subject to physical damage.
- (c) Applications: Underground, for use in direct burial, encased in concrete, embedded in concrete floors/ceilings slabs and in walls and in reinforced concrete ductbank. Above ground, encased or exposed.
- (d) Fittings: Connectors, couplings, straps, elbows, expansion joint fittings, and conduit bodies shall be of the same material and manufacturer as PVC tubing. Expansion/contraction fitting shall be telescopic sleeve type with O-rings gasket.
- (e) Cement shall be solvent type for PVC conduit by same manufacturer.

E71.10 Preparation

- (a) Carefully clean conduits before and after installation. Clean burrs from ends and free inside surface from imperfections likely to damage wires or cables.
- (b) Immediately before wires or cables pulled into any conduit run, snake with steel band with tube cleaner equipped with spherical mandrel, diameter minimum 85% of nominal inside diameter of conduit. Remove and replace conduits not passing mandrel.

E71.11 Installation - General

- (a) Minimum conduit size 21 mm unless indicated otherwise. No reduction in sizes shall be permitted without the acceptance of City of Winnipeg.
- (b) Prior to installation of conduit, check installation does not hinder or obstruct equipment or space allocated to other Products.
- (c) Protect conduits from entrance of water or other foreign matter, by adequate and complete plugging overnight or when Work temporarily suspended. Plug ends of conduits with plastic plugs to ensure plugged or capped ends form watertight seal.
- (d) Install surface mounted conduit parallel to, or at right angles to, structure lines, walls, ceilings or floors. Form bends, off-sets and supply necessary fittings for installation of conduits.
- (e) Install conduits to allow conductors drawn-in without excessive strain or damage.
- (f) Install fish wire in conduits to facilitate wire/cable pulling and additional fish wire left in place to facilitate pulling additional wires and cables.
- (g) Exposed conduits shall be metallic and conduits embedded in concrete shall be non-metallic unless otherwise indicated.
- (h) Use bends or off-sets only where necessary. Make bends and offsets in field with correct tools to avoid flattening of conduit. Split, deformed or damaged conduits not permitted.
- (i) Install specified expansion or deflection fittings where conduits cross expansion/contraction or deflection joints.
- (j) Install rigid hot-dipped galvanized steel conduits unless indicated otherwise. To be used for all electrical power circuits unless noted otherwise.
- (k) Where rigid conduit enters pull boxes, junction boxes, panelboards and cabinets, install iron hub fittings.
- (l) Fasten conduits with anchors spaced maximum 1500 mm apart. Fasten clamps to concrete or masonry with specified anchors.
- (m) Install hot-dipped galvanized steel supports necessary to mount conduit fittings, conduit and boxes in locations where no mounting surface available.
- (n) Identify conduits at both ends.
- (o) Install all conduits (metallic, non-metallic) to meet CEC and NFPA 130 requirements.
- (p) Have Site inspected by City of Winnipeg after laying conduits but before backfill or concrete pouring.
- (q) Flexible metal conduit shall not be used for connecting to panelboards.
- (r) Conduits are to be concealed in areas accessible to public, unless indicated otherwise.
- (s) Install separate ground conductor in all conduits sized to CEC unless noted otherwise.

E71.12 Installation - Metallic Conduits

- (a) Fasten conduits by specified clamps spaced maximum 1.5 m apart. Fasten clamps to concrete or masonry with specified anchors.

- (b) Apply Red Glyptal compound to threads of rigid galvanized metal conduit and fittings. Touch-up scratches and wrench marks with touch-up paint as work progresses.
- (c) Install metallic conduit unless indicated otherwise.
- (d) Installation of buried rigid, non-metallic conduit shall be at least 300 mm away from other services such as gas or water lines or as indicated/approved by City of Winnipeg.

E71.13 Installation - Non-Metallic Conduits

- (a) Make joints in conduit with jointing cement approved for use with PVC conduits. Where non-metallic conduit passes through expansion joint, install expansion coupling.
- (b) Where conduits are exposed, make transitions from non-metallic conduits to metallic conduits at minimum 150 mm below concrete surface.
- (c) Direct buried and embedded in concrete conduits must be installed in parallel to or at right angles to the structure lines, walls, floors, ceilings from bends and offsets.

E71.14 Bending Radius - Metallic And Non-Metallic Conduits

- (a) Make bends in conduit of following minimum radii:

Size of Conduit	Minimum Radius of Bend
21 mm & 27 mm	300 mm
41 mm	450 mm
53 mm	600 mm
103 mm	900 mm

E72 **Direct Buried Underground Conduits and Ducts**

E72.1 Description

- (a) Labour, Products, equipment and services necessary for direct buried underground conduits/ducts Work in accordance with the Contract Documents.

E72.2 References

- (a) CSA C22.2 No. 85, Rigid PVC Boxes and Fittings.
- (b) CSA C22.2 No. 211.2, Rigid PVC (Unplasticized) Conduits.
- (c) CEC, Canadian Electrical Code.

E72.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Technical data supplemented by bulletins, component illustrations, detailed views, technical descriptions of items and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - (iii) Product transportation, storage, handling and installation requirements.
 - (iv) Location, depth and routing of conduits/ducts buried or encased in concrete.
 - (v) Provide conduit identification, circuit numbers, conduit routing length and conduit type.
- (b) Closeout Submittal(s):
 - (i) Submit copy of full set of reviewed Shop Drawings and, if applicable, Marked-up Shop Drawings.
 - (ii) Submit warranty information.

E72.4 Materials - Rigid PVC Conduit/Duct

- (a) Manufacturers:
 - (i) Ipex Scepter.
 - (ii) Royal.
- (b) Components:
 - (i) PVC tubing shall be in accordance with CSA C22.2 No. 211.2, Schedule 40, sunlight resistant, FT-4 rating, fire resistant, impact and chemical resistant, non-corrosive and non-magnetic.
 - (ii) Used in direct burial, encased or in concrete reinforced duct bank.
 - (iii) PVC conduit fittings shall be of the same material and manufacturer as PVC conduit.
 - (iv) Cement shall be solvent type for PVC conduit of the same manufacturer as PVC conduit.
 - (v) Rigid type EB1 and DB2/ES2 (CSA C22.2 No. 211.1) PVC conduit is not permitted.

E72.5 Materials – Fish Wire

- (a) Yellow, waterproof, polypropylene rope, minimum 6 mm diameter.

E72.6 Materials – Warning Tape

- (a) 0.10 mm thick polyethylene tape manufactured by Brady or Seton.

E72.7 Installation – Direct Buried Conduits/Ducts

- (a) Install rigid PVC conduits/ducts in accordance with manufacturer's instructions, in locations indicated on Contract Drawings and in accordance with the CEC.
- (b) Use manufactured curved segments for sweep bends. For large radius bends use equal straight segments joined together with deflection couplings to give maximum deflection at each coupling of 5 degree.
- (c) Buried conduits/ducts shall run parallel to or 90 degree to building lines.
- (d) At joints, apply jointing cement in accordance with manufacturer's instructions.
- (e) Prior to backfill, notify City of Winnipeg to verify location, depth and routing of conduits/ducts.
- (f) Install fish wire in empty conduits/ducts to facilitate wire and cable pulling.
- (g) Immediately before pulling wires or cables into conduit run, snake conduits with steel band attached to tube cleaner equipped with spherical mandrel of diameter minimum 85% of nominal inside diameter of conduit. Remove and replace conduits not passing mandrel.
- (h) Clean conduits/ducts ends of burrs. Thoroughly clean with suitable mandrels to remove dirt, concrete and imperfections likely to damage wires or cables during pulling operation.
- (i) Remove or replace conduits/ducts not permitting free passage of wires and cables.
- (j) Protect conduits/ducts from entrance of water or other foreign matter by capping overnight, or if Work is temporarily suspended. Cap unused conduits/ducts for watertight seal.
- (k) Place red plastic warning tape above centreline of each conduit/duct, 300 mm below grade, through entire length of run unless indicated otherwise.
- (l) Close both ends of spare ducts and future ducts with bell end plug of same material duct, inserted into a coupling to form a watertight seal.
- (m) Backfill conduits/ducts.

E72.8 Bending Radius – Direct Buried Conduits/Ducts

- (a) Make bends in conduit of following minimum radii:

Size of Conduit	Minimum Radius of Bend
21 mm & 27 mm	300 mm
41 mm	450 mm
53 mm	600 mm
103 mm	900 mm

E73 **Electrical Identification**

E73.1 Description

- (a) Labour, Products, equipment, and services necessary for identification of electrical equipment and systems in accordance with Contract Documents.

E73.2 References

- (a) CEC, Canadian Electrical Code.

E73.3 Identification Requirements

- (a) Use identification system on Shop Drawings.
- (b) Identification to be in English.
- (c) Develop principal equipment numbers as specified in this Section.
- (d) Manufacturer's Nameplate:
 - (i) Mount manufacturer's nameplate with raised letters on each piece of equipment, mechanically fastened using stainless steel rivets or screws.
 - (ii) Indicate:
 - Size.
 - Model.
 - Manufacturer's name.
 - Serial number.
 - Performance data.
 - Electrical data: Including voltage, cycle, phase, power, and motor size.
 - Service information.
 - Manufacturing date.
- (e) Install approval label and registration plates (i.e., CSA or ULC) as required by authorities having jurisdiction.

E73.4 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Catalogue cut sheets, technical data, and standard details.
 - (ii) Manufacturer's installation requirements and instructions.
 - (iii) Equipment schedule indicating equipment location (including room number), service, identifier, nameplate type, and nameplate colour.
 - (iv) Fasteners, colour of background, dimensions, thicknesses, finishes, and colour of identification letters per application.
 - (v) Composite identification label and fastener detail.
 - (vi) Nameplate drawings complete with associated wording.

E73.5 Materials – Nameplates

- (a) Fabricate nameplates to withstand wear or deterioration of lettering in located environment.
- (b) Equipment and component nameplates: Black letters on white background.
- (c) Manufacturer(s):
 - (i) Brady Canada.
 - (ii) Seton Canada.

E73.6 Materials – Conduit and cable tags

- (a) Circular, stainless steel tags. Size to suit electrical identifier, with identification markings machine engraved uppercase, 6 mm high, black lettering. Tags to be complete with stainless steel wire, clamps, and associated fasteners.
- (b) Manufacturer(s):
 - (i) Brady Canada.
 - (ii) Seton Canada.

E73.7 Materials – Wire markers:

- (a) White, slip-on polyolefin printable markers with black imprint.
- (b) Manufacturer(s):
 - (i) Brady Canada.
 - (ii) Thomas & Betts.

E73.8 Materials – Buried conduit and cable marker:

- (a) 0.10 mm thick polyethylene electrical warning tape.
- (b) Manufacturer(s):
 - (i) Brady Canada.
 - (ii) Seton Canada.

E73.9 Materials – Permanent electrical colour coding tape:

- (a) 0.18 mm thick vinyl plastic tape.
- (b) Product(s) and Manufacturer(s):
 - (i) Scotch 35 Series, by 3M Inc.

E73.10 Installation

- (a) Install identification in accordance with manufacturer's written instructions.
- (b) Conduit and cable:
 - (i) Colour code conduit, cable, and metallic sheathed cable with permanent plastic tape or paint strip, in accordance with manufacturer's recommendation, at points where conduit or cable enters walls, ceilings or floors, and at 15 m intervals.
 - (ii) Identify embedded conduit and cable with tags securely affixed to surface of concrete adjacent to box, device or equipment from which it originates. Secure conduit and cable tags to substrate with minimum of two stainless steel fasteners.
 - Tags for embedded conduit and cable within tunnel and box structure safety walkways to be located on vertical concrete face of safety walkway.
 - (iii) Arrange numbering on conduit and cable tags to prevent numbers being obscured by adjacent conduits and cables.
 - (iv) Identify conduit and cable within 150 mm of box, device or equipment from which it originates and from which it ends.
 - (v) Identify conduit and cable penetrating walls, floor or ceilings on both sides.
 - (vi) Identify conduit and cable where they exit or enter from or to other raceway systems.
- (c) Wire:
 - (i) Identify power wiring with wire markers on both ends of phase conductors of feeders and branch circuit wiring in accordance with CEC.
 - (ii) Identify control wiring with wire markers. Number in accordance with wiring interconnection lists, schematic diagrams, and schedules where applicable.

- (iii) Identify individual wires with wire markers applied at both ends of wire.
 - (iv) Circuiting designation to include panel designation, circuit number, and wiring at devices, including terminal blocks and junction points.
 - (v) Provide wire identification system consistent with schematics.
 - (vi) Place identification labels within 10 mm of terminating point in visible location.
 - (vii) Maintain phase sequence and colour coding throughout Work.
- (d) For buried incoming services install buried-conduit and buried-cable markers on building where buried service enters.
- (e) Equipment:
- (i) Place identifying label on each cell or cubicle of electrical equipment, comprised of several cells or cubicles such as switchgear and motor control centres.
 - (ii) Visible manufacturer's trademarks, nameplates or names are not permitted in areas accessible to the public.
 - (iii) Provide high voltage equipment with warning signs, suitably engraved as required to meet requirements of inspection authority.
 - (iv) Identify junction boxes enclosing wires or connections with equipment nameplates including voltage, circuit number, and source.
 - (v) Provide equipment nameplates on equipment such as circuit breakers, disconnect switches, panelboards, and pushbutton stations.
 - (vi) Mount typewritten circuit directory with clear plastic cover on inside of each panelboard door, and indicate breaker or switch circuit number, rating, load description and load data, and panel number.
- (f) Nameplates:
- (i) Secure nameplates to equipment and substrates with minimum of two self-tapping stainless steel screws. Do not allow screws to extend more than 3 mm beyond enclosure interior wall and remove sharp ends. Adhesive type labelling is not permitted.
 - (ii) Wording on nameplates: To be acceptable to City of Winnipeg prior to manufacturing.
 - (iii) Ensure manufacturer's nameplates and authority approval (CSA, ULC) labels are visible and legible after equipment is installed.
 - (iv) Clean surface with alcohol before applying waterproof polyester labels.

E74 **Electrical Testing**

E74.1 Description

- (a) Labour, Products, equipment and services necessary electrical testing Work in accordance with the Contract Documents.

E74.2 References

- (a) ANSI/NEMA-ST-20, Dry Type Transformers for General Applications.
- (b) CAN/CSA C22.2 No. 29-M, Panelboards and Enclosed Panelboards.
- (c) CSA C9, Dry Type Transformers.
- (d) CEC, Canadian Electrical Code.

E74.3 General

- (a) Test conduits and ducts installed but required left empty for clean bore. Install fish wire and cap.
- (b) Testing methods and test results to CSA, the Electrical Code, Manitoba Hydro, authorities having jurisdiction and manufacturer's recommendations.
- (c) Perform testing with systems completely connected, both loaded and unloaded.

E74.4 Electrical Distribution System

- (a) Control and switching:
 - (i) Test circuits for correct operation of devices, switches and controls.
- (b) Polarity tests:
 - (i) Test circuits for correct operation of devices and polarity sequence.
- (c) Voltage tests:
 - (i) Perform voltage test at last outlet of each circuit. Maximum drop in potential permitted 3% on 120 V and 208 V branch circuits; 3% on 208 V feeder circuits; and 3% on 600 V feeder circuits.
- (d) Phase balance:
 - (i) Measure load on each phase at each switchboard, splitter, distribution panelboard and report results in writing to City of Winnipeg. Re-arrange phase connections as necessary to balance load on each phase as instructed by City of Winnipeg. Re-arrangement restricted to exchanging of connections at distribution points.
- (e) Supply voltage:
 - (i) Measure line voltage of each phase at load terminals of main breakers and report results in writing to City of Winnipeg. Perform supply voltage test to electrical equipment in use.
- (f) Conductors:
 - (i) Dielectric test on 120/208 V equipment and wiring: Apply 500 V DC for one minute between phase conductors and between each phase conductor and ground. Test voltages for 600 V equipment and cables as recommended by manufacturers of equipment and cable.
 - (ii) Insulation resistance test: After dielectric test complete, measure insulation resistance by approved resistance measuring instrument. Insulation resistance between connected system and ground: minimum values prescribed under Insulation Resistance in the CEC.
 - (iii) Remove and replace shorted, grounded or defective conductors.
- (g) Distribution panels:

- (i) Verify and record information for each distribution panel as to:
 - Manufacturer.
 - Amp rating.
 - Voltage.
 - Phasing.
 - Correct operation of each breaker.
 - Labelling.
- (h) Transformers:
 - (i) Conduct field inspections and tests, prior to energizing, to CSA C9 and CAN/CSA C22.2 No. 47-M.
 - (ii) Operation: Verify and record sound level (dB) per ANSI/NEMA-ST-20 information for each transformer.
 - (iii) Record transformer nameplate data as follows:
 - Manufacturer.
 - kVA.
 - Impedance.
 - Primary voltage.
 - Secondary voltage.
- (i) Grounding
 - (i) Verify resistance and continuity of driven electrodes, connections, grounding conductors, main bonding conductors and supplementary bonding conductors.
- (j) Heat Tracing and Snow Melting
 - (i) Use 2500 V DC megger to test cables for continuity and insulation value and record readings as follows:
 - On cable reel.
 - After installation.
 - Before sand/concrete placement.
 - During concrete pour.
 - 24 hours after paving stone/concrete placement.
 - (ii) Advise City of Winnipeg where resistance of 1000 megohms or less is measured.
- (k) Ducts/Conduits
 - (i) Verify each underground duct or conduit to contain no blockages by pulling through appropriately sized mandrel in presence of City of Winnipeg.

E75 **Dry Type Transformer**

E75.1 Description

- (a) Labour, Products, equipment and services necessary for transformer equipment in accordance with the Contract Documents.

E75.2 References

- (a) IEEE, Institute of Electrical and Electronics Engineers.

E75.3 Submittals

- (a) Submit the following:
- (b) Shop Drawing(s):
 - (i) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - (iii) Product transportation, storage, handling, and installation requirements.
 - (iv) Elevations, sections and details, dimensions, gauges, and finishes.
 - (v) Complete electrical wiring diagrams including electrical schematics and sequence of operation.

E75.4 Products

- (a) Transformer
 - (i) Schneider 5S4F - Low voltage transformer, encapsulated dry type, 1 phase, 5kVA, 600V primary, 120/240V secondary, Type 3R
 - (ii) Or approved equal.

E75.5 Installation

- (a) Install ground rods. Measure ground resistance. Add additional rods to meet Code requirements.
- (b) Install transformer.
- (c) Connect non-current carrying metal parts in vault to wall ground strap.
- (d) Set transformer taps for secondary voltage of 120/240 V at no load.
- (e) Install hangers and brackets to mount the transformer up high.
- (f) Do grounding work to IEEE 80 except where specified otherwise.

E76 Dry Type Transformer

E76.1 Description

- (a) Labour, Products, equipment and services necessary for panelboard Work in accordance with the Contract Documents.

E76.2 References

- (a) ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by Hot-Dip Process.
- (b) CSA C22.2 No. 29, Panelboards and Enclosed Panelboards.
- (c) CAN/CGSB-1.81-M, Air Drying and Baking Alkyd Primer for Vehicles and Equipment.
- (d) CAN/CGSB-1.104-M, Semigloss Alkyd Air Drying and Baking Enamel.
- (e) CSA C22.2 No. 0.4, Bonding of Electrical Equipment.
- (f) CSA C22.2 No. 5, Moulded Case Circuit Breakers, Molded – Case Switches and Circuit-Breaker Enclosures.
- (g) CSA C 22.2 No. 94-M, Special Purpose Enclosures.
- (h) **CEC, Canadian** Electrical Code.

E76.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - (i) Technical data, supplemented by bulletins, component illustration, detailed views, technical descriptions of items, and parts lists.
 - (ii) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - (iii) Product transportation, storage, handling, and installation requirements.
 - (iv) Elevations, sections and details of components, dimensions, gauges, finishes and relationship to adjacent construction.
 - (v) Schematic, complete panel circuit schedule in accordance with Contract Documents.

E76.4 Commissioning Submittal(s):

- (a) Submit Test Procedures.
- (b) Submit Certificate of Readiness.
- (c) Submit Test Reports.
- (d) Submit Closeout Report.

E76.5 Manufacturers

- (a) Schneider Electric.
- (b) Cutler-Hammer.

E76.6 Materials

- (a) Steel sheet: ASTM A653, Z275 coating designation; galvanized steel sheet.
- (b) Stainless steel sheet: ASTM A240, type 304.
- (c) Expanding type metallic anchors: Cinch two unit threaded anchorages.
- (d) Bolts: 10 mm diameter to suit anchors.

E76.7 Panelboard

- (a) Panelboards: To CSA C22.2 No. 29 and Canadian Electrical Code requirements, including barriers.
- (b) EEMAC 3R, rated at 600/347 V, 3 phase, 4 wire, for distribution of normal power for navigational lighting circuits and electric heating circuits as shown on Contract Documents and unless noted otherwise.
- (c) Panelboard interiors factory assembled, with bolt-on circuit breakers and designed so circuit breakers for replacement without disturbing adjacent devices and without removing main bus connectors.
- (d) Panelboards with tin plated copper buses, bus bracing 22 kA unless noted otherwise.
- (e) Main bus bars shall be rated for continuous current as indicated on the Contract Documents. Bussing shall be of sufficient cross-sectional area to meet CSA C22-2 No. 29 standard for temperature rise.
- (f) Solid neutral bus shall be designed to meet the requirements of CSA C22.2 Nos. 0.4 and 29. Neutral bussing shall have a suitable lug for each outgoing feeder and spaces on the panel board.
- (g) Solidly bonded copper ground bus shall be provided.
- (h) All circuit carrying parts shall be insulated from ground and phase-to-phase by high dielectric strength barrier or equivalent.
- (i) Main circuit breaker and main lug panel board interior shall be field convertible for top or bottom incoming feed.
- (j) All unused space provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
- (k) Interior trim shall be dead-front construction to shield user from energized parts. Empty spaces shall be provided with blanking plates.
- (l) Connections with solderless lugs on main and neutral busbars and at circuit breaker load terminals.
- (m) Cabinets of steel sheet, thickness equal to code gauge for similar steel cabinets, fabricated in C form type style and having spot-welded seams.

E76.8 Circuit Breakers (Main and Branch)

- (a) All circuit breakers: Moulded case, over-centre, trip-free, toggle mechanism, operated with quick-make, quick-break contact action, calibrated at 40°C, bolted into panel assemblies of busses and connectors. Trip ratings as shown on the Contract Documents.
- (b) Circuit breakers: one, two or three pole as required, equipped with thermal and magnetic trip units having inverse time current characteristics. Two-pole and three-pole breakers shall have common trip action between individual trip elements for each pole. Automatic tripping indicated by breaker handle assuming distinctive position from manual "on" and "off" positions.
- (c) Circuit breakers (main and branch) frame size as shown on Contract Documents meeting requirements of CSA C22.2 No. 5M with minimum 22 kAIC unless noted otherwise.
- (d) Circuit breakers handle and faceplate shall indicate rated ampacity. Standard construction of circuit breakers shall comply for reverse connection without restrictive line or load markings.
- (e) Branch circuit breaker shall be CSA or cUL listed as HACR (Suitable for Heating, Air-conditioning Loads) or SWD (Switch duty of fluorescent or High Intensity Discharge Lighting Load).

- (f) Provide ground fault circuit breaker with 30 mA sensitivity as shown on Contract Documents. Ground fault circuit-breaker with minimum 10 kAIC at 208 V or 600 V.

E76.9 Enclosures

- (a) Constructed from galvanized steel sheet, of thickness equal to code gauge for similar steel cabinets, fabricated by "forming up" and having spot-welded seams. Panelboard cabinet assembly to comply with CSA enclosure type 2.
- (b) Enclosure width shall be maximum 660 mm, minimum 508 mm.
- (c) Enclosures shall have end walls with knockouts complete with welded interior mounting studs.
- (d) Finish on enclosures and trim as follows:
 - (i) High quality metal primer coat to CAN/CGSB-1.81-M, Type 1 and filler and Body coats then applied on inside and outside surfaces.
 - (ii) Finish coats alkyd base enamel conforming to CAN/CGSB-1.104-M colour conforming to CGSB 1-GP-12c, Section 5, Code 501-211, Grey Semi-gloss, type 11. Each enamel coat dried and rubbed before following coat applied.
 - (iii) Cardholder for circuit designation cards, consisting of heavy white paper under transparent cover and mounted in suitable metal frame, supplied on back of each panel door.
- (e) Trim
 - (i) Trim: Galvanized steel sheet, of code thickness.
 - (ii) Trim shall be one piece with hinged door and mounted with trim screws door-in-door. Mounting shall be flush or surface as indicated on the Contract Documents.
 - (iii) Front cover plate complete with lock shall be hinged to door.
 - (iv) Each door with latch and flush cylinder type lock operated with key. Supply two keys for each lock. Fasten trim to cabinets by means of approved non-corroding clamps.
- (f) Panel Circuit Schedule
 - (i) After panelboards phase balanced, fill-in panel circuit schedule and insert it into cardholder provided on back of panel door. Schedule typewritten and neatly arranged indicating which loads fed by each circuit.

E76.10 Installation

- (a) Install support channels to concrete and masonry substrates.
- (b) Where no mounting surface available, install steel supports for mounting of panelboard cabinets.
- (c) Install panelboards to support channels in locations shown on Contract Drawings and in accordance with manufacturer's written instructions. Use minimum of 4 fasteners for each panel.
- (d) Where panelboard cabinets mounted on concrete surfaces, mount cabinets with minimum of 4 bolts and anchors.
- (e) Set panelboards plumb, true and square with adjacent surfaces at location shown on Contract Drawings.
- (f) Make electrical connections, including grounding.

E77 Lighting Equipment

E76.1 Description

- (a) Labour, Products, equipment, and services necessary for lighting equipment Work in accordance with the Contract Documents.

E76.2 References

- (a) CSA C22.2 No. 9.0, General Requirements for Luminaires.
- (b) CSA C22.2 No. 250.0, Luminaires.
- (c) CAN/CSA-C22.2 No. 250.13, Light Emitting Diode (LED) Equipment for Lighting Applications.
- (d) NEMA SSL-1, Electronic Drivers for LED Devices, Arrays, or Systems.
- (e) CEC, Canadian Electrical Code.
- (f) UL 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products.

E76.3 Submittals

- (a) Submit the following Shop Drawing(s):
 - a. Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists.
 - b. Luminaire photometric data: Computer generated illuminance print out for area lit by luminaire.
 - c. Elevations, sections, and details of fixtures and components, dimensions, gauges, finishes, and relationship to adjacent construction.
 - d. Manufacturer's technical documentation for lamps such as operating voltages, wattage, lumens, rated life, colour temperature K, base type, and lamp shape.
- (b) Commissioning Submittal(s):
 - (i) Submit Test Procedures.
 - (ii) Submit Certificate of Readiness.
 - (iii) Submit Test Reports.
 - (iv) Submit Closeout Report.

E76.4 Green Lighting Design

- (a) Use energy-efficient lamps.

E76.5 Extended Warranty

- (a) Provide warranty for full replacement parts and labour included from the date of Substantial Performance, except warranty period is extended to 5 years.

E76.6 Materials and Accessories

- (a) Electrical equipment and devices: CSA approved or ULC listed.

E76.7 Luminaires

- (a) Provide luminaires as noted in lighting fixture schedules shown on the Contract Drawings.
- (b) LED module/diode manufacturer(s):

- (i) Cree, Inc.
 - (ii) Philips Lighting Holding B.V.
 - (iii) Osram-Sylvania Ltd.
 - (iv) Nichia Corporation.
- (c) LED Lamps/Driver:
- (i) Colour temperature of 4000 K +/-250, unless otherwise specified.
 - (ii) Minimum CRI of 65.
 - (iii) Form factor: Round or square in accordance with the application.
 - (iv) Efficacy: Minimum 90 lm/W.
 - (v) L70 of $\geq 100,000$ hours (70% of initial lumens) at 25°C outdoor and 55°C for indoor, and supported by IES LM-80 and IES TM-21 calculations.
 - (vi) With fixture-integrated passive heat sinking.
 - (vii) IES file based on IES LM-79.
 - (viii) Provide IP rating and, where applicable, for hazardous locations.
 - (ix) Photo cell compatible with LED Driver.
 - (x) LED fixtures to be in service 24/7. Colour temperature shift or L70 rating de-rating is

E76.8 INSTALLATION

- (a) Light Fixtures:
- (i) Install lamps/LED engines in all fixtures unless otherwise indicated on Contract Drawings.
 - (ii) Install lighting fixtures in locations indicated on Contract Drawings, or as directed by City of Winnipeg. Align luminaries parallel or perpendicular to building grid line.
 - (iii) Luminaires to be properly cleaned at time of installation. Luminaries showing marks or scratches due to handling or tool-marked will be rejected without cost to City of Winnipeg.
 - (iv) Do not daisy-chain light fixture wiring. Provide junction boxes and individual wiring to each light fixture.

E78 Snow Melting and Heat Tracing

E78.1 Description

- (a) This Specification shall cover all operations relating to a UL Listed and CSA Certified snow melting heat tracing system consisting of mineral insulated heating cable, connection kits and electronic controller.

E78.2 Submittals

- (a) Product Data
 - (i) Heating cable data sheet
 - (ii) UL, CSA approval certificates for snow melting
 - (iii) Snow melting design guide
 - (iv) System installation and operation manual
 - (v) System installation details
 - (vi) Connection kits and accessories data sheet
 - (vii) Controller/Power Panel data sheet
 - (viii) Controller/Power Panel wiring diagram
- (b) Quality Assurance
 - (i) Manufacturer to show minimum of thirty (30) years' experience in manufacturing mineral insulated (MI) heating cables.
 - (ii) Manufacturer will be ISO-9001 registered.
 - (iii) Manufacturer to provide products consistent with UL 515, CSA 22.2 No 130-03 and IEEE 515.1 requirements.
 - (iv) System installer shall have a complete understanding of product and product literature from manufacturer or authorized representative prior to installation. Electrical connections shall be performed by a licensed electrician.
 - (v) The system (heating cable, connection kits, and controller) shall be UL Listed and CSA Certified for snow melting.

E78.3 Materials

- (a) HDPE Jacketed Copper Sheathed Mineral Insulated Heating Cable
 - (i) Heating cable shall be Raychem MI heating cable manufactured by nVent Thermal.
 - (ii) The heating cable shall consist of a single conductor surrounded by magnesium oxide insulation with a solid, seamless copper sheath.
 - (iii) The heating cable shall have an extruded high density polyethylene (HDPE) jacket to protect the cable from corrosive elements that can exist in the concrete.
 - (iv) The heating cable shall be factory terminated with a minimum 7 foot cold lead (unheated) length.
 - (v) The heating cable shall operate on line voltages of 600 volts without the use of transformers.
 - (vi) The heating cable shall be part of a UL Listed and CSA Certified system.
 - (vii) The MI heating cable tag shall have the following markings:
 - Complete heating cable model number
 - Agency listings
 - Serial Number
 - Lot/Batch ID
- (b) Heating Cable Installation Accessories

- (i) Prepunched strapping – Used to maintain proper spacing of the MI heating cable during installation. (Catalog Number: SPACER-GALV)
 - (ii) Snow Melting Caution Sign – The snow melting caution sign is required by national electrical codes to indicate that an electrical snow melting system is installed in the slab. (Catalog Number: SMCS)
- (c) Control Methodology
- (i) Group Control
 - Group controller shall be Raychem SMPG3 snow melting and de-icing power distribution and control panel.
 - Heating cable manufacturer shall provide a group snow/ice melting controller with built-in GFPD compatible with selected heating cable.
 - Group snow/ice melting controller shall have an integrated 30-mA ground-fault circuit breakers.
 - Group snow/ice melting controller shall have 3 ground-fault circuit breakers rated up to 50 A. Group snow/ice melting controller shall have a main circuit breaker
 - Group snow/ice melting controller shall be capable of operating with supply voltages of 600 V three phase (SMPG3)
 - Group snow/ice melting controller shall be capable of supporting up to six (6) type SNOW OWL aerial temperature and moisture sensors.
 - Group snow/ice melting controller enclosure shall be NEMA 4.
 - Group snow/ice melting controller shall have an adjustable hold-on timer (0 – 10 hours).
 - Group snow/ice melting controller shall have an integrated high-limit temperature sensor.
 - Electronic snow/ice melting controller shall have contacts (floating switch contacts rated at 5 Vdc at 10 mA) to interface with an Energy Management Computer (EMC).
 - Inputs: Override On, Override Off
 - Outputs: Supply, Snow/Ice, Heat
 - Digital controller shall have c-UL-us approvals.

E78.4 Construction Methods

- (a) Comply with manufacturer's recommendations in the Surface Snow Melting - MI Installation and Operation Manual (H57754).
- (b) Install and secure the heating cable in accordance with the Surface Snow Melting - MI Installation and Operation Manual (H57754).
- (c) Install electric heating cable according to the drawings and the manufacturer's instructions. The installer shall be responsible for providing a complete functional system, installed in accordance with applicable national and local requirements.
- (d) Grounding of controller shall be equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- (e) Connection of all electrical wiring shall be according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

E78.5 Quality Control

- (a) Start-up of system shall be performed by factory technician or factory representative per the owner's requirements.

- (b) The system shall be commissioned in accordance to the Surface Snow Melting - MI Installation and Operation manual.
- (c) The heating cable circuit integrity shall be tested using a 1000 Vdc megohmmeter at the following intervals below. Minimum acceptable insulation resistance shall be 20 megohms.
 - (i) Before installing the heating cable
 - (ii) Continuously during concrete or asphalt pour
 - (iii) After concrete or asphalt pour is complete
 - (iv) Prior to initial start-up (commissioning)
 - (v) As part of the regular system maintenance
- (d) The heating cable circuit integrity shall be tested using a 1000 Vdc megohmmeter at the following intervals below. Minimum acceptable insulation resistance shall be 20 megohms.
- (e) The technician shall verify that the Raychem SMPG3 control panel control parameters are set to the application requirements.
- (f) The technician shall verify that the Raychem SMPG3 control panel alarm contacts are corrected connected to the BMS.
- (g) All commissioning results will be recorded and presented to the owner.

E78.6 Measurement and Payment

- (a) The supply and installation of the snow melting and heat tracing shall be a lump sum for all equipment for both tunnels.