

Capital Projects Group

Raceway for Electrical Systems Specification

Specification 26 05 34

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1. GENERAL

1.1. SCOPE OF WORK

- 1.1.1. Labour, products, equipment and services necessary for raceway for electrical systems Work.
- 1.1.2. Raceway is defined as any channel designed for holding wires, cables, or busbars, and, unless otherwise qualified in the Rules of the OESC, the term includes conduit (rigid and flexible, metal and non-metallic), electrical metallic and non-metallic tubing, underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters.
- 1.1.3. Raceways dedicated to rail corridor functions are excluded from this Specification. Refer to Metrolinx standard "Rail Corridor Raceway Requirements Guideline".

1.2. DESIGN REQUIREMENTS

- 1.2.1. The equipment furnished and the equipment installation, wiring methods and materials used shall conform to the latest edition of the Ontario Electrical Safety Code, Electrical Safety Authority (ESA) Bulletins and Supplements issued by the Electrical Safety Authority, and the applicable Metrolinx Standards. In case of any conflicts, the more stringent requirement shall apply.
- 1.2.2. Design Electrical equipment and systems to all applicable standards of CSA, ULc, IEEE, ESA.
- 1.2.3. Design electrical equipment and systems to Metrolinx DRM.
- 1.2.4. Design electrical equipment and systems to standards and codes to be latest editions adopted by and enforced by local authorities have jurisdiction.
- 1.2.5. Raceways shall be grounded and bonded in accordance with the OESC and Metrolinx standards including MX-ELEC TRAC EW-SPEC, MX-ELEC TRAC EW-DW, MX-ELEC STR-SPEC, and MX-ELEC EM. In case of any conflicts, the more stringent requirement shall apply.
- 1.2.6. All designs shall minimize EMF effects and do everything needed to reduce EMI on the site. The design shall include the selection and specification of equipment that will reduce or eliminate the EMI effects. Power and communication raceways shall be separated throughout the system. The only exception being Power-over-Ethernet wiring. Clearance between Power and communication raceways shall be application specific as per Contract Documents Refer to Metrolinx standard MX-ELEC EMI-SPEC.
- 1.2.7. Raceways shall be designed, supplied and installed as a complete system with all conduits, cable trays, fittings, supports, hangers and miscellaneous support materials and hardware as required for the complete systems in accordance with the applicable codes and regulations and as specified herein and on the Contract Documents.

- 1.2.8. Raceways shall follow building line with perpendicular changes in direction.
- 1.2.9. Raceways shall be designed to complement the building design; raceways in public or Metrolinx staff areas shall be concealed.
- 1.2.10. Raceways shall present a neat and clean appearance when installed.
- 1.2.11. Raceways shall not be mounted directly to walls and ceilings. They shall be hung or mounted on U-channel supports.
- 1.2.12. Refer to Section 2 of this Specification for design requirements of specific raceway types.
- 1.2.13. Where permitted by Code and approved by Metrolinx, cable may shall be installed outside of raceways in accordance with the OESC requirements (supported free run, direct buried). This includes armoured cable such as Teck.
- 1.2.14. Raceways for cablebus or solid busbar used for interconnection of transformers to switchgear or switchboards or similar high current applications shall be designed per application per Code and standards and submitted for Metrolinx Approval.
- 1.2.15. Raceways that cross the rail corridor are permitted and shall meet the most stringent requirements set by AREMA, CSA, OESC, and Metrolinx Standard "Rail Corridor Raceway Requirements Guideline".
- 1.2.16. Minimum conduit size 21 mm unless indicated otherwise. No reduction in sizes shall be permitted without the acceptance of Metrolinx.
- 1.2.17. Communications conduit shall be 53 mm unless indicated otherwise.
- 1.2.18. Home-run conduit shall be minimum 53 mm (home run defined as conduit running from the last pull point before the load or destination going back to the electrical or communication room).
- 1.2.19. Spare capacity for future additions:
 - a) In general raceways shall be provided with 25% spare capacity in the form of unused space within the raceway unless other requirements are stated in this Specification.
 - b) Duct banks of two or more conduits shall be provided with 25% spare and unused conduits (rounded up to nearest unit conduit).
- 1.2.20. Tunnel designs shall utilize floor raceways and wall chases or cavities. The design will include all transition methods required in the design to transition between floor, wall and ceilings in the tunnel to platform, canopy and across any openings like stairs elevators. The design shall allow for providing services required to service facilities on the other side of the tunnel which are furthest away from the power or signal source tunnel entrance.

- 1.2.21. Exposed conduits shall be metallic, and conduits embedded in concrete shall be non-metallic unless otherwise indicated.

1.3. RELATED WORKS

- 1.3.1. Section 26 05 00 Electrical General Requirements.
- 1.3.2. Section 26 05 13 - Medium-Voltage Cables.
- 1.3.3. Section 26 05 21 - Electrical Conductors and Cables.
- 1.3.4. Section 26 05 31 - Splitter Boxes, Junction Boxes and Pullboxes.

1.4. REFERENCE STANDARDS

- 1.4.1. Ontario Electrical Safety Code (OESC).
- 1.4.2. Ontario Building Code (OBC).
- 1.4.3. Metrolinx Standards, Drawings and Specifications.
- 1.4.4. Metrolinx Design Requirement Manual (DRM).
- 1.4.5. Metrolinx Electrical Identification and Nomenclature Specification MX-ELEC ID-SPEC.
- 1.4.6. CAN/CSA G164, Hot Dip Galvanizing of Irregular Shaped Articles.
- 1.4.7. CSA C22.1, Canadian Electrical Code, Part 1, Safety Standards for Electrical Installations.
- 1.4.8. NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems.
- 1.4.9. UL 2196, 2 Hour Fire Test for Fire Resistive Cables (RTRC- Phenolic).
- 1.4.10. NEMA VE-1, Metal Tray Systems.
- 1.4.11. NEMA VE-2, Cable Tray Installation Guidelines.
- 1.4.12. ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- 1.4.13. ASTM E136, Standard Test Method for Behaviour of Materials in a Vertical Tube Furnace 750°C.
- 1.4.14. CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
- 1.4.15. CSA C22.2 No. 211.2, Rigid PVC (Unplasticized) Conduit.
- 1.4.16. CSA C22.2 No. 26, Construction and Test of Wireway, Auxiliary Gutters and Associated

- 1.4.17. CSA C22.2 No. 45, Rigid Metal Conduit.
- 1.4.18. CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
- 1.4.19. CSA C22.3 No. 7 Underground systems.
- 1.4.20. CAN/CSA C22.2 No. 62, Surface Raceway Systems.
- 1.4.21. CSA C22.2 No. 83, Electrical Metallic Tubing.
- 1.4.22. CSA C22.2 No. 85, Rigid PVC Boxes and Fittings.
- 1.4.23. CAN/CSA C22.1 No.126.1, Metal Cable Tray Systems.
- 1.4.24. CAN/CSA C22.1 No.126.2, Non-Metallic Cable Tray Systems.
- 1.4.25. EEMAC E14-2, Industrial Controls and System Standard.
- 1.4.26. National Electrical Manufacturers Association (NEMA)
- 1.4.27. NEMA FG 1, Fibreglass and Cable Tray Systems.
- 1.4.28. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.

1.5. SPARE PARTS

- 1.5.1. Not Applicable

1.6. TRAINING

- 1.6.1. Not applicable

1.7. WARRANTY

- 1.7.1. Refer to Section 26 05 00

1.8. DELIVERY, STORAGE AND HANDLING

- 1.8.1. Deliver cable tray systems and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.
- 1.8.2. Store cable trays and accessories in original cartons and in clean dry space; protect from weather and construction traffic. Wet materials should be unpacked and dried before storage.

1.9. SUBMITTALS

- 1.9.1. Product Data and Shop Drawings Package:

- a) Submit manufacturer's Product data indicating:
 - 1) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists.
 - 2) Submit manufacturer's product data sheets for cable tray, fittings and accessories, indicating dimensions, materials, and finishes, including classifications and certifications.
 - 3) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol.
 - 4) Product transportation, storage, handling, and installation requirements.
 - 5) Product identification.
 - 6) Identify types of cable trays used.
- b) Submit Shop Drawings indicating:
 - 1) Location, depth and routing of conduits/ducts buried or encased in concrete.
 - 2) Provide conduit identification, circuit numbers, conduit routing length and conduit type.
 - 3) Submit shop drawings showing materials, finish, dimensions, accessories, layout, and installation details.
 - 4) Show actual cable tray installation details and suspension system.
 - 5) Elevations, sections and details, dimensions, gauges and finishes.
 - 6) Adjacent construction, elevations, sections and details of components, dimensions, gauges, finishes and relationship to adjacent construction.
 - 7) Fabrication and installation of cable tray, fittings and supports.
 - 8) The Drawings, which constitute a part of the Specifications, shall indicate the general route of the cable runway systems. Data presented on these drawings is as accurate as preliminary surveys and planning can determine until final equipment selection is made. Accuracy is not guaranteed and field verification of all dimensions and routing, is required.
 - 9) Specifications and Drawings are for assistance and guidance, but exact routing, locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting system layout drawings.

1.10. QUALIFICATIONS

- 1.10.1. Refer to Section 26 05 00.
- 1.10.2. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum 10 years documented experience, whose products have been in satisfactory use in similar service for not less than 10 years.
- 1.10.3. Regulatory Requirements: Furnish Products listed and classified by CSA and ULC, as suitable for application.

2. PRODUCTS

2.1. GENERAL

- 2.1.1. Equipment shall be able to withstand the environmental conditions stated in Section 26 05 00 without damage or degradation of operating characteristics.
- 2.1.2. Equipment installed in classified hazardous areas shall be suitable rated for the classification.
- 2.1.3. Fish Wire for conduits: Yellow, waterproof, polypropylene rope, minimum 6 mm diameter.
- 2.1.4. Warning tape for buried raceways: 0.10 mm thick polyethylene tape, yellow.
- 2.1.5. Provide raceway grounding with a #12 AWG copper conductor run the whole length of the raceway in accordance with OESC (Ontario Electrical Safety Code) requirements. Raceway shall not be treated as ground or bonding path.

2.2. RIGID GALVANIZED STEEL (RGS) CONDUIT

- 2.2.1. Material: Hot-dip galvanized steel tubing. Metallic rigid conduit other than hot-dip galvanized rigid steel is unacceptable.
- 2.2.2. Applications: Indoor and dry locations. Permitted in hazardous locations in accordance with OESC, Section-18, hazardous locations and as indicated on Contract Drawings.
- 2.2.3. 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.

2.2.4. Conduit shall be threaded at both ends.

2.3. EPOXY OR PVC COATED RIGID GALVANIZED STEEL CONDUIT (RGSEC)

2.3.1. Material: Hot-dip galvanized steel conduit with 1.020 mm gray PVC or epoxy coating with no sags, blisters or other surface defects. Metallic rigid conduit other than hot-dip galvanized rigid steel is unacceptable.

2.3.2. Applications: locations exposed to the environmental elements (indoor/outdoor)

2.3.3. Fittings: All fittings (e.g. threaded hubs, couplings, conduit bodies, straps, elbows) shall be PVC or epoxy coated rigid galvanized steel and shall have no sags, blisters or other surface defects.

2.3.4. Conduit shall be threaded at both ends.

2.3.5. PVC/Epoxy shall be applied at factory of origin. All fittings shall be of the same type and treatment as the adjoining conduit. All repairs done on deficient conduit requiring PVC/epoxy shall be done at factory of origin. PVC/epoxy treatment, including repairs, shall not be permitted on site and shall be done in the factory of origin.

2.4. FLEXIBLE METAL CONDUIT

2.4.1. Material: Flexible steel armour.

2.4.2. 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. It shall be limited to maximum 600 V.

2.4.3. Applications: Exposed or concealed work.

2.4.4. Fittings: Rugged steel/malleable iron construction, electro-zinc plated, nylon insulated throat complete with bushing and locknut.

2.4.5. Grounding conductor to be installed in every conduit.

2.5. LIQUID-TIGHT FLEXIBLE CONDUIT

2.5.1. 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.

2.5.2. Restrictions: Not permitted in hazardous classified locations, embedded in concrete, aggregate or cinder fill. It shall be limited to maximum 600 V.

2.5.3. Applications: Indoor, outdoor, concealed, wet and dry locations.

- 2.5.4. 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.
- 2.5.5. Outdoor installation must have a drip loop.
- 2.5.6. Maximum length allowed is 1.5 m.
- 2.5.7. Grounding conductor to be installed in every conduit.

2.6. RIGID PVC CONDUIT

- 2.6.1. Material: Schedule-40, sunlight resistant, FT-4 rating, fire resistant, impact and chemical resistant, non-corrosive and non-magnetic.
- 2.6.2. Restrictions: Not permitted in hazardous classified locations. It shall not be subject to physical damage. It shall be limited to maximum 600 V.
- 2.6.3. Applications: Underground, for use in direct burial, encased in concrete, embedded in concrete floors/ceilings slabs and in walls and in reinforced concrete ductbank. Use above ground shall be no more than 300 mm above grade, encased or covered. PVC conduit is not to be used above ground or be exposed.
- 2.6.4. 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.
- 2.6.5. Cement shall be solvent type for PVC conduit by same manufacturer.
- 2.6.6. Rigid type EB1 and DB2/ES2 (CSA C22.2 No. 211.1) PVC conduit is not permitted.

2.7. ELECTRICAL METALLIC TUBING (EMT)

- 2.7.1. EMT shall not be used without Metrolinx special approval.

2.8. ELECTRICAL NON-METALLIC TUBING (ENT)

- 2.8.1. ENT shall not be used.

2.9. CABLE TRAY

- 2.9.1. General
 - a) Cable tray may be used to hold and support a variety of wiring and cables including:
 - 1) Power distribution cables.
 - 2) Control wiring and cables.

- 3) Telecommunication wiring and cables.
- 4) Fibre optical cables.
- b) Cable tray includes various sub-types and requirements are provided in this Specification.
- c) Cable tray shall be in accordance with NEMA VE-1 and as shown on Contract Drawings.
- d) Various components of cable tray shall be fully interchangeable, readily and easily assembled in field.
- e) Provide longitudinal conductive barriers where different voltage systems are located in the same cable tray.
- f) Provide #2 AWG copper bonding jumpers where cable trays sections are spliced together. Provide jumper on both side rails at each splice plate or anywhere trays are not mechanically continuous.
- g) Cable tray shall at minimum support a 90 kg concentrated load of midspan over and above stated cable load.
- h) Seismic restraints to local governing building code requirements to prevent horizontal movement.
- i) Size cable tray for contain cables to occupy 60% maximum of cross-sectional area;
- j) Size cable tray to contain cables without projecting above top of tray.
- k) Minimal cable tray sizes indicated on Contract Drawings will not be reduced without Metrolinx permission.

2.9.2. Fabrication

- a) Remove burrs and sharp edges from cable tray.
- b) Leave no holes in cable tray except as shown on Contract Drawings or required by this Specification.
- c) No screws for bonding lugs shall protrude into cable tray. Ensure maximum contact area between grounding terminal lugs and steel cable tray, smooth bare metal free of paint or foreign material.
- d) After fabrication of wireway, degrease and clean inside and outside components of wireway, except for bare stranded bonding jumper.
- e) Painted Equipment:

- 1) Apply first coat of accepted corrosion resisting metal primer followed by filler coat.
- 2) Apply two coats of CIL Alkyd Base grey enamel by dipping. Bake and rub each coat.

2.9.3. Ladder Cable Tray

- a) Ladder Cable Trays shall only be used in mechanical rooms, electrical rooms, shops, canopies, or concealed ceiling spaces.
- b) Material: Hot dipped galvanized steel.
- c) The tray shall consist of two longitudinal members (side rails) with transverse members (rungs) welded to both side rails. Both side rails and rungs shall be I-beam configuration. Side rails shall have a splice retention groove to accept a splice plate. Side rails reinforced with flanges; Maximum rung spacing of 150 mm (6"). Tray sections shall be 3 m (10'). Minimum width of 600 mm or as per Contract Documents.
- d) Aluminum (6063-T6) or an approved non-conductive material may be used where specified in Contract Documents.
- e) Cable tray shall be in compliance with CSA C22.2 No. 126.1 and NEMA VE1.
- f) Cable tray shall meet required NEMA/CSA load ratings with safety factor of 1.5 and be able to support depending on the class of tray minimum of 97 kg/m (65 lb/ft) to 299 kg/m (200 lb/ft). Class shall be selected based on conductor mass and mass of person (90 kg) plus 50% spare mass capacity as a minimum ((cable mass + 90 kg) x 150% x 1.5).
- g) Cable trays shall be cantilever-supported for ease in installation of cables.
- h) The tray shall be supported every 1.52 m (maximum distance, shorter support distances may be used as required).
- i) Fittings: horizontal elbows, end plates, drop outs, vertical risers and drops, tees, wyes, expansion joints and reducers where required, manufactured accessories for cable tray supplied.
- j) Fasteners: 6.4 mm diameter bolts in metallic masonry expansion anchors.
- k) Cable tray supports, hardware and accessories: Hot dip galvanize after fabrication to CAN/CSA G164.
- l) Radii on fittings: 600 mm minimum or as indicated in Contract Documents.
- m) Solid covers including fittings shall be provided where indicated on Contract Documents.

2.9.4. Wire Mesh Tray Requirements

- a) Wire mesh Tray is to be used as a wire management system under raised floor rooms and in radio communication rooms only. It is for telecommunication cabling.
- b) The wire mesh tray shall be supported every 1.22 m (maximum distance, shorter support distances may be used as required).

2.9.5. Channel Cable Tray Requirements

- a) Channel Cable Tray shall be used to branch off from backbone cable tray when conduit solution is not desirable. The runs are to be kept to within 3 m.

2.9.6. Single Rail Cable Tray Requirements

- a) This type of tray is not to be used.

2.9.7. Trough Cable Tray

- a) Cable trough can refer to a concrete cable trough which is often installed at ground level. This Specification applies to a trough of ventilated or solid steel, the concrete cable trough is not specified here.
- b) Trough cable tray is to be used for moderate heat generating applications.
- c) Trough cable tray may be solid bottom or ventilated.
 - 1) Ventilated trough cable tray shall be selected over ladder tray for aesthetics only. No drooping of small cables is visible. Trough cable tray provides better support of the cable than ladder tray, but this additional support is not significant. Covers are also available which can be hinged or bolt on refer to Contract Documents.
 - 2) Solid trough cable tray (with covers) is to be used to provide EMI/ RFI shielding. The solid tray must have no breaks or holes in the completed installation.
 - 3) Solid trough cable tray system shall have a method of moisture control in the cable trays. If the solid trough cable tray is not being used for EMI/RFI shielding, then provide 1/4-inch drain holes in the bottom of the cable tray at three-foot intervals (at the middle and very near the sides).

2.9.8. Cable Tray Accessories

- a) Factory made conduit connectors, couplers, fittings, tee sections, elbows, universal dropouts.
- b) Dividers constructed of same materials as tray, to separate cables as required to isolate separate voltage sources or functions (power and communication).

- c) Covers of solid or louvered type as required by the application. The covers are to be hinged or physically fastened down.
- d) Grounding and bonding jumpers and hardware.

2.10. SURFACE AND LIGHTING FIXTURE RACEWAYS

2.10.1. Surface Raceway System (Wiring Pulled In)

- a) Steel: CSA C22.2 No. 62, one piece, free of sharp edges.
- b) Corners, pull boxes, elbows, tees, two-piece assembly to facilitate site wiring.
- c) Finish: Gloss enamel.
- d) Switch, receptacle, extension boxes, adapters and utility fittings: As required.

2.10.2. Surface Raceway System (Wiring Laid In)

- a) Steel: CSA C22.2 No. 62, two piece, free from sharp edges.
- b) Finish: hot dipped galvanized steel or as specified
- c) Switch, receptacle, extension boxes, adapters and utility fittings: As required.

2.10.3. Surface Floor Raceway System

- a) Steel: CSA C22.2 No. 62, two piece, free from sharp edges manufactured as lay in type raceway.
- b) Finish: hot dipped galvanized steel or as specified

2.10.4. Channel Raceway:

- a) CSA C22.2 No. 62, steel, solid, free from sharp edges.

2.10.5. Plastic Raceway

- a) Plastic raceway: CSA C22.2 No. 62, rigid extruded PVC with slots on either side of raceway for exit of wiring.
- b) Channel: With solid snap on cover for entire length.

2.10.6. Lighting Fixture Raceway

- a) Linear fixture support system using channel type raceway with snap on cover.
- b) Channel: 1.6 mm minimum thick.
- c) Clamp hangers with threaded rod /chain /rod hangers.

2.10.7. Fittings

- a) Elbows, tees, couplings and hanger fittings: CSA C22.2 No. 62, manufactured as accessories to raceway supplied.

2.11. IDENTIFICATION

- 2.11.1. Furnish colour coding in accordance with Metrolinx Electrical Identification and Nomenclature Specification MX-ELEC ID-SPEC.
- 2.11.2. Provide identification for equipment and the sub-components in accordance with Metrolinx Electrical Identification and Nomenclature Specification MX-ELEC ID-SPEC.
- 2.11.3. Provide nameplates, warning signs and labels as required by the AHJ.

3. EXECUTION

3.1. INSTALLATION - GENERAL

- 3.1.1. The raceways must be installed using tools specified by the Manufacturer and the Installers must be trained and certified by the Manufacturer.
- 3.1.2. Install raceway in accordance with manufacturer's instructions to suit specific installation requirements.
- 3.1.3. Prior to installation of raceway, check installation does not hinder or obstruct equipment or space allocated to other Products.
- 3.1.4. Red Glyptal metallic type conductive compound for raceways to be applied to exposed threads of conduits and fittings.
- 3.1.5. Touch-up paint: In accordance with CAN/CGSB 1.181; zinc rich paint shall be used on conduits and fittings for scratches and wrench marks as work progresses.
- 3.1.6. Carefully clean raceways before and after installation. Clean burrs and free inside surface from imperfections likely to damage wires or cables or injury to personnel.
- 3.1.7. 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.
- 3.1.8. 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.
- 3.1.9. A drain fitting shall be provided at the lowest point of all conduit runs.

- 3.1.10. 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.
- 3.1.11. Install conduits to allow conductors to be drawn-in without excessive strain or damage.
- 3.1.12. Fasten exposed conduit to structures or support systems using straps, as follows:
 - a) One-hole straps for conduits 50 mm and smaller.
 - b) Two holes straps for conduits larger than 50 mm.
- 3.1.13. Fasten conduits with anchors spaced maximum 1500 mm apart. Fasten clamps to concrete or masonry with specified anchors.
- 3.1.14. Conduit fish wire: Install fish wire in conduits to facilitate wire and cable pulling and additional fish wire left in place to facilitate pulling additional wires and cables.
- 3.1.15. Conduit seal: Oil base compound, non-hardening and adheres to metal, masonry, wood or plastic. Product temperature ranges from 34 to 88°C; minimum installation temperature is -12°C. Manufacturer: Panduit; Cat. No. DS1 and DS5 or approved equivalent.
- 3.1.16. Use conduit 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 will not be accepted by Metrolinx.
- 3.1.17. Install specified expansion or deflection fittings where raceways cross expansion, contraction or deflection joints.
- 3.1.18. Replace broken conduits which may be caused inadvertently by construction activities.
- 3.1.19. Where rigid conduit enters pullboxes, junction boxes, panelboards and cabinets, install iron hub fittings.
- 3.1.20. Install hot-dipped galvanized steel supports necessary to mount conduit fittings, conduit and boxes in locations where no mounting surface available.
- 3.1.21. Identify conduits at both ends in accordance with Metrolinx Electrical Identification and Nomenclature Specification MX-ELEC ID-SPEC.
- 3.1.22. Maximum distance between pull points including manholes, handwell or pull boxes is 45 m.
- 3.1.23. Manholes, handwell and pull boxes shall be grounded as part of the raceway system.
- 3.1.24. Flexible metal conduit shall not be used for direct connections to panelboards or switchboards.

- 3.1.25. All conduit penetrations through floor slabs are to be installed to prevent water flow between floors, by means of cast in place galvanized sleeves, built up concrete pad, or sealed galvanized metal water dams. Seal conduit penetrations to prevent smoke or water passage.
- 3.1.26. Conduits are to be concealed in areas accessible to public, unless indicated otherwise.
- 3.1.27. Conduits are not allowed to pass through wayfinding sign boxes, light fixtures or enclosures.
- 3.1.28. Conduits are not allowed to obstruct the view of signage or light fixtures
- 3.1.29. Conduits shall not create any obstruction for maintenance.
- 3.1.30. Cap empty conduits and provide fish wire, allow 3 m of fish wire at each end.
- 3.1.31. Conduits terminating in enclosures shall include termination hardware.
- 3.1.32. Provide drainage of manholes and duct banks to storm sewer system per CSA C22.3 No. 7 Underground System.
- 3.1.33. Grading of ducts shall be from the high point in the line to one or both adjacent subsurface chambers and shall be not less than 1:400. See CSA C22.3 No. 7.
- 3.1.34. Make bends in conduit in accordance with Table 3-1.

Table 3-1: Conduit Minimum Bending Radius Table

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

3.2. INSTALLATION - CABLE TRAY

- 3.2.1. There shall be a minimum distance or clearance of 300 mm access above the tray or the width of the tray whichever is greater.
- 3.2.2. The cable tray system design and installation must take into account thermal expansion and contraction of the cable tray and any expansion joints in the structure.
- 3.2.3. Provide barriers where different voltage systems are run in the same cable tray.

- 3.2.4. Ground cable trays with copper conductor in accordance with OESC requirements. Attach the ground conductor to each tray section and fitting with an approved ground clamp. Grounding intervals shall not exceed 15 m. Bond all trays to building ground system at both ends.
- 3.2.5. Cable trays shall meet the requirements of a post disaster facility per OBC.
- 3.2.6. Contract Drawings are diagrammatic and do not identify required changes in elevations and architectural features. Site measure exact routing and lengths. Prior to start of work, prepare and submit detailed installation drawings, including plans, elevations and sections of proposed tray and routing. Coordinate such drawings with coordination drawings of trades. Include for design calculations to determine load limitations.
- 3.2.7. Provide tray complete with bonding jumpers/fittings and hardware.
- 3.2.8. Provide conduit fittings where conduits enter tray and provide dropouts at ends where cables exit/enter.
- 3.2.9. Supply cable installation rollers for pulling cables safely into tray. Provide rollers or other hardware to maintain cable-bending radii within cable manufacturer's recommended standards to suit type of cable.
- 3.2.10. System accessories to be supplied by system manufacturer and be as recommended by system manufacturer for specific applications.
- 3.2.11. Factory fabricate changes in direction, tees, 90° bends, universal dropouts, etc.
- 3.2.12. Install cable tray in locations shown on Contract Drawings, level, straight and parallel to structure or pipe rack lines, with minimum of directional changes.
- 3.2.13. Fasten cable tray to concrete ceiling with bolts in masonry expansion anchors along both sides of cable tray directly above handhole openings. Stagger fasteners 610 mm apart (i.e. 1.22 m between fasteners along same side). Employ horizontal brackets supported to ceiling slab by vertical threaded rod hangers. Do not secure assembly from ductwork, suspended ceiling structures, lighting, etc. Secure rod hangers directly to ceiling slab. Locate supports as not to interfere with removal or opening of covers. Typically locate spans at intervals $\frac{1}{4}$ span from supports, as recommended by tray manufacturer. Refer to drawing details and/or manufacturer's instructions. Include for provision of required seismic restraints as to comply with local governing building code requirements.
- 3.2.14. Drill hole in top of cable tray above handhole for conduit where circuits enter or leave cable tray. Install grounding bushing on end of conduit and bond conduit to cable tray with bonding jumper and No. 10 brass machine screw, lock washer and nut.

- 3.2.15. Telescope cable tray sections into each other and bond together by grounding jumpers provided on each component. Cap ends of each cable tray run with correct wireway end cap, secured to cable tray by means of self-tapping metal screws. Maintain tolerances on cable tray ends so close, but not excessively tight, fit made between parts.
- 3.2.16. Make bends and offsets in cable tray of radii recommended for largest cable being carried by tray.
- 3.2.17. Install cable tray expansion joints at 35 m maximum on straight runs.
- 3.2.18. Align and support cable tray on permanent members of structure or mechanical equipment supports. Do not secure to steel roof decks or temporary structures. Make maximum distance between centres of supports 3000 mm for horizontal straight runs and 2000 mm for vertical runs. Locate additional supports as shown on Contract Drawings or as required to prevent distortion, kinks, sway or sags.
- 3.2.19. Provide supports and fittings suitable for maximum tray loading at maximum span.
- 3.2.20. Provide ventilated cable tray covers on vertical cable tray sections and where shown on Contract Drawings. Provide minimum of four (4) cover clamps on each side of 3000 mm length or less.
- 3.2.21. Provide ventilated cable tray covers on runs passing through floors up to 2000 mm above floor level.
- 3.2.22. Support cables in vertical sections with cushion clamps. Install woven stainless-steel wire cable grips at upper extremity of each cable. Supply grommets cut-outs for cable entry into substation equipment.
- 3.2.23. Install separation dividers in cable tray for power cables of different voltage ratings and for control and communication cables.
- 3.2.24. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections.
- 3.2.25. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.
- 3.2.26. Cables in cable tray:
 - a) Install cables individually.
 - b) Lay cables into cable tray. Use rollers when necessary to pull cables.
 - c) Secure cables in cable tray at 1.0 m centres maximum, with cable clamps.
- 3.2.27. Provide sample of tray to Metrolinx prior to start of work.
- 3.2.28. Utilize system manufacturer's proper grounding and bonding fittings and hardware.

- 3.2.29. Install expansion connectors where cable tray crosses building expansion joints.
- 3.2.30. After installation is complete, install warning signs on tray in visible locations.
- 3.2.31. Separate waste materials for reuse and recycling in accordance with Waste Management Plan.

3.3. INSTALLATION - DIRECT BURIED CONDUITS/DUCTS

- 3.3.1. Install rigid PVC conduits/ducts in accordance with manufacturer's instructions, in locations indicated on Contract Drawings and in accordance with the OESC.
- 3.3.2. 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 degrees.
- 3.3.3. Buried conduits/ducts shall run parallel to or 90 degrees to building lines.
- 3.3.4. At joints, apply jointing cement in accordance with manufacturer's instructions.
- 3.3.5. Prior to backfill, notify Metrolinx to verify location, depth and routing of conduits/ducts.
- 3.3.6. Place warning tape above centreline of each conduit/duct, 300 mm below grade, through entire length of run unless indicated otherwise.
- 3.3.7. 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.

3.4. INSTALLATION - CONCRETE ENCASED CONDUITS/DUCTS OR METAL RIGID STEEL PIPE

- 3.4.1. Certain areas require the underground raceways be protected by concrete encased conduits/ducts or metal pipe. Examples of this are heavy vehicles or heavy traffic areas or under tracks.
- 3.4.2. Perform concrete Work necessary to complete installation in accordance with Contract Drawings. Concrete shall be steel reinforced.
- 3.4.3. At joints, apply jointing cement in accordance with manufacturer's instructions.
- 3.4.4. Arrange conduits in duct bank and secure in place with duct spacers, installed at 1500 mm intervals. Joints shall be staggered at 150 mm in adjacent layers.
- 3.4.5. Make joints between steel and PVC ducts with steel-to-PVC adapters threaded on one end to take rigid steel conduit elbows where run passes through floor slabs or rises above grade. Extend concrete encasement 100 mm above finished floor.

- 3.4.6. 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.
- 3.4.7. Close both ends of spare ducts and incomplete runs with bell and plugs of same material as conduits/ducts. Ends shall have watertight seals.
- 3.4.8. Place warning tape above centreline of each conduit/duct, 300 mm below grade, through entire length of run unless indicated otherwise.
- 3.4.9. Protect conduits/ducts from entrance of water or other foreign matter by capping overnight, or if Work is temporarily suspended. Cap unused conduits and ducts for watertight seal.
- 3.4.10. Prior to placement of concrete, notify Metrolinx to verify location, depth and routing of conduits/ducts.
- 3.4.11. Buried and encased conduits/ducts shall run parallel to or 90 degrees to building lines.
- 3.4.12. Protect ducts crossing through foundation walls from shear forces by concrete encasement extended outward approximately 1000 mm from wall and connected to wall by reinforcing steel or dowels to form integral structure.

3.5. INSTALLATION - METALLIC CONDUITS

- 3.5.1. Fasten conduits by specified clamps spaced per OESC. Fasten clamps to concrete or masonry with specified anchors.
- 3.5.2. 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.

3.6. INSTALLATION - NON-METALLIC CONDUITS

- 3.6.1. Make joints in conduit with cement approved for use by conduit Manufacturer.
- 3.6.2. Where non-metallic conduit passes through expansion joint, install expansion coupling.
- 3.6.3. Make transitions from non-metallic conduits to metallic conduits 150 mm below concrete surface. Extend conduit transitions minimum 100 mm above finished floor.
- 3.6.4. 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.

- 3.6.5. Concrete slabs and walls with cage type steel reinforcement shall have the conduits placed in centre of the concrete element avoiding interference with reinforcement and with appropriate tie-offs at regular intervals to prevent displacement during concrete placement.
- 3.6.6. Concrete slabs, floors and walls with single layer of steel reinforcement shall have conduits placed in the centre of the concrete element avoiding interference with reinforcement and with appropriate tie-offs at regular intervals to prevent displacement during concrete placement. Conduits in hollow blocks walls shall be installed inside the hollow sections with tie offs at regular intervals to avoid displacement during placement of concrete.
- 3.6.7. Conduits in concrete slabs on grade shall be installed below steel reinforcement with tie offs at regular intervals to avoid displacement during placement of concrete.

3.7. EXISTING CONDUIT

- 3.7.1. Assume existing conduits in Work area contain live circuits. Coordinate with Metrolinx for power isolation to live circuits.
- 3.7.2. Conduits located in Work area that obstruct and interfere with Work, shall be traced to source and rerouted. Coordinate with Metrolinx for conduit rerouting and temporary connections to existing equipment. Existing equipment shall be maintained and remain operable during duration of Work.

3.8. FIRESTOPPING AND SMOKE SEALS

- 3.8.1. Maintain the integrity of all floors and fire separations by installing firestopping and smoke seals for all electrical services passing through floors or fire separations.
- 3.8.2. Where raceway penetrates fire rated construction, provide ULC listed and labelled, fire stopping and smoke seal materials or fittings to protect integrity of fire rated construction. Install work in compliance with ULC standards and where required by local governing codes, provide tray type suitable for plenum environments.

3.9. TESTING

- 3.9.1. Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance.
- 3.9.2. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1/CSA C22.2 No. 126. 1-09.

END OF SECTION