METROLINX

Capital Projects Group Performance Specifications for Electric Traction Enabling Works

MX-ELEC TRAC EW-SPEC-2016

Revision 1
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Authorization

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Preface

This is the first revision of the Performance Specifications for Electric Traction Enabling Works (MX-ELEC TRAC EW-SPEC-2016), hereafter referred to as the "ET EW Specifications". Enabling works in this context refers to the engineering and design effort or review of projects within corridors intended for future electrification with the purpose of integrating with and preparing for future electrification. Any projects affected by Electrification shall be subject to these specifications and the corresponding set of design standards, Enabling Works Electric Traction Standards (MX-ELEC TRAC EW-DW-2016).

The purpose of the ET EW Specifications is to ensure all new construction is compatible with the future electrification of the GO network and that the infrastructure is constructed and maintained such that Electrification can be implemented in a safe and efficient manner.

This revision incorporates stakeholder comments, including:

- Updated abbreviation table
- Clarification of vertical clearance requirements
- Update to horizontal clearances table
- Requirements for Underpasses
- Clarification of grounding and bonding requirements
- Minor edits for clarification and readability

The most current version of the ET EW Specifications is intended for use by suitably qualified professionals. It is not a substitute for coordination and compliance with all applicable local codes, standards, manuals, and approvals for fire protection, life safety, and security measures that are part of the planning, design and implementation of an electrified rail network.

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Tables

Acronyms and Abbreviations

TABLE 0-3 ACRONYMS AND ABBREVIATIONS

Acronym and Abbreviation	Full Name
AAR	Association Of American Railroad
ac	Alternating Current
ADJ	Adjustment
AGWB	Aluminum Ground Wire (Bare)
AGWC	Aluminum Ground Wire (Covered)
AR	Authority's Representative
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASTM	American Society For Testing And Materials
ATF	Autotransformer Feeder
ATFZ	Autotransformer Feeder Zone
ATM	Along Track Movement
AWG	American Wire Gage
AWS	American Welding Society
BWA	Balance Weight Termination Anchor
C	Celsius
CCZ	Current Collector Zone
CGWC	Copper Ground Wire (Covered)
CL	Center Line
CLR	Clearance
CP	Counterpoise
CSA	Canadian Standards Association
CW	Contact Wire
CWB	Counterpoise Wire (Buried)
CWH	Contact Wire Height
dc	Direct Current
^{o}C	Degree Celsius
DG	Down Guy

TABLE 0-3 ACRONYMS AND ABBREVIATIONS

Acronym and Abbreviation	Full Name
DGW	Down Guy Wire
DIA	Diameter
DIST	Distribution
DRM	Design Requirement Manual
DVP	Don Valley Parkway
DWG	Drawing
EA	Emergency Alarm
EB	Eastbound
EGC	Equipment Grounding Conductor
EN	European Standards
ELEV	Elevation
ET	Electric Traction
FDN	Foundation
FDRI	Feeder Wire (Insulated)
FRA	Federal Railroad Administration
FRE	Fiberglass-Reinforced Epoxy
FTA	Fixed Termination Anchor
FW	Feeder Wire
GALV.	Galvanized
GBCW	Grounding And Bonding Wire
GENL	General
GTCC	GO Transit Control Center
H/HT	Height
HORIZ	Horizontal
HRL	High Rail
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IR	In Running
JW	Jumper Wire
kg	Kilogram
kg/M	Kilogram Per Meter
LG	Long
LPS	Lightning Protection System
LV	Low Voltage (120V Nominal Voltage)

TABLE 0-3 ACRONYMS AND ABBREVIATIONS

Acronym and Abbreviation	Full Name
m	Meter
MF	Maintenance Facility
MGB	Main Grounding Bar
M/C	Monitor And Control
MIN	Minimum
mm	Millimeter
MOD	Modified
MP	Milepost
MPA	Mid Point Anchor
MPTW	Mid Point Tie Wire
MV	Medium Voltage
MW	Messenger Wire
N	Newton
NFPA	National Fire Protection Association
N.O.	Normally Open
NOM	Nominal
NTS	Not To Scale
O/LAP	Overlap
OCLZ	Overhead Contact Line Zone
OCS	Overhead Contact System
OH	Overhead
OOR	Out-Of-Running
OESC	Ontario Electrical Safety Code
Pa	Pascal
PITO	Point Of Intersection Of The Turnout
PS	Paralleling Station
PSF	Pound Per Square Foot
PVC	Polyvinyl Chloride
P.S.	Point Of Switch
RAC	Rail Association of Canada
RC	Return Cable
REINF	Reinforcement
rms	Root-mean-squared
ROW	Right-Of-Way
SCADA	Supervisory Control And Data Acquisition
SM	Single Mode
SPD	Surge Protection Device
SQ	Square

TABLE 0-3 ACRONYMS AND ABBREVIATIONS

Acronym and Abbreviation	Full Name
SS/SST	Stainless Steel
STA	Station Distance
STD/(S)	Standard/Standards
STN	Passenger Station
SW	Static Wire
SWS	Switching Station
T/	Top Of
TBD	To Be Determined
TBS	Transmission Backbone System
TOR	Top Of Rail
TPF	Traction Power Facility
TPRS	Traction Power Return System
TPSS	Traction Power Substation
TRK	Track
TRKS	Tracks
TVM	Ticket Vending Machine
TWA	Tie Wire Anchor
TWPC	Traction Wayside Power Control Cubicle
TYP	Typical
UP	Union Pearson Express
V	Volt
VERT	Vertical
VLD	Voltage Limiting Device
VMS	Visual Message Sign
W	Width
WP	Working Point

Definitions

For a list of terms and definitions, please refer to the *Capital Projects Group Glossary*.

1. Chapter 1 - General

1.1 Design Criteria Overview

1.1.1 Purpose and Extent

Metrolinx intends to implement electrification over a large portion of their system: USRC, Barrie, Lakeshore West, Lakeshore East, Stouffville and Kitchener corridors. This will consist of a 25kVac system delivering power to trains by the use of an overhead contact system (OCS) in conjunction with power collection via a pantograph mounted on the roof of the vehicles.

This performance specification is provided to establish the necessary measures to ensure the compatibility between current construction projects and the future Metrolinx electrification. The specifications and criteria within are intended to provide the guidelines required to include elements in current project designs to facilitate electrification in the future. These criteria will cover the requirements for OCS support and electrification grounding and bonding.

1.1.2 Other Metrolinx Electrification Project Documents

1) GO Transit Design Requirements Manual (DRM)
2) MX-ELEC TRAC EW-DW-2016, GO Electrification Enabling Works ET Standards
3) MX-ELEC STR-SPEC-2017, Performance Specifications for Structures Passing Over Electrified Corridors

1.2 Basis of Design

1.2.1 The Metrolinx Electrification system shall be a 2 x 25 kV ac (1 x 25 kV ac in the limits of the Pearson subdivision), 60 Hz autotransformer traction electrification system. All proposed new stations and existing station rehabilitation projects shall include provisions to accommodate autotransformer feeders, OCS wire support and the traction power return system.

1.3 Regulations, Codes, Standards and Guidelines

1.3.1 Federal and National Regulations and Codes

1) Transport Canada – Standard Respecting Railway Clearances TC E-05
2) Canadian Standards Association (CSA)
3) CAN/CSA C22.2 No 0 General Requirements, Canadian Electrical Code, part 2
4) CAN/CSA C22.3 No.1 Overhead Systems
5) CAN/CSA C22.2 No.0.4 - Bonding and Grounding of Electrical Equipment
6) CAN/CSA C22.3 No.2 - General Grounding Requirements and Grounding Requirements for Electrical Supply Stations
7) CSA B72 – M87 (Reaffirmed 2008) – Installation Code for Lightning Protection Systems.

1.3.2 Provincial Regulations and Codes

1) OESC Ontario Electrical Safety Code

1.3.3 Standards and Guidelines

1) American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering
2) Railway Association of Canada (RAC) Standards
3) IEEE 80: Guide For Safety In AC Substation Grounding;
4) EN 50122-1: Railway Applications, Fixed Installations – Protective Provisions Relating to Electrical Safety and Grounding;
5) IEC 60479: Effects of Current on Human Beings and Livestock
6) NFPA 780: Standard for Lightning Protection Systems
7) IEC 60305-1: Protection Against Lightning

1.4 General Design Parameters

1.4.1 Units of Measurement – The Metric system is to be used.

1.5 Design Life

1.5.1 Electrification elements (such as OCS poles, OCS Foundations and Ground Conductors) installed within platforms or slabs shall have a design life that matches or exceeds that of the platform/slab and no less than 30 years.

1.5.2 Electrification elements exposed to climate shall be reasonably protected from the environment in the period before the electrification contractor begins construction and have a design life of no less than 30 years.

1.6 Standardization

1.6.1 Design shall use standard materials and equipment where possible. Standardization ensures ease of procurement and inventory management, minimizes staff training, optimizes maintenance, and avoids long lead times for materials, equipment, and components.

1.6.2 Equipment and materials shall meet industry standards, be available off the shelf, and supplied by established manufacturers. Selection of equipment and materials shall consider long-term costs, ease of construction and maintenance, and readily available technical support.

1.6.3 Effort shall be made to standardize the appearance of all exposed elements such that there is a unified aesthetic between all visible structures. Direction will be given from Metrolinx on final finish.

1.7 Durability

1.7.1 Design shall assess potential for deterioration of materials and assemblies, including deterioration specific to exposure to the environment. Materials and detail assemblies shall be durable with minimal maintenance and repairs throughout their design life. For surface and assembly for which appearance is important, durability shall include maintenance required to preserve appearance. Design shall take into account the following aspects of durability:

1) Control of moisture
2) Control of corrosion (including material compatibility)
3) Control of exposure to industrial and vehicular pollution

4) Minimize damage from wear and tear

5) Ease of repair; ease of access

6) Protect grounding appurtenances from vandalism

2. Chapter 2 – Trackway Clearances

2.1 General

2.1.1 Purpose and Extent

This chapter provides specifications for required clearances for the Metrolinx Electrification Project facilities. It includes an allowance for Metrolinx maintenance equipment and other equipment that may be operated within the Metrolinx tracks. Criteria will define static, dynamic, fixed equipment, and structure gauge envelopes. They have been developed to accommodate the following:

- The widest and tallest existing Metrolinx rolling stock, and proposed rolling stock currently under contemplation.
- Accommodate other passenger train equipment operating in the project area.
- Additional freight clearance requirements; Canadian National rolling stock currently under contemplation for each portion of the rail corridor as defined by AAR Plate Equipment Diagrams (Plate 'H').

2.2 Vertical Clearances

2.2.1 Transport Canada's TC E-05 specifies clearance to non-electrified tracks owned or operated by railway companies. Diagram 1 of TC E-05 provides minimum vertical and horizontal clearances that must be provided. However, electrification requires greater vertical clearance between vehicles and overhead structures to account for the space required by OCS conductors and electrical clearances that must be provided for safe operation.

2.2.2 Minimum vertical clearances shall be measured from the Metrolinx top of rail (TOR). Minimum vertical clearances should be carried to a point laterally from the centerline of the most outside track to a minimum of the horizontal clearance requirement (see Section 2.3). This horizontal requirement shall not be less than the TC E-05 plate projected up along the track super elevation. This minimum vertical clearance shall be no less than that shown in Table 2-1 unless otherwise approved by Metrolinx. For overhead obstructions which are continuous obstructions longer than 10m along the track, a site-specific review and evaluation will be required prior to obtaining Metrolinx approval.

TABLE 1: MINIMUM VERTICAL CLEARANCES

Item	Minimum Vertical Clearance
TOR to lowest point of overhead obstruction	7584mm

2.3 Horizontal Clearances

2.3.1 Minimum horizontal clearances shall be measured from the track centerline (TCL) of the closest Metrolinx track to the feature being cleared.

TABLE 2: MINIMUM HORIZONTAL CLEARANCES

Item	Minimum Horizontal Clearance
TCL to face of bridge abutment on inside of curve	2546mm + 25.4mm*(DOC) +(SE*YD/1510)
TCL to face of bridge abutment on outside of curve	2546mm + 25.4mm*(DOC)
TCL to face of OCS Pole	2900[1]mm + 25.4mm*(DOC)
TCL to canopy edge (see EW-ET-0227)	2650mm (tangent track with no SE)

Notes:

1. Where 2900mm cannot be met, a reduced clearance can be submitted to Metrolinx for approval.
2. DOC = Degree of Curve
   SE = Superelevation (mm)
   YD = Vertical height of dynamic envelope (mm)

2.4 Clearance to Third Party Facilities

2.4.1 Where facilities owned and operated by third parties are involved, the clearance requirement of this document and those of the third party shall be compared and the larger dimension used.

2.4.2 Clearances are subject to operating agreements with 3rd party railroad authorities including but not limited to CN, CP, VIA and Amtrak.

3. Chapter 3 – Traction Power Systems

3.1 General

3.1.1 Purpose and Extent

This chapter provides the requirements for grounding and bonding of passenger stations for coordination with the future electrification and its traction power return system (TPRS). The TPRS consists of various components (such as running rails, rail bonding cables, and aerial static – groundwire and earth) to allow current from the electric train vehicle to ultimately return to its supply substation source under both normal operating conditions and under fault conditions.

Due to the presence of electric trains, its open wire distribution and traction return currents in the rails, it is necessary to provide grounding and bonding network at station platforms (and other conductive) elements along the right-of-way to: (i) facilitate an equal-potentiality for all normally non-current-carrying conductive equipment and structures, and (ii) ensure flow of all fault current (including lightning) towards the earth to protect personnel and equipment from damage.

3.2 Grounding and Bonding

3.2.1 General

The grounding and bonding system shall provide the means to carry traction electric currents into the earth, under both normal and fault conditions, without exceeding operating equipment limits, without thermal degradation or mechanical breakdown, and without adversely affecting continuity of service or personnel safety.

Adequate bonding shall be designed and installed throughout the entire electrified system to provide proper return circuits for the normal traction power currents and fault currents, with grounding connections as specified herein without affecting life and property.

Ground resistance measurements, ground potential rise studies and detailed design shall be performed to determine the extent of grounding and/or bonding within specific site condition, for coordination with the future electrified system.

All grounding and bonding designs shall be coordinated with the various discipline designs, including civil, architectural, electrical and electronic, mechanical, and plumbing, traction power supply and distribution, communications, and signaling.

All grounding and bonding designs shall be coordinated with electromagnetic compatibility and electromagnetic interference requirements, so that the respective designs do not conflict and render other systems ineffective.

All grounding and bonding designs shall be coordinated with any neighboring stray current and corrosion control measures for adjacent systems, as well as when in the vicinity of direct current traction power transit systems.

The grounding electrodes shall be contained within the right of way confines. The bonding material shall be capable of sustaining the short-circuit currents for up to the total switch-off (trip) time imposed on the system without thermal degradation or mechanical breakdown. The traction equipment bonding shall be capable of discharging a 15 kA fault from the OCS within 0.5 seconds.

Provisions for an electrification grounding and bonding system shall be implemented within the design of the new station or rehabilitation. This shall include any buried cable/wire and any connections required to be within or beneath platform surface. Required connections between grounding grid or counterpoise shall be provided for all proposed station elements and provisions shall be implemented to connect future electrification elements.

3.2.2 Regulations, Codes, Standards and Guidelines

Grounding and bonding is to be designed and implemented primarily in accordance with the regulations, codes, standards and guidelines as listed in section : 1.3

3.2.3 Overhead Contact Line Zone

A live broken contact line, or live parts of a broken or de-wired pantograph or energized fragments, may accidentally come into contact with wayside structures and equipment. As derived from European standard EN 50122-1, the OCLZ describes the area extending down and outwards from an electrified overhead catenary wire (as detailed in the Enabling Works Standards, MX-ELEC TRAC EW-DW-2016). Metallic objects and equipment at passenger stations within the OCLZ shall be properly grounded and

bonded. The grounding and/or bonding configuration to be employed is dependent upon the equipment involved. Special considerations are given to railroad signal, railroad communications and 3rd party utilities as described herein.

3.2.4 Step and Touch Potentials

An electrical safety analysis shall take into account criteria for the ground potential rise (refer to IEEE Standard – 80). The analysis shall be undertaken to assess which normally non-current carrying conductive parts need to be grounded and bonded, and the appropriate method of implementation shall be identified to ensure that the step and touch potentials are within permissible limits. The ground potential rise study shall be submitted for MX review.

The grounding and bonding of other non-current carrying equipment, enclosures and associated structure, including the OCS structures, rails, station platform metallic objects, and other conductive trackside equipment, shall be designed such that touch voltages do not exceed the values indicated below (derived from EN 50122-1: 2011 section 9.2.2).

TABLE 3: PERMISSIBLE VOLTAGE BASED ON CURRENT FLOW

Duration of Current Flow (seconds)	Permissible Voltage in V (rms)
0.02	865
0.05	835
0.1	785
0.2	645
0.3	480
0.4	295
0.5	220
0.6	180
< 0.7	155
0.7	90
0.8	85
0.9	80
1.0	75
≤ 300	65
> 300 (where accessible to the public under all power supply feeding conditions)	60
> 300 (in workshops and similar locations)	25

3.2.5 Grounding and Bonding at Station Platforms

Station platform areas require special consideration to mitigate step and touch potentials where passengers could simultaneously come in contact with rolling stock car bodies and metallic objects on the platform. In addition, the need to protect personnel and equipment against traction power fault conditions if the OCS or auto-transformer feeder wire were to fall/energize this area. The configuration defined in AREMA, Chapter 33, Section 7.5.1.1 Method B, and as described herein, shall be employed at passenger station areas.

1) Retrofit Stations

For retrofit installations of existing stations platform grounding, a counterpoise wire (#4/0 AWG copper, 37 strand) shall be installed along the entire length of each platform with the conductor buried in earth and extending a minimum of 15m beyond the ends of the platform with a tested ground resistance value of 5 ohms (maximum). If necessary, additional provisions for grounding shall be made to achieve the 5 ohm value. The buried counterpoise wire may be installed on the track side of the platform at a depth (410mm – 610mm) to avoid damage from track maintenance operations.

A hand-hole enclosure, with a copper bus bar, shall be installed at each end of the platform for this counterpoise to service as a testing location, as well as permit the connection to the rails via an impedance bond. The impedance bond connection location is to be coordinated with the signal system design in the future. The counterpoise shall be connected to the rails at one end only so as not to adversely affect broken rail detection. This hand-hole enclosure shall be polymer concrete unless in areas subjected to vehicular traffic along the right of way, otherwise it shall be precast concrete suitable for placement in roadways. Underground enclosures subjected to soil surcharges from train axel loading shall meet Cooper E80 (minimum) loading requirements.

Additional retrofit construction is required at the station to install bonding jumpers from this counterpoise to platform metallic objects. The bonding jumpers shall be #4/0 AWG (minimum) copper in size. All normally non-current-carrying metallic structures and miscellaneous metallic items on the platform (including platform reinforcement steel, any OCS poles, stairways, platform shelters, elevators, or other features) shall be bonded directly to the counterpoise. Small non-current carrying metallic items (less than 2 x 3 m: including manhole covers, trash receptacles, platform heating manifold cover, information display cases, or other features) are not required to be bonded to the counterpoise. In addition, for existing concrete platforms, a portion of the station platform end, near the hand-hole enclosure, shall have its rebar exposed to permit a bond between the rebar and the counterpoise wire.

Where OCS poles are planned to be within station platform areas, their foundations shall be grounded per OCS requirements for a maximum of 25 Ohms. The foundation grounding shall be bonded to the station counterpoise further reducing the foundation grounding resistance to a maximum of 5 Ohms.

In areas where portal type OCS structures are anticipated and have their foundations in multiple platforms, the OCS poles shall only be bonded to the counterpoise only at one platform. This is so not to create a cross-bond point.

2) New Stations and Stations with Extensive Platform Rehabilitation

For newly constructed platforms, if concrete platforms are to be constructed, the top layer of rebar shall be made electrically continuous by exothermically welding the longitudinal rebar splice/overlaps across the length of the platform, in addition to exothermically welding the perpendicular rebar crossings to the longitudinal bars every 15.25m on center.

The electrically continuous top layer of rebar, if concrete platforms are to be constructed, and a #4/0 AWG, 37 strand bare copper wire (counterpoise) shall be installed along the entire length of the platform to facilitate bonding of station metallic objects to the traction return system. The counterpoise shall be within the slab, exothermically connected to the rebar approximately every 30.5m, and extended a minimum of 15m beyond the ends of the platform with ground rod connection. The network of rebar and counterpoise ground shall have a tested grounding resistance value of 5 ohms (maximum). If necessary, additional provisions for grounding shall be made to achieve the 5 ohm value.

A hand-hole enclosure, with a copper bus bar, shall be installed at each end of the platform for this counterpoise to service as a testing location, as well as permit the connection to the rails via an impedance bond. The impedance bond connection location is to be coordinated with the signal system design in the future. The counterpoise shall be connected to the rails at one end only so as not to adversely affect broken rail detection. This hand-hole enclosure shall be polymer concrete unless in areas subjected to vehicular traffic along the right of way, otherwise it shall be precast concrete suitable for placement in roadways.

All normally non-current-carrying metallic structures and miscellaneous metallic items on the platform (including platform reinforcement steel, any OCS poles, stairways, platform shelters, elevators, or other features) shall be bonded directly to the counterpoise. The bonding jumpers shall be #4/0 AWG (minimum) copper in size. Small non-current carrying metallic items (less than 2 x 3 m: including manhole covers, trash receptacles, platform heating manifold cover, information display cases, or other features) are not required to be bonded to the counterpoise.

Where OCS poles are planned to be within station platform areas, their static wire is to be isolated from the OCS poles, and its foundation grounded per OCS requirements for a maximum of 25 Ohms. The foundation grounding shall be bonded to the station counterpoise further reducing the foundation ground resistance to a maximum of 5 Ohms.

In areas where portal type OCS structures are located, and have their foundations in both inbound and outbound platforms, the OCS poles shall only be bonded to the counterpoise only at one platform. This is so not to create a cross-bond point.

3) Station Electrical and Electrical Utility Services

Installations for the electrical services shall conform to EN 50122-1:2011 Section 7.4.4.1, where it permits the exposed conductive parts to be bonded directly to the return circuit and then disconnecting the circuit ground wire that originates from the electrical panelboard to the exposed conductive part of the equipment within the OCLZ. The ground connection, which originates from the

electrical panelboard to the exposed conductive part of the equipment within the OCLZ, shall be removed only after the electrification is ready for service. A connection shall also be made from the counterpoise to the main ground bus bar of the station power supply. If there is only one electrical supply for separate platforms (with separate counterpoises) on each side of the tracks, underground connection shall be made between counterpoises, while only one connection is to be made from one counterpoise to one impedance bond so as not to create a cross bond. In any event, a cross bond shall not be created.

Non-metallic raceways should also be used to route these incoming power circuits when entering the station platform area and other locations within the OCLZ.

Low voltage power distribution raceways within the station shall be non-metallic.

4) Station Utilities (water, gas, sewer)

Where metallic piping is used for water/gas/sewer utilities entering station platform areas, an insolation/isolation coupling shall be installed when entering the OCLZ. The portion of the utility that is within the OCLZ shall be bonded to the station counterpoise. The electrical insulation value of the coupling is to be determined from the ground potential rise study (Section 3.2.1).

3.2.6 3rd Party Utilities

1) Existing Utilities

Existing buried 3rd party utilities will not require additional bonding to the traction return system. Each utility owner should be advised of the future electrification project.

Exposed metallic utility piping (water, sewer, gas, electric) outside the OCLZ shall be grounded in accordance with the Utility's requirements.

Exposed metallic utility piping that is within the OCLZ requires bonding to the traction return system. If continuously running within the OCLZ area, then its metallic piping shall be broken into sections of approximately 305m with approved insulating collars and be bonded at its midpoint to the nearest OCS structure via #4/0 AWG copper wire. Any existing earth-made ground connections from these utilities may remain. If other mechanisms were used to ground these facilities, Metrolinx shall be advised.

2) New Utilities

New buried 3rd party utilities under the tracks are to be installed in a steel casing pipe with its ends sealed to prevent leakage and ingress of moisture and soil. This is to facilitate any future utility replacement, if necessary, and helps protect the railroad track bed infrastructure if the utility carrying liquid or pressurized substances were compromised.

Exposed metallic utility piping (water, sewer, gas, electric) outside the OCLZ shall be grounded in accordance with the Utility's requirements.

Every effort must be made to keep new 3rd party utilities outside the OCLZ area. New exposed 3rd party utilities inside the OCLZ are to have their carrier pipe enclosed in a steel casing pipe that is isolated from the carrier pipe by approved insulators. The steel casing pipe shall have insulating collars

at approximately 305m with its midpoint bonded to the nearest OCS structure via #4/0 AWG copper wire.

3.3 Overpasses

3.3.1 All overpasses including pedestrian walkways, architectural treatments or other structures crossing over the track shall have provisions included for the bonding and grounding of these elements in accordance with the Performance Specifications for Structures Passing Over Electrified Corridors (MX-ELEC STR-SPEC-2017). The design of these elements shall be coordinated with Metrolinx Electrification.

3.4 Underpasses

3.4.1 All underpass structures shall have provisions for the bonding and grounding of the bridge abutments and piers, and exposed metallic objects such as hand rails, parapets, decks, and walkways. Grounding plates shall be provided at each side face of each abutment for the bonding of the future OCS structures. The design of these elements shall be coordinated with Metrolinx Electrification.

4. Chapter 4 – Overhead Contact System (OCS)

4.1 General

4.1.1 Purpose and Extent

This chapter covers requirements for the future implementation of OCS support structures. This includes all elements required to be installed through current contracts for the future OCS support structural elements which may include OCS portals, cantilevers and other wire supporting structures.

4.2 OCS Description and General Performance Requirements

4.2.1 General OCS Arrangement

A typical OCS support structure consists of either a simple cantilever or a portal structure. All OCS wires, and ancillary wires, including feeders and static wires, are attached to these structures with wire support assemblies.

A typical cantilever consists of a single pole from which pipe and wire attachment assemblies are supported.

A typical portal consists of two (2) columns with a crossbeam between them which supports catenary assemblies. These support assemblies consist of a drop pipe and a set of pipe assemblies used to support and register the overhead contact system. These poles and cross beam may also support Auto-Transformer feeder wires, catenary feeders and static wires.

4.2.2 Spacing of OCS Supports

Project specific locations of future OCS support poles shall be coordinated with Metrolinx Electrification. OCS Supports will be placed with a maximum span of 60m between supports in tangent track. An average span of 45m-55m is expected in the provided OCS layout, although this may decrease if site constraints require. Any modifications to the OCS layout requires approval and coordination with Metrolinx Electrification.

4.2.3 Integration with Station Elements

1) Where possible, OCS poles shall be integrated with station elements such as shelters or canopies to minimize the visual impact of electrification structures. Where columns are to be integrated, a full strength splice shall be provided for the future electrification contractor to attach overbuild at a height of no less than 300mm above the top of canopy/shelter. The requirements for these integrated poles are detailed in section 4.4.

2) Where there is no shelter or canopy, a stand-alone OCS pole foundation shall be supplied. This foundation will consist of a caisson with a square pedestal and embedded anchor bolts. The locations and design of these foundations shall be coordinated with Metrolinx Electrification. Any modifications of these locations or design requires approval and coordination with Metrolinx Electrification.

4.3 Environmental Conditions and Climatic Loading Requirements

4.3.1 Climatic Loading Requirements

The following load cases shall be considered for the design of structural elements which will support future OCS structures:

TABLE 4: CLIMACTIC OCS WIRE LOADING CASES

Load Case		Design Condition	Temperature (°C)	Wind Pressure (N/m^2)	Wind Speed (km/h)	Radial Ice (mm)
Operating	1	Reference	16	0	0	0
	2	Operating Ice	-20	0	0	12.5
	3	Minimum Temperature	-40	400	90	0
Non-Operating	4	Heavy Loading	-20	400	90	12.5
	5	High Wind	16	766	125	0
	6	High Temperature	75	0	0	0

4.3.2 Wire loading

Loading imposed from the OCS to integrated station elements shall be provided by Metrolinx Electrification. These loads will include vertical weight, curve pull from tensioned wires and wind-on-wire loading, and shall be assumed to be acting in a condition and orientation as to result in a worst case loading condition combined with station element loading.

4.4 OCS Structural Requirements

4.4.1 General

Provisions for future OCS supports shall be designed with the future overbuild considerations included. The intent of these provisions is to allow the future electrification contractor to install the remaining elements required to support the OCS via splice or standalone drilled foundation. Splices and

foundations provided for this purpose shall be designed to resist all future loads as indicated in 4.3.2. OCS structures and foundation shall meet the requirements of CSA, AREMA standards, Ontario Electrical Code and Metrolinx General guidelines.

4.4.2 OCS Poles

Integrated columns which support both OCS and Canopy or shelters shall be designed for strength and serviceability under the load cases described in section 4.3.

1) Deflection of the support structure shall be kept at a minimum of 75mm in the across-track direction at the height of the future catenary supports. This shall be calculated as the deflection of the steel in addition to the effect of rotation at the top of foundation. This deflection will be calculated at a height of 9000mm above the top of high rail.

4.4.3 OCS Splices

Integrated columns which support both OCS and canopy or shelters shall be provided a splice for the future electrification contractor to attach the remaining overbuild. This splice shall be designed to resist all future loads and shall have a bolt hole pattern consistent with the design provided by Metrolinx Electrification.

5. Chapter 5 – Assurance

5.1 General

5.1.1 Purpose and Extent

This chapter provides requirements for the quality assurance, inspection, record keeping and documentation required during the construction of provisional electrification elements. The intent is to provide assurance for the future electrification installer to utilize these items which have had advanced installation.

5.2 Quality Assurance

Grounding and Bonding:

5.2.1 A ground potential study and ground grid design shall be prepared by a Professional Engineer licensed to practice in the Province of Ontario and submitted to the Engineer for review.

5.2.2 Ground resistance test procedures must be submitted to Metrolinx for approval prior to any work being performed.

OCS Drilled Shaft Foundations:

5.2.3 Quality Control Inspection will be in accordance with the following:

1) The Metrolinx Construction Manager reserves the right to inspect all piers at the time of drilling to ensure that the assigned depth and /or bearing strata has been reached. The Metrolinx Construction Manager shall be notified prior to drilling.

5.2.4 Project Record Documents:

1) The Contractor shall keep a record independent of that made by Metrolinx, including items completed each day. These records shall be forwarded in triplicate each day during drilled pier operations to Construction Manager and shall include:

- Date of drilling; concrete placement
- Job and weather conditions
- Drilled shaft Designation; Type, size and depth
- Elevation of ground surface and bottom of drilled shaft
- Log of each pier drilled with soil or rock strata encountered
- Water entry and flow
- Drilling difficulties and obstructions
- Casing size and location
- Bottom cleanout and water removal
- Description of bearing material
- Plumbness
- Location of drilled pier center with respect to design location
- Reinforcing cage placement
- Composition and properties of drilling slurry
- Concrete composition and measured slump
- Method of concrete placement
- Volume of concrete placed
- Log of concrete placement operations
- Results of integrity testing
- Description of any grouting operations to repair drilled shaft
- Other pertinent construction details.

5.2.5 Materials and installed work may require testing at any time during progress of work. Allow free access to material stockpiles and facilities.

5.2.6 Bottom of shaft will be visually inspected (video or photograph) and approved by the Construction Manager. The visual inspection will be provided by the Contractor.

Formwork:

5.2.7 Design calculations for formwork shall be prepared by a Professional Engineer licensed to practice in the Province of Ontario and submitted to Metrolinx for review.

Concrete Reinforcement:

5.2.8 Product Data:

1) Manufacturer's product data and installation instructions for proprietary manufactured materials and reinforcement accessories shall be submitted for review.

2) Manufacturer's product data and installation instructions for proprietary exothermic metal splicing systems and proprietary mechanical coupler splicing systems (when such splicing methods are permitted) shall be submitted for review.

Structural Steel and Aluminum

Shop details, welding procedures, erection diagrams, erection procedure and test reports for fasteners shall be submitted for review.

5.2.9 Certificates:

1) For each lot/heat or load of reinforcing steel, structural steel, and/or aluminum delivered to the jobsite, mill affidavits, mill test certificates or test reports of compliance or similar certification shall be provided, certifying the grades and physical and chemical properties of the material complies with the material requirements of the approved documents. Materials with CVN toughness properties delivered to the job site shall be identified separately using color coding or tags.

2) For galvanized reinforcing bars, furnish certificates, mill certificates or test reports of compliance with ASTM A767 shall be provided.

3) For welding personnel, furnish welder qualification / certificates or affidavits attesting the welders' qualifications to perform the indicated joints, materials and positions by The Canadian Welding Bureau shall be provided.

4) For each joint required to be welded, copies of approved / stamped welding procedures shall be provided (e.g. CWB approved welding procedures).

5) For each visual welding inspector, non-destructive examination welding inspector, and/or inspection organization copies of qualifications / certifications shall be provided (e.g. CWB welding inspector ticket, CGSB welding inspector ticket).

6) For each welding fabricator, a copy of their quality system to control the welding or certification documents shall be provided (e.g. CSA W47.1 certificate).

7) For mechanical coupler splicing, furnish certificates or affidavits attesting to the crew's special qualifications to perform the splicing.

OCS Pole Splices

5.2.10 Source Quality Control

1) Material and fabrication procedures are subject to inspection and tests in the mill, shop, and field by the AR. These inspections and tests shall not relieve the Contractor of the responsibility for providing materials and fabrication procedures that are in compliance with the requirements.

5.2.11 Field Measurements: When required, all field measurements shall be taken prior to preparation of Shop Drawings and fabrication.

5.2.12 Shop Assembly: contractor shall pre-assemble components in the shop, to minimize field splicing and assembly of units at the project site. Units shall only be disassembled to the extent necessary for shipping and handling. Components shall be clearly marked, with permanent markings, for easy assembly at site of installation.

5.2.13 Material Testing: When requirements of clause 5.2.9(1) cannot be met, the chemical compositions and appropriate mechanical properties shall be determined for all materials used by laboratory testing at a facility acceptable to the AR.

Weld Quality Control

5.2.14 Competency of personnel

Welding personnel shall be qualified in accordance with:

- CSA W47.1 for welding of steel; or
- CSA W47.2 for welding of aluminum; or
- CSA W186 for welding or reinforcing bars.

1) Documentation:

(a) Complete information regarding location, type, size and length of all welds shall be clearly shown on the fabrication and erection documents (ref: CSA W59-18 Clause 4.1.1.2).

(b) The welding fabricator / erector shall follow approved welding procedure data sheets (WPDS) for welded joints used by the company in accordance with the project requirements.

(c) Where qualification testing is required for welding procedures, the fabricator shall conduct testing accordingly and provide procedure qualification records (PQR) and laboratory test results along with the WPDS.

(d) For the base materials with CVN toughness properties welding procedures require to be tested in order to prove that the weld metal and heat affected zone meet or exceed the CVN toughness properties of the base materials to be used (e.g. CVN testing in accordance with Annex E of CSA W47.1).

(e) Where welding inspection is performed as specified in the contract the welding inspector or welding inspection shall provide inspection reports clearly identifying the inspection results, if any repairs are required and to what extent.

5.2.15 Repairs

1) Prior to commissioning, the welds identified as required to be repaired shall be repaired as specified by the Engineer and re-examined at the fabricator's cost.

5.3 Inspection

5.3.1 Cooperate with the Construction Manager and furnish services as required for inspecting and obtaining data.

5.3.2 Grounding and Bonding

1) Grounding and Bonding elements shall be inspected prior to embedment in concrete and tested as per the requirements in section 5.4.

2) Visual inspection (Photographic or Video) of embedded Grounding and Bonding provisions shall be performed prior to the pouring of any concrete

5.3.3 OCS Drilled shafts

1) Drilled Shaft construction inspection will be performed by the Construction Manager retained by Metrolinx. The Contractor shall provide access to the work for inspection at all times. No drilled shafts shall be installed except in the presence of the Construction Manager

2) An inspection form including all necessary information fields as specified in Section 5.2.2 shall be provided to Metrolinx for approval prior to any work being performed.

5.3.4 Welds

1) Welding inspectors shall be certified in accordance with:

- CSA W178.2 or AWS QC1 for visual welding inspection;
- CAN/CGSB 48.9712 (ISO 9712) for non-destructive testing.

2) OCS and other structures

(a) The extent of the visual welding inspection shall be 100 %.

(b) The results of all visual welding inspection shall be recorded and reported to Metrolinx.

(c) The acceptance criteria and procedures for visual welding inspection shall be as specified in CSA W59 or CSA W59.2 as applicable.

3) Reinforcing bars

(a) The extent of the visual welding inspection shall be 100 %.

(b) The results of all visual welding inspection shall be recorded and reported to Metrolinx.

(c) The acceptance criteria and procedures for visual welding inspection shall be as specified in CSA W186.

5.4 Testing

5.4.1 Grounding and Bonding

1) Ground resistance testing shall be performed in accordance with the Ground Resistance Test Procedures as approved by Metrolinx. Test results shall include at a minimum, but not limited to:

(a) Individually performed test resistance values of each OCS foundation (when not bonded to counterpoise) – not to exceed 25 Ohms.

(b) Test resistance values of station platform ground grid from the noted ground enclosure at each end of the platform – not to exceed 5 Ohms.

(c) Test resistance values of various metallic platform items (columns, railings, canopies) – not to exceed 5 Ohms.

5.4.2 Concrete Reinforcement

1) The following Quality Control inspections and tests shall be performed by the Contractor:

- Placement of reinforcing steel, including bar supports, tied laps and intersections, welded wire fabric, and bar mats.
- Welded splices and joints.
- Exothermic coupler splices.
- Mechanical coupler splices.

2) Specific requirements for inspections and tests include the following:

Placement:

- Visual inspection of reinforcing steel in place.

Welds:

- The requirements of 5.3.4 (3) shall be met.

Exothermic Coupler Splices:

- Continuous visual inspection for the first eight hours, minimum, of the work as performed by any crew, and again by any replacement crew. All splices shall be visually inspected before concrete may be placed.
- Visual inspection will be performed in accordance with the product manufacturer's instructions and recommendations for such inspection.
- Inspections shall measure and record all voids. Exothermic splices acceptable, provided measured "void limits" per end do not exceed manufacturer's specified "void limits."
- Splices indicating improper fill, slag at tap hole, or blowouts shall be rejected.
- Mechanical Coupler Splices: Test 100 percent of the couplers, using an appropriate click-type torque wrench calibrated to an appropriate minimum turning torque that must be applied to the extent that further turning is resisted. Where tests reveal failure of couplers to be properly tightened, couplers must be removed and replaced.
- Chemically bonded reinforcement: the bond shall demonstrate that it can develop 100% of the tensile strength of the bar.

3) For exothermic coupler splices, qualification splices shall be provided for each position as follows:
   - One sample splice for the first 25 splices; thereafter, one sample splice for every 50 splices.
   - Sample splices shall be laboratory tested for strength in tension (125 percent of the yield strength of connecting bars).

5.4.3 Non-destructive examination for OCS and other structures

1) Non-destructive testing of welds shall be performed on a random selection conducted by the AR comprising of no less then 20% of the total number of poles.

2) The volumetric method for non-destructive examination shall be selected in that way that the welds selected for such examination can be 100% verified:
   (a) All poles selected for testing shall be tested by the ultrasonic and magnetic particle methods. In addition, one quarter of these poles, or a minimum of 2 poles of each type/size, selected at random by the Engineer, shall also be tested by the radiographic method.
   (b) Ultrasonic or radiographic testing shall be performed on the complete penetration welds between the pole shaft and pole base, and on any circumferential welds in the pole shaft, for each pole being tested. Magnetic particle testing shall be performed on all other welds including longitudinal seam welds, welds at handholes, etc.
   (c) For each tested pole that is found to be unacceptable, weld testing shall be performed on a further sample of two (2) poles of each size, selected at random by the AR.
   (d) All non-destructive examination shall be recorded and reported to Metrolinx.

(e) The acceptance criteria of the result shall be as specified in CSA W59 or CSA W59.2 as applicable.

5.4.4 Concrete placed in shafts:

1) Field test and inspections:

(a) The volume of concrete in place shall be carefully monitored throughout the entire concrete placement. Soundings shall be taken on a regular basis, as directed by the Construction Manager. Soundings also shall be used to compare actual volume versus computed volume of the segment measured between sounding intervals. Any substantive discrepancy shall be cause for investigation and corrective actions.

(b) Soundings shall be made at frequent intervals of time to confirm that the mouth of the tube is embedded 1500mm in fresh concrete. Such soundings shall be made before lifting the tube and the amount of lift shall be controlled to prevent loss of seal.

(c) Quality control tests shall be performed in accordance with this Section. The Contractor shall cast one set of cylinders for every 40 cubic meters of concrete, or fraction thereof, delivered to the site.

2) The following procedures will be used by the Construction Manager to evaluate and approve the concrete:

(a) Concrete test cylinders for compressive strength testing for acceptance, and for referee testing purposes where required, shall be cast, cured and transported according to CSA A23.2-3C, entitled "Evaluation and Acceptance of Concrete," except that samples shall be obtained on a random basis with a minimum of twelve (12) cylinders prepared (7 and 28 day tests) which will be taken for each 20 m^3 meters of concrete or one set per day, whichever is more frequent.

(b) Slump shall be measured according to CSA A23.2-5C.

(c) Air content shall be measured according to CSA A23.2-4C. The air meter shall be calibrated at least once a year according to CSA A23.2-4C and a copy of the calibration certificate shall be with the air meter and available for review, when requested.

(d) Temperature shall be measured according to CSA A23.2-17C

3) The Contractor shall assume all costs incurred in connection with any investigation required by the Construction Manager and/or with any removal and replacement of concrete not achieving the quality requirements specified in this Section.

(a) Where the strength of concrete for two out of three sets of compressive strength tests performed by the Contractor falls below the minimum compressive strength required, samples of in place concrete shall be taken and tested by the Construction Manager, at the Contractor's expense. Concrete failing to meet the requirements of this Section shall be removed and replaced at no cost to Metrolinx.

5.5 Submittals

5.5.1 Documentation for provisional electrification items shall be provided to Metrolinx as assurance for the future electrification installer. This documentation shall be provided as a single, separate package such that the future electrification installer will have a complete set of documents for assurance.

5.5.2 Grounding and Bonding

1) Shop Drawings/Detailed Design Drawings: Shall include a layout showing the location and type of each grounding conductor and connection.

2) Catalog Cuts shall be provided for all grounding material.

3) Ground Resistance test results and GPR Studies shall be provided.

5.5.3 OCS Drilled Shaft Foundations

1) Shop Drawings: Shall include a layout showing the location of each foundation; foundation details; reinforcement steel schedule; bills of material; details; pertinent dimensions; spacing for each foundation; and casing diameter and wall thickness.

2) Submit a detailed work plan of the procedures to be used for placement of reinforcing cages and concrete.

3) Certified mill test reports for reinforcing steel and steel casing shall be provided if requested.

4) Reports: the following reports shall be provided directly to the Construction Manager as requested, with one copy to others as designated:

   (a) Record and maintain information pertinent to each drilled pier and cooperate with other testing and inspection personnel to provide data for required reports.

   (b) Provide a certified drilled pier report for each drilled pier, recording the following:

   - Actual elevation at bottom and top
   - Elevation of rock (if any)
   - Final centerline location at top
   - Variation of shaft from plumb
   - Result of tests performed
   - Depth of rock socket (if applicable)
   - Levelness of bottom
   - Seepage of water
   - Still water level (if allowed to flood)
   - Elevation of bottom and top of any casing left in place
   - Any unusual conditions from original design,
   - Dates of starting excavation, completion of excavation

5) Certification by a land surveyor licensed in the province of Ontario that each foundation conforms to the tolerances specified and the dimensions and elevations shown shall be provided. The certification shall include "as-built" reports of field established dimensions, locations, plumbness, and top and bottom elevations.

5.5.4 Concrete Reinforcement

1) Product Data: manufacturer’s product data for manufactured products specified and indicated shall be submitted at least 30 days prior to ordering any material.

2) Shop Drawings:

(a) Reinforcement lists, bending diagrams and schedules, and placement plans and details for all reinforcing steel shall be submitted for review. Reinforcement lists shall include:

- Weights
- Descriptions,
- Details,
- Dimensions,
- Arrangements and assemblies,
- Locations of reinforcing steel.
- Number of pieces,
- Sizes, and markings of
- Reinforcing steel
- Laps
- Splices
- Supporting devices and accessories
- Any other information required for fabrication and placement. Indicate any adjustments required.

(b) Check Contract Drawings for anchor bolt schedules and locations, anchors, hangers, inserts, conduits, sleeves, and any other items to be cast in concrete for possible interference with reinforcing steel. Required clearances on shop drawings shall be indicated.

(c) Detail reinforcing steel in accordance with requirements of RSIC and CSA G30.18-09. Individual weight of each bar, total weight of each bar size, and total weight of all bars on the list shall be indicated. Base calculated weights upon nominal weights shall be as.

5.5.5 Cast-in-Place Concrete

1) Shop Drawings:

(a) Test placement details shall be provided at least 15 days before test placement.

2) Product Data: for each type of product indicated, the following shall be provided:

(a) Design Mixtures: for each concrete mixture.

(b) Material test reports and certificates.

5.5.6 Formwork

1) Shop Drawings:

(a) All formwork and shoring shop drawings shall be signed and sealed by a Professional Engineer licensed to practice in the Province of Ontario. Shop drawings shall be submitted to Metrolinx for review.

(b) Shop drawings shall indicate, at a minimum:

- Pertinent dimensions, openings, methods of construction, types of connections, materials, joint arrangement and details, ties and shores, location of framing, studding and bracing, and temporary supports;
- Means of leakage prevention for concrete exposed to view in the finished construction;
- Sequence and timing of erection and stripping, assumed compressive strength at time of stripping, height of lift and height of drop during placement;
- Vertical, horizontal and special loads in accordance with "Loads" of S269.3-M92 (R2013), Section 5 and camber diagrams, if applicable.
- Notes to formwork erector showing type, size, number and location of conduits and pipes embedded in concrete according to S269.3-M92 (R2013), Section 6.7 and CSA A23.3, Section 6.2.

5.5.7 OCS Pole Splices

1) The Contractor shall submit the manufacturer's specifications and installation instructions for statement of no objection (SONO) for all components in this Section.

2) Shop Drawings for SONO shall be submitted, showing details and dimensions of all pole types and small parts steel, together with complete specifications of materials and components including supporting calculations.

   (a) Shop Drawings shall be prepared under seal of a Professional Structural Engineer registered in the Province of Ontario.

3) Certificates of compliance shall be submitted for all components covered by this Section.

4) Certification: A certification verifying that the materials have been designed, manufactured, inspected and tested in accordance with the applicable portion of the reference standards and these specifications shall be furnished.

5) Test Reports: Copies of reports of all factory tests as required by these specifications and referenced standards shall be furnished.

6) On shop drawings, welded connections shall be indicated using standard AWS welding symbols. Net weld lengths, and sizes shall be indicated.

7) Samples: An authentic sample of any component for which a SONO or conditional SONO has been issued by the Authority's Representative (AR) shall be submitted, as indicated on shop drawing reviews, when so requested by the AR, or as required in the specifications. All samples shall be identified with a tag label of suitable material, wired to the sample.

8) Approved welding procedures and welder qualifications to be used in fabrication shall be submitted.

5.5.8 Submission to local authority

1) For integrated OCS poles in station areas, the Contractor shall also submit all specifications, installation instructions, shop drawings, certificates, test reports, samples, and other submittals to the local municipal authority for SONO, in addition to Metrolinx's SONO.

2) Ground Potential Rise Study, results and design grounding packages shall be submitted to the Electrical Safety Authority for review and approval.

5.5.9 OCS Metal Fabrications

1) Shop drawings shall be submitted showing the following:

   (a) Sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and installation details.

   (b) Details for manufacturer's items or fabricated metalwork.

   (c) Field erection details showing cuts, copes, connections, holes, threaded fasteners and welds, both shop and field, by symbols conforming to AWS standards. Indicate net weld lengths.

2) Manufacturers' product data shall be submitted. Application instructions for galvanizing repair product shall be included.

3) Approved welding procedures and welder qualifications to be used in fabrication shall be submitted.

END OF SECTION