CONSTRUCTION SPECIFICATION FOR IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR BRIDGE STRUCTURES

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935.01 SCOPE

This specification covers the requirements for the installation of cathodic protection system using anode mesh.

935.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

935.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

935.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 602 Installation of Electrical Chambers
OPSS 603 Installation of Ducts
OPSS 604 Installation of Cable
OPSS 609 Grounding
OPSS 616 Footings and Pads for Electrical Equipment
OPSS 904 Concrete Structures
OPSS 913 Embedded Work in Structures for Electrical Systems
OPSS 928 Structure Rehabilitation - Concrete Removal
OPSS 929 Abrasive Blast Cleaning - Concrete Construction
OPSS 930 Structure Rehabilitation - Concrete Patches and Overlays

Ontario Provincial Standard Specifications, Material

OPSS 1302 Water
OPSS 2301 Impressed Current Cathodic Protection System for Bridge Structures

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

ASTM International

B 265-95	Titanium and Titanium Alloy Strip, Sheet and Plate
D 4285-83 (1993)	Test Method for Indicating Oil or Water in Compressed Air

Others

Ontario Traffic Signal Control Equipment Specifications (OTSCES)
NACE - National Association of Corrosion Engineers
Ontario Electrical Safety Code

935.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Cathode Connection means a cable connection of the following two types made to reinforcing bars:

a) CS: a current carrying cathode connection that is connected to the negative terminal of the rectifier.

b) CM: a non-current carrying cathode connection that is used to monitor the potential of the reinforcing steel with respect to a reference cell.

Corrosion Specialist means an individual having all of the following qualifications:

a) A minimum of 5 years experience in cathodic protection of reinforced concrete structures.

b) Is a NACE accredited cathodic protection specialist.

c) Is an Engineer.

Distribution Bar means a component of the anode that distributes current from the power feed point.

Instant-Off means the potential reading taken immediately after the current flowing to the system has been interrupted.

Subzone means the division of a concrete component into areas where the anode in an area is not continuous with the anode in the adjacent area.

Zone means an area of a concrete component energized by one rectifier unit consisting of one or more subzones.

935.04 DESIGN AND SUBMISSION REQUIREMENTS

935.04.01 Submission Requirements

935.04.01.01 Working Drawings

At least 8 weeks prior to commencement of production of the cathodic protection assembly, 4 copies of the Working Drawings for the components listed below shall be submitted to the Contract Administrator, for information purposes only. Prior to submission, an Engineer's seal and signature shall be affixed on the Working Drawings verifying that the drawings are consistent with the requirements of the Contract Documents.

a) The cathodic protection equipment assembly.

b) The cathodic protection terminal block assembly.

c) The cathodic protection remote monitoring and control unit.

d) The cathodic protection rectifier.

e) The wireless modem antenna.

The Working Drawings shall include the information specified in OPSS 2301.

The Working Drawings shall contain at least the following information:

a) Dimensioned layout drawings including sections, block diagrams, and details to show enclosure, equipment layout, and mounting arrangement.

b) Wiring diagram, including field location and function labels.

c) Detailed bill of materials including sources.

935.04.01.02 Technical Documentation

Four copies of the following documents for each rectifier and for the RMU containing at least the following information shall be submitted to the Contract Administrator:

a) Operation and maintenance manual.

b) Complete schematic diagrams and parts lists.

c) Drawings showing external and internal physical dimensions of the unit.

d) Manufacturer's data sheets and engineering technical data for all electronic, electrical components, and mechanical parts of the unit.

e) Detailed information and test procedures for trouble-shooting.

f) Performance reports including the 180 hour burn-in test for the rectifier and RMU documenting all of the required tests for the rectifier and for the RMU.

Two copies of the RMU software shall be submitted to the Owner.

935.04.01.03 Notification of Production

The Contract Administrator shall be given at least one week prior notice of the date of commencement of fabrication and the date of completion of fabrication of the following components:

a) The cathodic protection rectifier.

b) The cathodic protection remote monitoring and control unit.

935.04.01.04 Notification of Suppliers

The names of the suppliers of the cathodic protection control and monitoring equipment shall be submitted to the Contract Administrator, upon request.

935.04.01.05 Spacer Grid

The product data sheet of the glass fibre reinforced polymer bars (GFRP) spacer grid shall be submitted to the Contract Administrator prior to installation.

935.04.01.06 Anode Mesh and Distribution Bars

At least one week prior to the commencement of the installation of the distribution bars and the anode mesh, the following samples fabricated with the equipment and procedures to be used in the work together with the power setting used in welding the samples shall be submitted to the Contract Administrator:

a) Two 300 mm lengths of distribution bar overlapped and welded at 4 locations at 12 mm intervals.

b) Anode mesh welded at the diamond junctions to two 500 mm lengths of distribution bars.

935.04.01.07 Corrosion Specialist

At least one week prior to commencement of work on the structure, the name and qualifications of the corrosion specialist shall be submitted to the Contract Administrator.

935.04.01.08 Test Results

Within 3 Business Days of the completion of the tests required, the results of all tests that are specified to be recorded shall be submitted in writing to the Contract Administrator.

Each test result shall be identified by the corresponding test location.

935.05 MATERIALS

935.05.01 General

All electrical materials, equipment, components, or completed assemblies of components shall be approved according to the Ontario Electrical Safety Code.

935.05.02 Concrete Pad for Cathodic Protection

Concrete pad for cathodic protection shall be according to OPSS 616.

935.05.03 Cathodic Protection System

Cathodic protection system and its associated materials shall be supplied according to OPSS 2301.

935.05.04 Concrete for Blockout

Concrete used to fill blockouts for installation of cables in curbs, sidewalks, and barrier walls shall have a 28-Day strength of 30 MPa according to OPSS 1350. Nominal maximum size of aggregate shall be 9.5 mm.

935.05.05 Water

Water shall be according to OPSS 1302.

935.05.06 Non-Shrink Grout

Non-shrink grout shall be supplied from a source named on the ministry's DSM.

935.05.07 Spacer Grid

The spacer grid shall be according to OPSS 2301.

935.06 EQUIPMENT

935.06.01 AC Resistance Meter

The AC resistance meter shall be capable of measuring from 0.1 to 10,000 ohms, with an accuracy of ± 1 % of full scale, and shall be insensitive to AC and DC ground currents.

935.06.02 Multimeter

The multimeter shall have an input impedance of not less than 10 megohms when operated at a full scale of 100 mV DC.

The meter shall have an accuracy of ± 2.5 % of the reading in DC volts with a resolution of 0.1 mV.

935.06.03 Clamp-On Ammeter

The clamp-on ammeter shall be capable of measuring DC current ranging from 1 to 4,000 mA.

The ammeter shall measure DC current with an accuracy of ± 2.0% and a resolution of 1 mA.

935.06.04 Air Compressor - Air Blasting

The air compressor for air blasting shall have a minimum capacity of 3.5 m^3/min. The compressed air shall be free of oil according to ASTM D 4285-83 and be forced through a nozzle at a minimum pressure of 300 kPa.

935.06.05 Pressure Wash Equipment

The pressure wash equipment shall produce a minimum pressure at the nozzle of 1.4 MPa.

935.06.06 Holiday Detector

The holiday detector shall have pulse type output voltages adjustable to produce from 300 to 3,000 volts. The device shall be equipped with a 300 mm wide conductive steel or copper brush to scan the concrete surface and shall produce a loud audible signal when metals that are electrically connected to the reinforcement are detected.

935.06.07 Concrete Cover Meter

The cover meter shall have a digital read out for measurement of cover and an audio signal indicating detection of reinforcing steel bars in concrete with cover up to 150 mm. The accuracy of the meter shall be ± 5% of full scale.

935.06.08 Resistance Welder

The resistance welder shall be as recommended by the anode system manufacturer.

935.07 CONSTRUCTION

935.07.01 General

935.07.01.01 Sequence of Work

The cathodic protection work shall not commence until the repairs in the areas to receive cathodic protection have been completed fully or in sections and accepted by the Contract Administrator.

935.07.01.02 Access

The Contract Administrator shall have full access to the place of manufacture of the cathodic protection control and monitoring equipment.

935.07.01.03 Electrical

All electrical work shall be as specified in the Contract Documents.

All resistance measurements shall be made with an AC resistance meter, except when measuring resistance between two cathode connections.

935.07.01.04 Concrete Removal in Recesses and Cable Slots

The recesses for the embedded components and cable slots shall be sawcut prior to concrete removal. Concrete removal shall be according to OPSS 928.

935.07.01.05 Abrasive Blast Cleaning

Abrasive blast cleaning shall be according to OPSS 929.

935.07.01.06 Concrete Placement

Concrete shall be placed according to OPSS 904.

935.07.01.07 Curing

Curing of concrete and non-shrink grout shall be according to OPSS 904 utilizing the wet burlap method.

935.07.02 Cathode Connections

935.07.02.01 Installation

935.07.02.01.01 Scheduling

Cathode connections to the reinforcing steel shall be made after removal of concrete and abrasive blast cleaning in the removal areas.

935.07.02.01.02 Layout

The cathode CS and CM cables shall be connected to the reinforcing steel at the locations as specified in the Contract Documents. Alternative locations for cathode CS and CM connections shall be specified by the Contract Administrator, if required.

Adjustment up to 1 m shall be allowed for the cathode CS connections. The cathode CM connections shall be located between 600 mm and 1 m of the respective reference cells.

At the cathode connection positions specified, the location of the reinforcing steel bars shall be determined by means of a cover meter.

935.07.02.01.03 Preparation of Reinforcement and Recess

Concrete shall be removed to expose a 150 mm length of reinforcing bar.

The reinforcing steel and the concrete surface of the recess shall be abrasive blast cleaned and cleaned of all deleterious material by means of air blasting.

The reinforcing bar shall be ground locally to expose bare metal prior to making the thermite weld connection.

935.07.02.01.04 Connection of Reinforcing Steel

The connection shall be made centred on the ground portion of the reinforcing steel as specified in the Contract Documents. The bare portion of the cathode cable shall be protected by a copper sleeve and shall be connected by thermite welding to the reinforcing bar. Mechanical connections shall not be used.

When the weld has cooled, slag shall be removed and a 5 mm thick layer of silicone sealant shall be applied to the entire weld area of the bar and to all exposed copper cable. After setting of the silicone seal, all debris shall be removed from the recess and the surface of the recess shall be dampened. All free water shall be removed from the recess and the recess shall be filled with non-shrink grout according to the manufacturer's recommendations.

935.07.02.01.05 Cable Installation

Cable slots shall be created by saw cutting. Cable slots, each 6 mm wide by 10 mm deep, shall be sawn between the cathode connection locations and the junction box for the installation of cathode connection cables as specified in the Contract Documents. The edges of the slot shall be rounded where the slot meets the recess. Each slot shall contain only one cable.

When multiple cables converge in to one cable slot, the cable slot shall be adjusted to 9 mm wide by 23 mm deep and sawn from the point where all the cables converge at the install area to the corresponding junction box. Each cable shall share the common saw slot running to the junction box.

Immediately prior to placing material, the recesses shall be abrasive blast cleaned and all deleterious material contained inside the recesses and slots shall be removed by means of air blasting.

The cable shall be continuously contained in the slot between the cathode connection and the junction box and held in place with non-metallic plugs spaced at 600 mm on centres to prevent migration of the cable towards the surface.

Cables that will be unconnected at the junction box location for more than one week shall have a heat shrink end boot installed until the permanent connection is made.

Cable slots shall be backfilled with non-conductive low viscosity epoxy to the level of the original concrete surface according to the manufacturer's recommendations. Care shall be exercised to ensure that the slots are completely filled with epoxy and there is no excess epoxy spilled over the adjacent concrete surface along the slots.

935.07.02.01.06 Testing During Installation

Prior to filling cathode recesses, the mechanical soundness of each completed cathode connection shall be verified and the DC resistance and voltage between the ends of cables from cathode connections shall be measured and recorded.

The resistance between any two cathode connection cables in a single zone shall be less than 1.0 ohm and voltage shall be less than 1 mV. If the resistance is greater than 1.0 ohm, or voltage is greater than 1 mV, each individual cathode connection cable shall be checked and remedial work shall be performed as follows:

a) When the resistance between the end of the cable and the reinforcing bar to which it is connected is greater than 1.0 ohm or the voltage is greater than 1 mV, the cable shall be cut and reattached to the same reinforcing bar at least 150 mm away from the previous connection.

b) When the resistance between the end of the cable and the reinforcing bar to which it is connected is less than 1.0 ohm and voltage is less than 1 mV, additional cathode connections shall be installed at locations determined by the Contract Administrator.

Resistance and voltage measurements between pairs of cathode connection cables shall be repeated and recorded following remedial work.

When mechanical soundness of the cathode connections and continuity of reinforcing steel have been verified, patching of cathode cavities may proceed. After patches are placed, the resistance and voltage between pairs of cathode connection cables shall be measured and recorded to check the connections prior to placing anode.

The results of all tests shall be certified by the corrosion specialist and the certified test results shall be submitted to the Contract Administrator.

935.07.03 Reference Cells - Graphite and Silver-Silver Chloride

935.07.03.01 Installation

935.07.03.01.01 Scheduling

The recesses for reference cells and cable slots shall be saw cut prior to concrete removal.

Reference cells shall be installed after removal of concrete and abrasive blast cleaning in the removal areas.

935.07.03.01.02 Layout

The reference cells shall be placed at the locations as specified in the Contract Documents.

At the reference cell positions as specified in the Contract documents, the location of the reinforcing steel bars shall be determined by means of a cover meter.

A recess, 200 mm wide by 400 mm long, to accommodate the reference cell shall be cut into the concrete within 10 to 25 mm from a reinforcing steel bar with the longitudinal axis of the cell parallel to the reinforcing steel bar. The Contract Administrator may specify a smaller size recess, if necessary.

When reinforcing steel interferes with the placement of a cell, the recess shall be extended to permit installing the cell without cutting the reinforcing steel or a new recess shall be cut.

Reference cells shall not be positioned in a patched area or within 600 mm of a patched area.

To comply with the above requirements the cell may be moved a maximum of 1 m from the location as specified in the Contract Drawings.

The Contract Administrator shall specify alternative locations when the above conditions cannot be satisfied or when required.

935.07.03.01.03 Preparation of Recess and Cell Placement

The depth of the recess shall permit the reference cell to be installed with the adjacent reinforcing steel bar at the mid height of the cell. When 10 mm of cover is not provided to the top of the cell under the above conditions, the recess shall be deepened to provide the 10 mm of cover.

Reference cells installed adjacent to ducts containing post-tensioning steel shall be installed at the depth as specified in the Contract Documents or as directed by the Contract Administrator.

The concrete surface in the recess shall be abrasive blast cleaned and all deleterious material removed by means of air blasting.

The surfaces of the recess shall be dampened, all free water removed, and coated with non-shrink grout. The reference cell shall be placed tight against the side of the recess closest to the reinforcing steel; however, contact between the cell and the exposed reinforcing steel shall not be permitted. The recess, including cavities induced by saw cutting shall be filled with non-shrink grout according to the manufacturer's recommendations to the level of the original concrete surface.

935.07.03.01.04 Cable Installation

Cable slots shall be created by saw cutting. Cable slots, each 6 mm wide by 10 mm deep, shall be sawn between the reference cell recess and the junction box for the installation of the reference cell cables as specified in the Contract Documents. The edges of the slot shall be rounded where the slot meets the recess. Each slot shall contain only one cable.

When multiple cables converge in to one cable slot, the cable slot shall be adjusted to 9 mm wide by 23 mm deep and sawn from the point where all the cables converge at the install area to the corresponding junction box. Each cable will share the common saw slot running to the junction box.

Immediately prior to placing material, the recesses shall be abrasive blast cleaned and all deleterious material contained inside the recesses and slots shall be removed by means of air blasting.

The cable shall be continuously contained in the slot between the reference cell recess and the junction box and held in place with non-metallic plugs spaced at 600 mm on centres to prevent migration of the cable towards the surface.

Each cable left unconnected at the junction box location for more than 1 Day shall have a heat shrink end boot installed on it. The heat shrink end boot shall not be removed until the cable is permanently connected.

Cable slots shall be backfilled with non-conductive low viscosity epoxy to the level of the original concrete surface according to the manufacturer's recommendations. Care shall be exercised to ensure that the slots are completely filled with epoxy and there is no excess epoxy spilled over the adjacent concrete surface along the slots.

935.07.03.01.05 Testing During Installation

Upon completion of cell installation, the voltage and resistance between the reference cell and the cathode CM connection shall be measured and recorded.

If the AC resistance between the graphite cell and the cathode connection is less than 10 ohms or more than 1,000 ohms or if the voltage reading is unstable, the cell shall be removed and replaced. The voltage and resistance measurements shall be repeated and recorded.

The results of all tests shall be certified by the corrosion specialist and the certified test results shall be submitted to the Contract Administrator.

935.07.04 Rigid Ducts and Junction Boxes, Surface Mounted

The duct, fittings, and junction boxes shall be installed in neat straight lines. Rigid ducts shall be installed vertically and either horizontally or parallel to structural surfaces using offset bends or fittings where changes in alignment are necessary. When holes are specified to permit installation through concrete components, they shall be core drilled.

Expansion joints shall be installed according to the manufacturer's recommendations with at least one expansion joint between any two adjacent junction boxes. Conduit straps and junction boxes shall be fastened to the concrete surface by drilling and inserting stainless steel anchors and bolts.

Conduit straps shall be located at a maximum of 1.5 m centres and shall be one trade size larger than the conduit supported.

Ducts and junction boxes shall be installed after concrete repairs have been completed.

935.07.05 Rigid Ducts and Junction Boxes, Embedded in Concrete

The installation of rigid PVC junction boxes and rigid duct embedded in concrete shall be according to OPSS 913.

When cables are to be routed through the curb to a junction box mounted on the outside face of a deck, concrete shall be removed at the curb locations to the width and depth as specified in the Contract Documents. All sharp edges of concrete shall be rounded off. A hole shall be drilled to provide access to the junction box or to provide a deck entry hole where specified in the Contract Documents. A non-conductive duct shall be installed and grouted in place with non-shrink grout.

After the installation of the cables, the duct embedded in the curb shall be sealed with a silicone plug to a depth of 50 mm.

The cavities in the curb, barrier wall, or sidewalk shall be filled with concrete to the original surface according to OPSS 930.

935.07.06 Rigid Ducts, Direct Buried

The installation of rigid ducts direct buried shall be according to OPSS 603.

935.07.07 Extra Low Voltage Cables

The installation of the extra low voltage cables shall be according to OPSS 604.

The run of extra low voltage cable from the initial splice in the junction box to the cathodic protection cabinet shall be of one continuous length. Heat shrink identification sleeves shall be placed over the free end of each cable at the cathodic protection cabinet and at the end of each cable from the structure in the junction boxes with the number of the component as specified in the Contract Documents.

All splices, with the exception of anode distribution bars, shall be made in the junction boxes with compression connectors. Each splice shall be soldered after installation. Both ends of the connector shall be soldered to the cable.

All splices for reference cells and cathode CM cables shall be sealed and insulated with heat shrink tubing. The splices for the cathode CS cables shall be sealed and insulated with a motor splice kit.

Cable that will be unconnected at the junction box location for more than one week shall have a heat shrink end boot installed until the permanent connection is made.

935.07.08 Installation of Cathodic Protection Equipment Assembly

935.07.08.01 Concrete Pad and Ground Electrode

The concrete pad shall be constructed according to OPSS 616, except that the anchor bolts shall be drilled in place.

The installation of the ground wires and ground electrode shall be according to OPSS 609.

935.07.08.02 Installation of Cabinet

The pedestal and cabinet shall be installed squarely and symmetrically on the concrete pad with a neoprene gasket installed on the bottom channel of the enclosure and the bottom of the pedestal.

Holes for mounting bolts shall be drilled, as required, and anchor bolts installed.

935.07.08.03 Grounding

The ground bar installed on the inside and bottom part of the cabinet shall be connected to the system ground as specified in the Contract Documents.

935.07.08.04 Connection of Incoming Cables

The AC power supply shall be connected to the AC power distribution assembly. Each cable from the structure shall be connected to the proper terminal on the terminal block assembly conforming to the colour code and labelling.

Upon completion of wiring and connection, all incoming cables shall be bundled and held in place with nylon cable ties. Cables and connectors shall not be subject to stress during or after installation.

935.07.09 Anode Mesh and Distribution Bars

935.07.09.01 Handling and Storing

The anode mesh and distribution bars shall be handled and stored in such a manner to avoid breakage or shape distortion due to stretching. The anode mesh and distribution bar shall be kept clean and dry prior to installation.

935.07.09.02 Installation

935.07.09.02.01 Scheduling

The anode mesh and distribution bars shall be installed after all concrete patching and abrasive blast cleaning of the concrete surface has been carried out and prior to placement of the concrete overlay.

935.07.09.02.02 Layout

The anode mesh and distribution bars shall be installed on the concrete surfaces as specified in the Contract Documents. Alternative arrangement of anode mesh rows may be considered where it may be practical to use odd shapes of anode mesh, subject to the approval of the Contract Administrator.

935.07.09.02.03 Isolation

The anode mesh and distribution bars shall be electrically isolated from the reinforcing steel and from any metallic components on the surface of the structure prior to proceeding with the work. Only non-metallic fasteners shall be used.

When a deck has been scarified, a concrete cover survey on a 1.5 x 1.5 m grid shall be done after scarifying and prior to the installation of the anode mesh. The results of the survey shall be recorded and submitted to the Contract Administrator.

A spacer grid shall be placed between the anode mesh and distribution bars and the concrete in areas where cover to the reinforcing steel is less than 15 mm or with exposed reinforcing steel. The spacer grid GFRP bars shall be tied together with plastic ties thereby holding the grid together and secured to prevent bars from floating during the overlay pour. Non- conductive fasteners similar to those used to anchor the titanium mesh shall be used to secure the bars to the deck. The titanium mesh in the secured areas shall be placed on top of the GFRP grid and tied by plastic ties to the grid.

Exposed rebars shall not be protected with a coating of grout or epoxy as a means of isolation.

Immediately prior to installation of the anode mesh, all concrete surfaces shall be inspected for exposed metal such as tie-wire, tie-rods, bolts, and other metallic components. All exposed metal and metal within 5 mm of the concrete surface, which is continuous with the reinforcing steel, shall be identified by visual means and by means of a holiday detector and the metal shall be insulated by coating with two coats of epoxy or shall be removed as directed by the Contract Administrator. When epoxy is used, only the metal shall be coated.

935.07.09.02.04 Anode Mesh Placement

Adjacent rolls of anode mesh within the same zone shall be in contact with a minimum overlap of 100 mm.

When two or more zones or subzones are specified, the separation between anode mesh in adjacent zones or subzones shall be 150 ± 25 mm.

Anode mesh shall be cut, where necessary, to provide a separation of 150 ± 25 mm between the anode mesh and metal features mounted on or protruding from concrete surface.

At splices and at joints where irregularly shaped sections are added, the anode mesh shall be overlapped a minimum of 75 mm and both sections of the anode mesh shall be welded to the distribution bar.

The anode mesh shall be either offset a maximum of 75 mm from a concrete corner or shall be wrapped tightly around the corner.

The edge of anode mesh shall be offset 150 ± 25mm from the curb face throughout the length of the deck.

The location of embedded cables shall be determined and marked on the concrete prior to drilling for fasteners.

The anode mesh shall be held in place by non-conductive fasteners inserted in drilled holes. There shall be at least three fasteners installed across the full width of each roll of the anode mesh such that two anchors are placed 50 to 75 mm from the anode mesh edge with a third anchor in the centre. The maximum distance between two adjacent anchors along the length and width of the anode mesh shall not exceed 600 mm.

When the anode mesh is elevated as a result of the GFRP spacer grid, the mesh shall be secured to the GFRP bars by plastic ties.

Overlapping anode mesh may be attached with a common fastener.

The anode mesh shall be installed as close to the concrete surface as practical with a maximum offset from the surface of 3 mm.

Bulges shall be pressed down and additional fasteners shall be installed to maintain the specified clearance.

The anode mesh shall not be tensioned to such an extent that the anode mesh pattern is distorted. Edges of anode mesh cut to avoid contact with objects on the concrete surface shall be fastened at no more than 300 mm intervals.

All debris and dirt resulting from drilling holes for fasteners and others work associated with the installation of the anode mesh shall be removed from the concrete surface by air blasting at a minimum frequency of once per Day.

Under no circumstances shall the anode mesh be subjected to abrasive blast cleaning.

935.07.09.02.05 Distribution Bar Placement

Distribution bars shall be installed in straight lines as specified in the Contract Documents. The locations shall line up with junction box locations to facilitate connection within the box.

Where specified, distribution bars may be extended by overlapping approximately 200 mm and resistance welding every 12 mm.

The anode mesh shall be resistance welded to the distribution bars at every third diamond intersection point for a spacing of approximately 228 mm.

The welding procedures used shall be according to the anode mesh manufacturer's recommendations and shall be those used in making the samples for submission.

The distribution bars shall be protected by the application of heat-shrinkable tubing:

a) in conduit connecting to junction box.

b) where passing through curb.

c) where traversing concrete cracks greater than 1 mm.

d) where specified in the Contract Documents or by Contract Administrator.

The distribution bars shall enter the junction box through the conduit as specified in the Contract Documents. The two distribution bars shall be jumpered by a short stub of distribution bar resistance welded to them in the junction box.

The distribution bars shall be connected to the anode bus cables in the junction box by means of a bolted connector as specified in the Contract Documents. The threads of the bolt shall be coated with a locking compound. The connection and any exposed distribution bars shall be sealed and insulated with heat shrink tubing and heat shrink tape.

935.07.09.02.06 Concrete Surface Preparation after Anode Installation

Immediately after installation of the anode mesh and distribution bars, all debris resulting from the drilling of anchor holes and other accumulated dirt shall be removed from the concrete surface by air blasting.

The surface of the concrete with anode mesh and distribution bars in place shall be pre-wetted with water prior to application of the concrete overlay.

935.07.09.02.07 Protection during Placement of Concrete Overlay

During placement of concrete overlay, the anode mesh and distribution bars shall be protected against potential damage caused by construction equipment and workers by means of 20 mm thick plywood sheeting. The plywood sheets shall be removed as the placement of the overlay progresses.

935.07.09.02.08 Junction Box Entry

When wiring is to be routed to junction boxes embedded in new barrier walls or sidewalks, a blockout shall be created to permit installation of conduit and wiring.

After installation of the cables, the conduit in the curb shall be sealed with a silicone plug to a depth of 50 mm.

The cavities in the curb, barrier wall, or sidewalks shall be filled with concrete to the original surface according to OPSS 930. Alternatively, the cavity may be filled with non-shrink grout.

935.07.09.03 Testing

935.07.09.03.01 Pre-Installation

Prior to installing anode mesh and distribution bars, the quality of the weld between the anode mesh and current distribution bar shall be pull tested by preparing a sample weld and pulling the anode mesh from the distribution bar using pliers. If metal is pulled from one substrate, the weld is acceptable. If the anode mesh strand or strip breaks or is burned through, the weld power setting is too high. If the weld breaks, the power setting is too low. A similar test shall be carried out to determine the quality of the weld when two distribution bars are welded together. The weld power setting shall be adjusted to obtain satisfactory welds.

One week prior to the commencement of the installation of the distribution bars and the anode mesh, the following samples fabricated with the equipment and procedures to be used in the work together with the power setting used in welding the samples shall be submitted to the Contract Administrator:

a) Two 300 mm lengths of distribution bars overlapped and welded at four locations at 12 mm intervals.

b) Anode mesh weld at the diamond junctions to two 500 mm lengths of distribution bars.

935.07.09.03.02 During Installation

935.07.09.03.02.01 Weld between Anode Mesh and Distribution Bars

During installation of the anode mesh and distribution bars, random pull tests shall be performed on the weld connecting as follows to verify the adequacy of the welds:

a) The anode mesh to the distribution bar.

b) The distribution bar to the distributor bar.

935.07.09.03.02.02 Short Circuits

Tests for short circuits shall be carried out by the corrosion specialist or a NACE accredited cathodic protection or corrosion technologist under the direct supervision of the corrosion specialist.

Tests for short circuits between the anode mesh, distribution bars, the reinforcing steel, and all metallic appurtenances shall be done during installation of the anode mesh and continuously monitored during application of the concrete overlay.

Short circuits shall be removed and the area retested prior to proceeding with the concrete overlay.

When the area of potential short circuits is equal to or less than 150 x 150 mm, the anode mesh shall be cut clear of the exposed reinforcing steel or in areas where the cover to the reinforcing steel is less than 15 mm. When the area of potential shorts circuits is greater than 150 x 150 mm, the anode mesh shall be separated from the concrete surface using a GFRP spacer grid.

The location and extent of the areas requiring treatment and the treatment undertaken to eliminate the short circuit shall be recorded and submitted to the Contract Administrator.

Prior to installation of the waterproofing on the concrete overlay and at each stage, a test shall be done to confirm that there are no short circuits by temporarily applying a direct current using a portable DC power supply sufficient to produce and applied current density of 10 mA/m^2. When the occurrence of a short circuit is detected, the short circuit shall be located and removed.

The results of all tests shall be certified by the corrosion specialist and the certified test results shall be submitted to the Contract Administrator.

935.07.09.04 Trial Operating Period - Acceptance Testing

935.07.09.04.01 General

Prior to the acceptance of the Work, it shall be demonstrated that all components of the cathodic protection system, including the rectifier and RMU, are in proper working order. Short circuits are not permitted between the anode mesh and its hardware and the reinforcing steel or any other metallic components of the structure in contact with the reinforcing steel, such as drainage pipe or expansion joints.

Field readings taken during the trial operating period shall be taken by a NACE accredited cathodic protection or corrosion technologist under the direct supervision of the corrosion specialist.

The system shall be energized for a period of 72 hours at a power level that applies an average current density of 2 mA/m^2 on all cathodically protected areas of the structure. If AC power is not available at the site at the time of the trial operating period, power shall be provided to the rectifier and remote monitoring by means of a portable generator.

Field testing of the installed cathodic protection system shall only be conducted with the Contract Administrator and a representative of the Owner in attendance.

The Contract Administrator shall be informed 4 Business Days in advance of the planned trial operating period.

When measuring the potential of reference cells, the negative lead of the multimeter shall be connected to the reference cell lead wire and the positive lead to the cathode CM wire. The polarity sign of the reading shall be recorded.

Testing shall be done when the air temperature is at least 5 °C.

The results of all tests shall be certified by the corrosion specialist and the certified test results shall be submitted to the Contract Administrator.

A training session for the demonstration of the use of the RMU software including downloading of site data shall be carried out at the ministry's Bridge Office in St. Catharines.

935.07.09.04.02 Testing Prior to Energizing the System

935.07.09.04.02.01 Embedded Components

Immediately prior to energizing the system, the following measurements shall be manually recorded on site at the cathodic protection cabinet with a portable multimeter and AC resistance meter:

a) Reference cell potential, in mV, relative to cathode CM cable.

b) Voltage between each anode or anode bus and cathode CS cable, in volts.

c) Resistance, AC, between each reference cell and cathode CM cable, in ohms.

d) Resistance, AC, between each anode or anode bus and cathode CS cable, in ohms.

e) Resistance, DC, between CM and CS cathode connections, in ohms.

f) Voltage between CM and CS cathode connections, in mV.

To meet the requirements of this specification, the readings obtained shall be according to requirements as shown in Table 1.

935.07.09.04.02.02 Rectifier

It shall be demonstrated in the presence of the Contract Administrator that the rectifier assemblies will function properly throughout the full operating range of the output current and voltage according to OPSS 2301. The rectifier assemblies shall not be connected to the cathodic protection system at the time the testing is conducted.

935.07.09.04.02.03 Remote Monitoring and Control Unit

It shall be demonstrated in the presence of the Contract Administrator that the operation of the RMU meets the requirements according to OPSS 2301.

935.07.09.04.03 Testing after Energizing the System

After the system is energized, the following readings shall be manually recorded on site at the cathodic protection cabinet for a period of 72 hours using a portable multimeter and clamp-on ammeter.

a) Total current and voltage for each rectifier.

b) Current flow to each area of the system, zones or subzones or both, or anode bus, as applicable.

c) Reference cell potentials, on and instant-off.

Manual readings shall be verified with portable computer on site connected to the RMU and at a computer located at a remote location.

The manual readings and the RMU readings from the portable computer on site shall be taken on an hourly basis during the work hours and the readings obtained from the remote location computer shall be taken on an hourly basis.

All the measurements obtained by the RMU shall be the same as the readings obtained manually on site. The RMU shall be calibrated using gains and offsets, as required.

The results of all tests shall be certified by the corrosion specialist and the certified test results shall be submitted to the Contract Administrator.

Immediately after the 72-hour readings are made, the system shall be switched off and allowed to depolarize for a period of 4 hours. At the end of the 4-hour depolarization period, reference cell potentials shall be recorded and the differences between instant-off readings at 72 hours and the 76-hour depolarized readings shall be calculated. Voltage between anodes and cathode shall also be recorded.

The performance of the system shall be monitored during the trial operating period and appropriate actions shall be taken to repair any defects detected. The trial operating period shall be repeated as many times as required to prove proper functioning of the system.

Within 7 Days of the completion of the trial operating period, an acceptance testing commissioning report shall be submitted to the Contract Administrator recording:

a) The dates and times of the periods of trial operation.

b) Names of individuals collecting and recording data.

c) Testing equipment used, manufacturer and model number, including power source, if applicable.

d) All readings noted above, labelled as to appropriate zone, subzone, or bus, as applicable.

e) All remedial action taken.

The acceptance testing commissioning report shall bear the seal and signature of the corrosion specialist and certify that:

a) The rectifier and remote monitoring unit are functional.

b) The wiring of the system is according to the Contract Drawings, and the labelling and identification of wire terminations is correct in the control panel.

c) All areas, zones and subzones, or buses, as applicable, of the system were functional and received current flow during the trial operating period.

d) There are no short circuits between anodes and cathodes.

e) There are no short circuits between reference cells and cathode.

f) The accuracy of all meters and proper circuit polarity has been verified using a multimeter.

935.07.10 Remedial Work

Work not meeting the acceptance testing requirements shall be repaired or replaced. Proposals for correcting deficiencies shall be submitted to the Contract Administrator for approval prior to commencement of the remedial work.

935.07.11 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

935.08 QUALITY ASSURANCE

935.08.01 Anode Mesh

A manual pull test will be randomly conducted on the weld connecting the anode mesh to the distribution bar to check the weld quality.

935.08.02 Control and Monitoring Equipment

The Contractor, through the agreement to purchase control and monitoring equipment, shall ensure the ministry's representative be permitted access to the place of assembly of the cathodic protection equipment assembly while work on the unit is being performed for the purpose of inspecting the work and examining plant records, certificates, materials being used, process of fabrication, and to request further tests, as required.

935.08.03 Acceptance and Rejection

Work not meeting the requirements of this specification shall be subject to rejection.

935.09 MEASUREMENT FOR PAYMENT

935.09.01 Actual Measurement

935.09.01.01 Cathode Connections
Reference Cells
Cathodic Protection Cabinets
Concrete Pad for Cathodic Protection

For measurement purposes, a count shall be made of each of the above items installed.

935.09.01.02 Anode Mesh

Measurement of anode mesh shall be by area in square metres for the full surface of the concrete being treated with no deduction for minor surface areas not covered, such as at corners, cutouts and the like, nor any addition for surface areas requiring overlapping mesh.

935.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

935.10 BASIS OF PAYMENT

935.10.01 Cathode Connections - Item
Reference Cells - Item
Cathodic Protection Cabinets - Item
Concrete Pads for Cathodic Protection - Item
Anode Mesh - Item
Extra Low Voltage Cables for Cathodic Protection - Item
Cathodic Protection Rectifiers - Item
Cathodic Protection Remote Monitoring and Control Units - Item
Rigid Ducts and Junction Boxes for Cathodic Protection - Item
Acceptance Testing for Cathodic Protection - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

TABLE 1
Resistance and Voltage Requirements

Component	Resistance Ohms	Voltage
Reference Cell - Graphite	10 - 1000 (AC)	Stable
Reference Cell - Silver-Silver Chloride	As per manufacturer's recommendations.	Stable
Cathode Connection	< 2 (DC)	< 1 mV
Anode	< 3 (AC)	Stable

Appendix 935-A, November 2014
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.