



**MATERIAL SPECIFICATION FOR IMPRESSED CURRENT  
CATHODIC PROTECTION SYSTEM FOR BRIDGE STRUCTURES**

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**2301.01 SCOPE**

This specification covers the material requirements for impressed current cathodic protection systems for highway bridge structures.

**2301.01.01 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.

## **2301.01.02 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.

## **2301.02 REFERENCES**

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

### **Ontario Provincial Standard Specifications, Construction**

OPSS 603	Installation of Ducts
OPSS 609	Grounding
OPSS 935	Impressed Current Cathodic Protection System for Bridge Structures

### **Ontario Provincial Standard Specifications, Material**

OPSS 1350	Concrete - Materials and Production
OPSS 2410	Extra Low Voltage Cables

### **CSA Standards**

C22.2 No. 0.4-M1982 (R1993)	Bonding and Grounding of Electrical Equipment, Protective Grounding
C22.2 No. 5.1-M91	Molded Case Circuit Breakers
C22.2 No. 38-95	Thermosetting Insulated Wires and Cables
C22.2 No. 41-M1987 (R1993)	Grounding and Bonding Equipment
C22.2 No. 56-77 (R1992)	Flexible Metal Conduit and Liquid Tight Flexible Metal Conduit
C22.2 No. 65-93	Wire Connectors
C22.2 No. 85-M89	Rigid PVC Boxes and Fittings
C22.2 No. 158-1987 (R1995)	Terminal Blocks
C233.1-87 (R1995)	Gapless Oxide Surge Arrester for Alternating Current Systems
C57-1966 (R1994)	Electrical Power Connectors for Use in Overhead Line Conductors

### **ASTM International**

B 265-95	Titanium and Titanium Alloy Strip, Sheet and Plate
A 666-94	Specification for Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar for Structural Applications

## Others

Ontario Traffic Signal Control Equipment Specification (OTSCES)  
Ontario Electrical Safety Code

### 2301.03 DEFINITIONS

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

**Constant Current** means an operating mode in a rectifier in which the current is set at a fixed level and the voltage varies according to the anode-to-concrete resistance.

**Constant Voltage** means an operating mode in a rectifier in which the voltage is set at a fixed level and the current varies according to the anode-to-concrete resistance.

**Equipment Assembly** means a cabinet containing the assembled and wired cathodic protection control and monitoring equipment.

**Spacer Grid** means a grid of cross-laid glass fibre reinforced polymer bars (GFRP) used to isolate the anode mesh and distribution bars from the reinforcing steel in order to prevent contact and subsequent shorts.

**Instant-Off** means as defined in OPSS 935.

**Interruption** means switching on and off the rectifier output.

**Rectifier** means a device used to convert alternating current to direct current. In a cathodic protection system, the rectifier is used to regulate the voltage and current output to each zone.

**Remote Monitoring and Control Unit (RMU)** means a device used to control the operating parameters of a rectifier, collect and transfer operating data of the rectifier and embedded instrumentation to a remote computer, and performs depolarization tests.

**Zone** means as defined in OPSS 935.

### 2301.04 DESIGN AND SUBMISSION REQUIREMENTS

#### 2301.04.01 Design Requirements

##### 2301.04.01.01 Cathodic Protection Rectifier

##### 2301.04.01.01.01 General

A rectifier shall be provided for each zone as specified in the Contract Documents. Each rectifier circuit shall be individually controlled and shall be capable of operating in constant current or constant voltage.

Each rectifier circuit shall be able to operate separately. Adjustment of the output of any rectifier circuit shall not affect the preset output of any other rectifier circuit.

The rectifier shall not exceed 970 mm high x 450 mm wide x 320 mm deep. The rectifier shall be enclosed with access openings for the display, control, and external terminal blocks. The rectifier shall be equipped for mounting on a rack in the cathodic protection cabinet.

#### **2301.04.01.01.02 AC Input**

The rectifier shall operate on a nominal line voltage of 120 Volts AC, 60 Hz. The rectifier shall be equipped with a 3-wire cord with a 3 prong plug for AC power supply. The rectifier shall accept an AC voltage input range of 95 to 135 VAC.

#### **2301.04.01.01.03 DC Output**

The DC output of each rectifier circuit shall have two modes of operation; constant current or constant voltage. The circuit shall provide a visual indication of the mode of operation. The rated DC output of the rectifier circuit shall be 25 volts, 2 amperes. Each rectifier circuit shall be capable of operating from 0 to 100% of the rated amperage and voltage output. The output of each circuit shall be filtered with full wave rectification and shall be electrically isolated from the line input. The output ripple shall not exceed 5% of output voltage when measured at the rated output voltage and current.

Each rectifier circuit shall be equipped with a 0.1 ohm current shunt, precise to 1%, and connected in series with the rectifier output circuitry. The wattage shall be compatible with the rectifier output.

#### **2301.04.01.01.04 DC Panel Meters**

Each rectifier circuit shall have a digital DC panel meter for measuring voltage and current.

The meter shall have an accuracy of  $\pm 0.5\%$ . The operating temperature of the meter shall be from -30 to +60 °C. The input impedance shall be at least 10 Mega ohms.

#### **2301.04.01.01.05 Interruption Capability**

The rectifier shall be designed with devices to allow manual interruption and remote electronic interruption for the purpose of instant-off measurements and depolarization testing.

A secondary switch for manual interruption shall be incorporated into the wiring and supplied on the cathodic protection terminal block assembly.

#### **2301.04.01.01.06 Remote Monitoring and Control of Output Current, Voltage and Potential**

The rectifier shall be designed with devices so that the output current and voltage of each rectifier circuit can be monitored and the output current and voltage controlled remotely from zero to full rated DC output, with infinite resolution.

#### **2301.04.01.01.07 Operating Temperature and Humidity**

The rectifier shall be capable of operating when the ambient temperature is between -30 to +60 °C and the relative humidity is between 10 to 100%. The rectifier shall shutdown automatically on thermal fault above +60 °C and shall be capable of restarting automatically on cooling.

#### **2301.04.01.01.08 Protection Devices**

Each rectifier circuit shall be designed with an in-line breaker or other means to protect against overloads and short circuits.

#### **2301.04.01.01.09 Lightning and Surge Protection**

The rectifier shall be designed with lightning and voltage surge protection for the AC input and the DC output according to CAN/CSA-C233.1.

#### **2301.04.01.02 Cathodic Protection Remote Monitoring and Control Unit**

##### **2301.04.01.02.01 Operational Requirements**

The remote monitoring and control unit (RMU) shall be capable of monitoring the "on", "off", and "instant-off" readings of the embedded instrumentation, and the output voltage and current of the rectifier for each zone. The RMU shall be capable of controlling the output current and voltage and be capable of performing depolarization tests.

##### **2301.04.01.02.02 Physical Requirements**

The RMU shall not exceed 200 mm high x 450 mm wide x 500 mm deep. The RMU shall be enclosed with stainless steel panels, with access openings for the display, control, and external terminal blocks. The RMU shall be equipped for mounting on a rack in the cathodic protection cabinet.

##### **2301.04.01.02.03 Hardware Requirements**

###### **2301.04.01.02.03.01 General**

The RMU shall be equipped with a real time clock, a modem, and operating software.

The RMU shall operate on a nominal line voltage of 120 Volts AC, 60 Hz. The RMU shall be equipped with a 3-wire cord with a 3 prong plug for AC power supply. The RMU shall accept an AC voltage input range of 95 to 135 VAC.

The RMU shall be capable of measuring a minimum of 16 analog input parameters for each zone as specified in the Contract Documents.

A switch shall be provided on the front panel of the RMU to bypass the remote control of the current and voltage to allow on-site adjustment of the DC output.

The RMU shall be designed with a current limiting device that can be manually adjusted so that malfunction of the RMU will not result in excessive rectifier current output.

The RMU shall be equipped with a device that will automatically reset the RMU if the program does not operate properly.

###### **2301.04.01.02.03.02 Interrupter**

An on/off interrupt device shall be provided for conducting depolarization tests for each zone. The interrupt device shall be capable of opening the circuit within 50 milliseconds after the interrupt signal is given. The output current interrupt signal shall not interfere with normal operation of the rectifier when the RMU malfunctions.

###### **2301.04.01.02.03.03 Communication**

The RMU shall be equipped with two RS232 ports for local accessing the system running parameters. All functions provided by the RMU software including the downloading of the stored data shall be available through these ports.

The communication shall be performed via one RS232 port using a wireless data modem. The RMU shall be capable of connecting directly to a portable computer in the field via the other RS232 port. The cable for connecting the RMU and the portable computer shall be supplied with the RMU and the connections shall be made via two part plug-in connectors.

The RMU shall communicate to the remote rectifier system using a wireless data communication system using the following networking technologies: HSPA+ with fallback to HSUPA; HSDPA; UMTS; EDGE; GPRS; or EV-DO, revision A, with fallback to CDMA EV-DO, revision 0, CDMA1xRTT, comprising of an RS232 Serial Port HOST interface. A transparent point to point or point to multipoint link should be implemented between the RMU and the remote system, containing RS232 links as communication input/output terminals.

#### **2301.04.01.02.03.04 Data Storage**

The program shall operate so that recorded data is preserved in the event of a power failure to the unit.

The RMU shall have a minimum of 32 GB battery backed data storage.

#### **2301.04.01.02.03.05 Real-Time Clock**

The RMU shall be designed with a real time clock to time stamp recorded data, to indicate occurrence of and duration of, and power failures to the unit. The clock shall have a minimum resolution of one second and shall compensate for leap years and days of the month.

#### **2301.04.01.02.03.06 Operating Temperature and Humidity**

The RMU shall operate when the ambient temperature is between -30 to +60 °C and relative humidity is in the range of 10 to 100%. The RMU shall shutdown automatically on thermal fault when the ambient temperature is above +60 °C and shall restart automatically on cooling.

#### **2301.04.01.02.03.07 Protection Devices**

The RMU circuit shall be protected against current overloading and short circuit using an inline fuse or other means.

#### **2301.04.01.02.03.08 Lightning and Surge Protection**

The RMU shall have lightning and surge protection according to CAN/CSA-C233.1 for the AC input and DC output.

#### **2301.04.01.02.03.09 System Operating Indicator**

The RMU shall be designed with a system operating indicator located on the front panel.

#### **2301.04.01.02.04 Software Requirements**

##### **2301.04.01.02.04.01 General**

The software program shall be manually driven and shall include a help menu.

The RMU software shall be compatible with Microsoft Windows 7 Professional for desktop and laptop computer applications.

#### **2301.04.01.02.04.02 Screen Display at Connection**

The software shall present the user with a request for a password upon connection of the RMU either by a portable computer via one of the RS232 ports or a remote computer via a modem.

Two password security levels shall be provided:

- a) The OPERATOR password shall be alpha numeric with a minimum of 4 characters and a maximum of 12. The operator function shall be designed to permit the user to monitor the cathodic protection system, perform depolarization testing, and permit the user to change the parameters in the program.

When a password is entered, the program shall display a message to acknowledge the entered password as correct or not. The user shall have three opportunities to enter the correct password.

If the entered password is still incorrect after three attempts, the program shall terminate further communications for 30 minutes.

- b) The MONITOR password shall be alpha numeric with a minimum of 4 characters and a maximum of 12.

The monitor function shall be designed to permit the user to monitor the cathodic protection system and perform depolarization testing, but shall not permit the user to alter any parameters in the program.

#### **2301.04.01.02.04.03 Screen Display with OPERATOR Password**

When the OPERATOR password is entered, the OPERATOR menu shall be displayed on the screen providing the options as shown in Table 1.

#### **2301.04.01.02.04.04 Screen Display with Monitor Password**

When the MONITOR password is entered, a MONITOR menu providing the options as shown in Table 2 shall be displayed on the screen.

The options specified are selected options from the OPERATOR menu as shown in Table 1.

#### **2301.04.01.03 Cathodic Protection Terminal Block Assembly**

The design shall be according to CSA C22.2 No. 158.

The rail shall be designed to accommodate two terminal block zone assemblies.

### **2301.05 MATERIALS**

#### **2301.05.01 General**

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

**2301.05.02 Cathodic Protection Equipment Assembly**

**2301.05.02.01 Fan and Thermostat**

The fan and thermostat shall be according to the OSTCES.

**2301.05.02.02 Wireless Modem Antenna**

The wireless modem antenna shall be a 1/4 wave rod, weatherproof and waterproof, and shall be supplied ready for installation as a unit.

**2301.05.02.03 Wire Connections**

All wire connectors shall be according to CSA C22.2 No. 65.

**2301.05.02.04 Grounding and Bonding Equipment**

All equipment used for grounding and bonding shall be according to CSA C22.2 No. 0.4 and No. 41.

**2301.05.02.05 Thermoset Wires and Cables**

All interconnecting cables shall be according to CSA C22.2 No. 38, shall be at least 19 strand copper, type RWU90 cross link, -40 °C. The AC wiring shall be #14 AWG. The wires in the cables connecting the remote monitoring unit, the rectifier, and the terminal block assembly shall be #22 AWG.

The wire for the rectifier output DC current shall be #12 AWG. The bonding wire to the ground bar shall be No. 6 AWG.

**2301.05.02.06 Lightning and Surge Protection**

Lightning arresters shall be according to CAN/CSA-C233.1 and meet low voltage applications therein. The protection device shall be rated at a minimum of 650V.

AC surge and lightning protection shall be installed inside the 401C cathodic protection cabinet. The protection shall be used on the AC input side of both the rectifiers and RMU.

DC surge and lightning protection shall be installed inside the 401C cathodic protection cabinet. The protection shall be used on the DC power output side for rectifiers.

The AC and DC surge and lightning protection shall be supplied as specified in the Contract Documents.

**2301.05.02.07 Fasteners**

All fasteners shall be Type 304 stainless steel according to ASTM A666.

**2301.05.02.08 Cable Separation**

AC, DC and signal wires shall be shielded electrically from each other to prevent electrical interference.

**2301.05.03 Cathodic Protection Cabinet**

The cathodic protection cabinet shall be Model 401C according to the OTSCES.

The pedestal and all other associated components shall be according to the OTSCES.



**2301.05.04 Cathodic Protection Rectifier**

The rectifier shall be supplied by sources as specified in the Contract Documents.

The rectifier and RMU shall be fully compatible in operation. The rectifier and the RMU shall be supplied by the same supplier.

**2301.05.04.01 Thermoset Wires and Cables**

Wire shall be according to CSA C22.2 No. 38.

**2301.05.05 Cathodic Protection Remote Monitoring and Control Unit**

The RMU shall be supplied by sources as specified in the Contract Documents.

The rectifier and RMU shall be fully compatible in operation. The rectifier and the RMU shall be supplied by the same supplier.

**2301.05.05.01 Wiring**

All wiring used in the RMU shall be PVC insulated with a temperature range of -40 to +60 °C at 150V. Cables providing AC power to the RMU shall be according to CSA C22.2 No. 38.

**2301.05.06 Cathodic Protection Terminal Block Assembly**

The cathodic protection terminal block assembly, including fasteners, shall be manufactured from corrosion resistant materials so that exposure to moisture will not impair the effectiveness of the assembly. The assembly shall be mounted on a DIN rail according to the requirements for mounting on an OTSCES rack.

Each terminal block zone assembly shall have a design specific number of terminal points as shown in Table 3.

Each terminal point shall be capable of accommodating all wire sizes from #6 AWG to #14 AWG.

Terminals 1 to 4, anodes, shall be interconnected with a jumper.

Terminals 5 to 8, cathode structure (CS), shall be interconnected with a jumper.

The assembly shall be equipped with a simple 15 ampere on/off switch, single pole, double throw switch manufactured according to CSA C22.2 No. 5.1 to provide a secondary manual interrupt for the rectifier.

Electrical materials shall be according to CSA C22.2 No. 158.

Extra low voltage cable shall be according to CSA C22.2 No. 38 and shall be at least 7 strand type RWU90 cross link, -40°C.

**2301.05.07 Cathodic Protection AC Power Distribution Assembly**

The AC power distribution assembly, including the enclosure, circuit breakers, wire connectors, grounding and bonding equipment and thermoset wires shall be supplied as per the OTSCES.

### **2301.05.08 Identification Marking**

The identification marking for the cabinet, rectifier and remote monitoring, and control unit shall be weather resistant on a corrosion resistant metal plate.

### **2301.05.09 Extra Low Voltage Cables for Cathodic Protection**

All extra low voltage cable shall be according to OPSS 2410 or shall be type RWU90, cross link, -40°C, minimum 7-strand copper according to CSA C22.2 No. 38.

#### **2301.05.09.01 Anode Bus Cables**

The anode bus cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #6 AWG with black insulation, without splicing.

#### **2301.05.09.02 Cathode Connection Cables**

The cathode CS bus cable from the junction box to the rectifier of the cathodic protection cabinet shall be extra low voltage cable #6 AWG with white insulation, without splicing.

The cathode CM extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with red insulation, without splicing.

#### **2301.05.09.03 Reference Cell Cables**

##### **2301.05.09.03.01 Graphite Reference Cell Cables**

The reference cell extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with green insulation, without splicing.

##### **2301.05.09.03.02 Silver-Silver Chloride Reference Cell Cables**

The reference cell extension cable from the junction box to the control panel of the cathodic protection cabinet shall be extra low voltage cable #10 AWG with blue insulation, without splicing.

#### **2301.05.09.04 Grounding Materials**

The ground wire, ground electrodes, and connectors shall be according to OPSS 609.

#### **2301.05.09.05 Connectors**

The cable connectors shall be according to CSA C22.2 No. 65 and CSA C57.

### **2301.05.10 Rigid Ducts and Junction Boxes for Cathodic Protection**

#### **2301.05.10.01 Ducts and Fittings**

The ducts and fittings shall be rigid RE/PVC watertight and shall be according to OPSS 603.

The flexible liquid tight ducts and fittings shall be according to CSA C22.2 No. 56.

#### **2301.05.10.02 Junction Boxes**

The junction boxes shall be rigid PVC as specified in the Contract Documents and according to CAN/CSA C22.2 No. 85.

The boxes shall be supplied with predrilled holes for connectors and two 6 mm diameter drain holes. The drain holes shall be located with a minimum separation of 250 mm at the lowest point in the box where water may collect.

**2301.05.11                    Anode Mesh**

The anode mesh material shall be high purity titanium Grade 1, according to ASTM B265, and coated with a mixed metal oxide catalyst. The diamond dimensions for the anode mesh shall be 80 x 40 mm maximum. The anode mesh shall be supplied in minimum widths of 1 m and as specified in the Contract Documents.

**2301.05.11.01                Distribution Bars**

The distribution bars shall be titanium Grade 1, according to ASTM B265. The bars shall be 12 mm wide x 1 mm thick and shall be supplied in lengths at least 3 m long.

The surfaces of the bar shall be free of oxides, grease, and other contaminants.

The bars shall be supplied as specified in the Contract Documents.

**2301.05.11.02                Anode Mesh Fasteners**

The fasteners shall be fabricated from nylon 6/6 grade plastic suitable for long term embedment in concrete, shall be resistant to acid, and shall be capable of securing the mesh anodes in place on concrete surfaces.

The portion of the fastener embedded in the concrete shall be no larger than 8 mm diameter and no more than 33 mm in length.

The fasteners shall be supplied as specified in the Contract Documents.

**2301.05.11.03                Spacer Grid**

The spacer grid shall consist of 12 mm glass fibre reinforcing polymer bars (GFRP) in each direction with a bar spacing of not more than 200 mm.

**2301.05.12                    Reference Cells**

**2301.05.12.01                Graphite Reference Cell**

Graphite reference cells shall be 40 x 40 x 150 mm graphite bars, grade SR-45 or equivalent.

Cables for graphite reference cells shall be extra low voltage cables according to OPSS 2410 or shall be #10 AWG RWU90 with green insulation, type RWU90, cross link, -40°C, and minimum 7-strand copper according to CSA C22.2 No. 38.

The 40 x 40 x 150 mm graphite reference cell shall be fitted with a length of extra low voltage cable #10 AWG RWU90 with green insulation. The extra low voltage cable shall be sufficiently long to extend from the point of embedment to the splice in the junction box, without splicing.

The extra low voltage cable shall be securely attached to the graphite bar by means of a threaded brass connector. The cable shall be soldered in a hole in the centre of the brass connector. The brass connector shall be fitted into a drilled and tapped hole in the graphite bar. The brass connector shall be recessed at least 15 mm and shall have side clearances of 15 mm. After soldering, the recess shall be filled to fully seal out water from soldered area. The supplier shall install the cable prior to delivery of the reference cells to the site. The resistance between the end of the cable and the end of the graphite block shall not exceed 1 ohm.

The graphite reference cells shall be supplied as specified in the Contract Documents.

#### **2301.05.12.02 Silver-Silver Chloride Reference Cell**

Cables for silver-silver chloride reference cells shall be extra low voltage cables according to OPSS 2410 or shall be #10 AWG with blue insulation, type RWU90, cross link, -40°C, and minimum 7-strand copper according to CSA C22.2 No. 38.

The silver-silver chloride reference cell shall be fitted with a length of extra low voltage cable #10 AWG with blue insulation. The extra low voltage cable shall be sufficiently long to extend from the point of embedment to the splice in the junction box, without splicing.

The silver-silver chloride reference cells shall be supplied as specified in the Contract Documents.

#### **2301.05.13 Cathode Connections**

Cables for cathode connections shall be extra low voltage cables according to OPSS 2410 or shall be type RWU90, cross link, -40°C, and minimum 7 strand copper according to CSA C22.2 No. 38.

The cathode CS cable from the point of connection of the reinforcing steel to the junction box shall be extra low voltage #10 AWG RWU90 with white insulation, without splicing.

The cathode CM cable from the point of connection of the reinforcing steel to the junction box shall be extra low voltage #10 AWG RWU90 with red insulation, without splicing.

#### **2301.05.14 Silicone Seal**

The silicone seal shall be suitable for electrical applications and burial in concrete.

#### **2301.05.15 Heat Shrink Tubing and Splice Kits**

The heat shrink tubing and splice kit shall fully insulate and seal out water from the connection area of the splice and shall be suitable for burial applications.

Heat shrink tubing and splice kits shall be supplied as specified in the Contract Documents.

#### **2301.05.16 Heat Shrink Tape**

The heat shrink tape shall fully insulate and seal out water from the connection area of the splice.

#### **2301.05.17 Epoxy**

The epoxy shall be non-conductive low viscosity type and suitable for burial in concrete.

Epoxy shall be supplied as specified in the Contract Documents.

**2301.05.18                      Thermite Weld**

Cathode connections to the reinforcing steel shall be made by thermite weld.

**2301.05.19                      Thread Locking Compound**

The thread locking compound shall be a removable anaerobic setting liquid compound that when used in metal to metal contact positively locks and seals the threaded fastener to prevent corrosion and loosening.

**2301.07                              PRODUCTION**

**2301.07.01                      Cathodic Protection System Equipment Assembly**

Assembly of the cathodic protection system shall consist of the following equipment:

- a) Cathodic protection cabinet.
- b) Cathodic protection remote monitoring and control unit.
- c) Cathodic protection rectifier.
- d) Cathodic protection terminal assembly.
- e) Cathodic protection AC power distribution assembly.
- f) Fan with thermostat.
- g) Wireless modem.

The cathodic protection remote monitoring and control unit equipment shall be installed and wired in the cathodic protection cabinet according to the details on the Working Drawings and according to OPSS 935.

The wireless modem antenna shall be installed according to the antenna manufacturer's requirements.

All connections to ground shall extend to the ground bar.

All cables shall be bundled and held in place with nylon cable ties or shall be installed in wiring ducts or raceways.

**2301.07.02                      Identification Marking**

Each of the following cathodic protection system components shall have identification markings showing the manufacturer's name or trade mark; serial number, if available; and the date of manufacture permanently attached with adhesive to the assembly in a highly visible location.

- a) Cathodic protection cabinet.
- b) Cathodic protection rectifier
- c) Cathodic protection remote monitoring and control unit.

Each completed cathodic protection equipment assembly shall have identification marking showing the date, name and site number of the structure, and the assembler's name. The marking shall be weather resistant placed on a corrosion resistant plate permanently attached with adhesive to the inside of the door in a highly visible location.

The terminal block and each rectifier shall be labeled to show their respective zones.

**2301.07.03                      Quality Control**

**2301.07.03.01                  Cathodic Protection Equipment Assembly**

The entire assembly shall be tested using dummy loads prior to shipment to ensure that all components of the assembly are in good working order.

A representative of the supplier of the cathodic protection equipment assembly shall be on site for support and troubleshooting during testing of the installed cathodic protection system

**2301.07.03.02                  Cathodic Protection Rectifier**

The following pre-installation inspection and testing shall be performed:

The rectifier shall be fully tested at low, high, and nominal line voltage. The AC input voltage, current, watts, and the output voltage, current, and efficiency shall be recorded at each input voltage. All rectifier circuits shall be individually tested to ensure that each circuit meets the requirements of this specification.

Each control card shall be subjected to a continuous 180 hour burn-in test. Initially, power shall be applied to each card for 72 hours at an ambient temperature of +60 °C. Power shall be removed and the card cooled for 18 hours in an environment at -30 °C. Power shall be reapplied for 18 hours at -30 °C. The card shall remain energized for 72 hours during which time the ambient temperature shall be +60 °C. The control card shall be tested immediately after removal from the final high temperature cycle. Control cards failing the test shall be replaced and the 180 hour burn-in procedure repeated.

The 180 hour burn-in test required for the entire rectifier operating unit, including control cards, shall be carried out at a testing facility that is certified to International Standards Organization (ISO) 9001.

**2301.07.04.03                  Cathodic Protection Remote Monitoring and Control Unit**

The following pre-installation inspection and testing shall be performed:

The RMU shall be fully tested at low, high, and nominal line voltage.

Each circuit card shall be subjected to a continuous 180 hour burn-in test. Initially, power shall be applied to each card for 72 hours at an ambient temperature of +60 °C. Power shall be removed and the card cooled for 18 hours in an environment at -30 °C. Power shall be reapplied for 18 hours at -30 °C. The card shall remain energized for 72 hours during which time the ambient temperature shall be +60 °C. The card shall be tested immediately after removal from the final high temperature cycle. Circuit cards failing the test shall be replaced and the 180 hour burn-in procedure repeated on the new card.

The 180 hour burn-in test required for the entire RMU operating unit, including control cards, shall be carried out at a testing facility that is certified to ISO 9001.

**2301.08****QUALITY ASSURANCE****2301.08.01****Inspection**

All work is subject to an inspection by the Owner's representative prior to shipment.

The Owner's representative shall have free access to the place of manufacture of the assembly while work on the unit is being performed for the purpose of inspecting the work and examining plant records and certificates, materials being used, process of fabrication, and to make any tests as may be considered necessary.

**TABLE 1  
Operator Menu Options**

Option	Explanation
DATE	The DATE option shall display the present date in the form of yyyy/mm/dd (year/month/day). Provision shall be made to permit the OPERATOR to change the date.
TIME	The TIME option shall display the present time in form of hh:mm:ss (hour:minute:second). Provision shall be made to permit the OPERATOR to change the time.
DOCUMENTATION	The DOCUMENTATION option shall provide for the display at least 10 lines of site information as last set by the OPERATOR and shall permit the OPERATOR to change information.
READ	<p>The READ option shall be designed to measure the values of the parameters of applied voltages, applied currents, and reference potentials in all the zones of the cathodic protection system and to display specific zones and all zones when requested by the user. Measurements shall be taken when the power to the rectifier is in the "on" or "off" state.</p> <p>Provisions shall be made for the number of zones specified with 16 channels one for each parameter per zone. The parameters required to be input shall be specified and shall be entered by the supplier. Each parameter shall be labelled and its corresponding unit displayed.</p> <p>The range and resolution required is as follows:</p> <p>Output current - 0 to 10 A with 10 mA resolution  Output voltage - 0 to 30 V with 10 mV resolution  Reference cell potential - <math>\pm 3</math> V with 1 mV resolution</p>

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Option	Explanation
INSTANT-OFF	<p>The INSTANT-OFF reading option shall be designed to simultaneously measure the instant-off readings of the output voltages, output current, reference cell potentials, and voltage probes in all the zones when the rectifier current is interrupted and display them for a specific zone or all zones.</p> <p>Provision shall be made to permit the OPERATOR to change the "off" time when the instant-off readings of the parameters are taken. The off time shall be measured in increments of 50 milliseconds, starting at 250 milliseconds.</p> <p>Each parameter shall be labelled appropriately and its unit displayed.</p> <p>The range and resolution required shall be as follows:</p> <p style="padding-left: 40px;">Output current - 0 to 10 A with 10 mA resolution Output voltage - 0 to 30 V with 10 mV resolution Reference cell potential <math>\pm 3</math> V with 1 mV resolution</p> <p>The rectifier shall automatically switch on again after the "instant-off" readings are recorded.</p>
DEPOLARIZATION	<p>The DEPOLARIZATION option shall be designed to perform a depolarization test. Provision shall be made to allow the OPERATOR to change the test duration and sampling rate of the depolarization test. The test duration shall be entered in hours 01 to 999 with a resolution of one hour. The sampling rate shall be shown in minutes 01 to 120 with a resolution of one minute.</p> <p>The values to be measured and stored for the test shall be:</p> <ul style="list-style-type: none"> <li>i the value of each parameter before turning the rectifier off.</li> <li>ii the "instant-off" value using the "off" period from the INSTANT-OFF option.</li> <li>iii the depolarized value of each parameter at the end of the test.</li> </ul> <p>The shift between the "instant-off" and the depolarized readings of all parameters shall be calculated at the end of the test.</p> <p>If a depolarization test is in progress, the message "Depolarization Test is in Progress" and the time remaining in the test shall be displayed.</p> <p>Provision shall be made to permit the user to terminate the test in progress.</p>
MODE	<p>The MODE option shall be designed to enable the OPERATOR to switch between the current and voltage control of the rectifier.</p>

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Option	Explanation
CURRENT ADJUSTMENT	The CURRENT ADJUSTMENT option shall be designed to make provision for the OPERATOR to adjust the current output level for each zone when the rectifier is operated in the current control mode. The output voltage shall be adjusted until the output current meets the set level.
VOLTAGE ADJUSTMENT	Adjust output voltage when the rectifier is operated in the voltage control mode.
PASSWORD CHANGE	The PASSWORD CHANGE option shall be designed to permit the OPERATOR to change the passwords for the MONITOR and OPERATOR levels. The passwords shall consist of alphabet A to Z or numbers 0 to 9 in any combination with a maximum of 12 characters.
PARAMETER CHANGE	The PARAMETER CHANGE option shall be designed to make provisions for the OPERATOR to modify the description and unit of any one parameter in each zone. The description shall consist of up to 20 characters.
TRENDING FREQUENCY CHANGE	The TRENDING FREQUENCY CHANGE option shall be designed to permit the OPERATOR to adjust the trending frequency. The trending frequency change shall be entered in increments of one minute from 1 to 180 minutes to control the amount of data stored in the trend and its resolution.
DOWNLOAD	The DOWNLOAD option shall be designed to permit the OPERATOR to download data from the RMU to the remote computer.
REPORT	The REPORT option shall be designed to provide a summary report showing the site information for the cathodic protection system as listed in the Documentation option, the "on" and "instant-off" values of the parameters, the depolarized readings at the end of the test, and the potential shift between the "instant-off" and the depolarized readings for each zone. Provision shall be made to permit the user to view the report on screen or to print a report at the users option.
BYE	The BYE option shall be designed to display the status of the rectifier indicating whether the rectifier is in the "on" or "off" state and the status of the depolarization test, and when the end of the session is confirmed shall terminate the communication.

**TABLE 2**  
**Monitor Menu Options**

<b>Option</b>	<b>Explanation</b>
DATE	Display present date.
TIME	Display present time.
DOCUMENTATION	The DOCUMENTATION option shall display the information last set by the OPERATOR.
READ	Measure and display parameters in a specific zone or in all the zones when the power to the rectifier is "on" or "off.
INSTANT-OFF READING	The rectifier shall be automatically switched on after the instant-off readings are recorded. The "off" time shall be that last set by the OPERATOR.
DEPOLARIZATION	The test duration and sampling rate displayed for the depolarization test shall be those last set by the OPERATOR.
REPORT	Produce summary report of depolarization test.
BYE	Terminate communication.

**TABLE 3**  
**Cathodic Protection Terminal Block Assembly Terminal Points**

	<b>Terminal</b>	<b>Terminal Colour</b>	<b>Lettering</b>	<b>Extra Low Voltage Cable Size AWG</b>
1	Anode	Black	A1	#6
2	Anode	Black	A2	#6
3	Anode	Black	A3	#6
4	Anode	Black	A4	#6
5	Cathode	White	CS1	#6
6	Cathode	White	CS2	#6
7	Cathode	White	CS3	#6
8	Cathode	White	CS4	#6
9	Cathode	Red	CM1	#10
10	Cathode	Red	CM2	#10
11	Cathode	Red	CM3	#10
12	Cathode	Red	CM4	#10
13	Graphite Reference Cell	Green	R1	#10
14	Graphite Reference Cell	Green	R2	#10
15	Graphite Reference Cell	Green	R3	#10
16	Silver-Silver Chloride Reference Cell	Blue	R4	#10

**Appendix 2301-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.