**SECTION 4.5**

**IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM**

**FOR WATER TRANSMISSION LINES**

**PART 1: GENERAL**

* 1. **Scope of Work**

Furnish all the necessary materials, labor, tools, equipment and associated appurtenances, as well as providing all operations necessary to install and test the required cathodic protection system components.

**PART 2: QUALITY ASSURANCE**

**2.1 Reference Standards**

Unless otherwise stated, the latest editions of the following documents are applicable for this specification:

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| --- | --- |
| ASTM C 94 | Ready Mixed Concrete |
| ASTM B 348 | Titanium and Titanium Alloy Bars and Billets |
| ASTM D 1248 | Polyethylene Plastics Extrusion Material for Wire Cable |
| ASTM D 3359 | Standard Test Method for Measuring Adhesion by Tape Test |
| CSA | Canadian Standards Association, Standard C22.2, No. 66 and No. 107 |
| NEC 70 | National Electrical Code |
| Dallas Electrical Code | |
| NACE RP-0169 | Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems |
| AWWA M9 Manual | Concrete Pressure Pipe |

|  |  |
| --- | --- |
| NACE RP-0572 | Recommended Practice for Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds |
| NEMA TC6 | PVC and ABS Plastic Utilities Duct for Underground Installation |
| NEMA TC9 | Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation |
| NEMA 4 | TYPE 3R Enclosures |
| UL 83 | Thermoplastic-Insulated Wires |
| UL 467 | Bonding and Grounding Equipment |
| UL 486A | Wire Connectors and Soldering Lugs for Use with Copper Conductors |
| UL 506 | Specialty Transformers |

* 1. **Requirements**
* Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the drawings and specifications. The certification shall reference the applicable section of the specifications and the applicable standard detail.
* Drawings: The drawings for the cathodic protection system are diagrammatic and not scaled for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with other utilities or mechanical and structural features. Note other existing utilities in the area and do not damage these utilities during excavation. Repair any damaged utilities to the satisfaction of the City of Dallas at the Contractor's expense.
* Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Dallas or its designated representative.
  1. **Submittals**

Following submittals shall be provided by the contractor:

* + 1. Catalog Cuts

Manufacturer's catalog cuts shall be submitted for each item. The catalog cuts shall include the manufacturer's name and shall provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

* + 1. Electrical Permits

Provide electrical permits for all transformer-rectifier locations.

* + 1. Logs

The Dallas Water Utilities representative shall be given a minimum of 48 hours notice prior to drilling the anode bore. Copies of detailed geological and resistance logs of each deep anode bore shall be typed by Contractor and submitted to the Dallas Water Utilities or its designated representative.

* + 1. Rectifier Operation and Maintenance Manual

The rectifier manufacturer shall include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, the manual shall include a circuit diagram and spare parts list. The rectifier shall be operated under full load conditions at the factory and shall be thoroughly inspected and tested by the manufacturer prior to delivery to the job site. Results of this testing shall be reported on a manufacturer's quality control form and shall be included in the operation manual. The rectifier manufacturer shall reference each operating manual by rectifier model number and individual serial number.

* + 1. Report

Submit six (6) operating, monitoring and maintenance reports for the cathodic protection systems. Included shall be all test data as required by Section 4.6, under *Method*section. The manuals shall include operating instructions, maintenance data, product data and test procedures.

* + 1. Drawings

As-built drawings of the cathodic protection installation shall be maintained by the Contractor during installation and construction. Drawings shall be revised to show exact locations of all rectifiers, anodes, wiring, connections and terminal boxes. All items of equipment and material shall be properly identified. The original as-built drawings shall be submitted to the Dallas Water Utilities or its designated representative.

**PART 3: PRODUCT**

* 1. **Impressed Current Anodes**

3.1.1 Description:

The anodes shall be mixed metal oxide coated titanium tubes.

3.1.1.1 Anode Substrate

The anode substrate shall be Grade 2 Titanium per ASTM B-348. The substrate shall be cleaned and the surface roughened. The cleaning shall remove all organic materials such as cutting oils, which could interfere with coating adhesion. Surface roughness shall be achieved by chemically etching the substrate as a minimum. Blasting the substrate may be used in addition to chemical etching, but not as a substitute. An anti-passivation layer shall be applied to the substrate prior to application of the mixed metal oxide coating.

3.1.1.2 Mixed Metal Oxide Coating

The prepared titanium substrate shall have an electro catalytic coating applied. Coating composition shall be iridium oxide and tantalum oxide. Total coating loading requirements shall be coordinated with the manufacturer’s proprietary information to achieve the required performance. The average gain rate for catalyst application shall not exceed 0.16 g/ft[[1]](#footnote-1)2 (1.7 g/m[[2]](#footnote-2)2) and the maximum gain rate for any single coat shall not exceed 0.25 g/ft[[3]](#footnote-3)2 (2.7 g/m[[4]](#footnote-4)2). Coating loading shall be measured using an X-ray gauge which is calibrated at least once per shift for the specific coating type. This test directly measures precious metal loading. Simple weight gain is not an acceptable measure. Adhesion of the catalytic coating shall be tested according to ASTM D 3359. The manufacturer shall certify conformance with these requirements.

3.1.1.3 Size

The tubular anode dimensions shall be 1.25” diameter x 48” long.

### 3.1.2 Anode Lead Wire Connection:

* The anode lead wires shall comply with the following:

Size: No. 8 AWG

No. of Strands: 7

Conductor O.D: 0.146”

Insulation: Halar®

Insulation Thickness: 0.020 min.

Jacket: HMWPE (black)

Jacket O.D.: 0.360” ± 0.018”

* The anode lead wire shall be attached internally in the longitudinal center of the tubular anode by use of a brass, wedge connector:
* The end of the lead wire shall be stripped and soldered to the designated half of the wedge connector using Kester 44 rosin cored solder.
* The connector halves shall be inserted from both ends of the anode tube and placed in the longitudinal center of the anode tube.
* The wedge shall be secured to the inside surface of the anode tube by tightening the expansion screw.
* Heat shrink tubing shall be applied to seal the end of the tube where the anode lead exits. The anode shall be inverted and a 6” length of No. 4 neoline textured polyester rope shall be inserted in the opposite end of the anode with a loop extending beyond the end of the tube.
* The entire tube shall be filled with SPL epoxy as supplied by Corrpro to form a positive moisture seal.
* The resistance of the finished connection shall not exceed 0.001 ohms.
* The pull-out strength of the connection shall not be less than the breaking of the strength of the No. 8 AWG wire or 520 pounds.
  + 1. Anode Backfill

SC 3 calcined petroleum coke, as manufactured by Loresco Inc., shall be used to backfill the impressed current anodes. Anode backfill shall conform to the following:

* Typical Chemical Analysis

Component Percent Composition

Carbon (fixed) 99.35 minimum

Ash 0.6 maximum

Volatiles 0 (950 ° C)

Moisture 0.05

* Physical Properties

Bulk Density 64 pounds/cubic foot

* Particle Analysis

Dust free with a maximum particle size of 1 mm.

# Deep Anode Components

Supply the following miscellaneous deep anode components:

* + 1. Surface Casing
* The deep anode shall be equipped with a Schedule 40 PVC casing.
* The casing shall be 10 inches diameter, and 10 feet long.
* Casing sealant shall be Aqua Plug or Perma Plug.
* The casing shall be terminated with a 10” diameter, Schedule 40 PVC cap.
  + 1. Vent Pipe
* Plastic vent pipe shall be used from the bottom anode to the surface for dissipating gases to the atmosphere.
* The plastic vent pipe shall be 1-inch diameter slotted piping (AllVent™) as manufactured by Cathodic Engineering Equipment Company or approved equal. The vent pipe above the coke breeze shall not be perforated.
* The plastic vent pipe shall extend above grade and the vent outlet shall be screened and installed in an inverted manner.

3.2.3 Exterior Grout for Surface Casing

* Standard grout designed for sealing around monitor or water well casing such as Aquaguard by Halliburton Energy Services. Product shall be submitted and must be approved as part of the drilling permitting process.

3.3 Transformer-Rectifier

Cathodic protection transformer-rectifier shall be air cooled, tap adjust Custom model as manufactured by Corrpower or approved equal and listed in CSA File No. 45382.

* + 1. DC Output Ratings
* Rectifiers shall be rated at 20 volt, 20 amperes D.C. Rectifiers shall be capable of supplying continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.
  + 1. AC Input Ratings
* Full rated DC output shall be obtainable with an AC input voltage at 5% below the nominal value. Continuous AC input voltage at 10% above the nominal value shall not damage the transformer, the diode bridge assembly, or exceed any component ratings. (Note: This shall apply provided that the rectifier has not been previously adjusted to exceed the maximum DC voltage or amperage rating of the unit.)
  + 1. Cooling
* Cooling shall be by natural air convection. Cabinets shall be vented for natural air convection and shall be screened against insects.
  + 1. Voltage Adjustments
* The output voltage shall be adjustable by means of not less than 25 approximately equal steps of secondary taps from 5 percent of rated voltage to full-rated voltage.
  + 1. Rectifying Elements
* Rectifying elements shall be silicon diodes sized as follows:
* The Peak Inverse Voltage (PIV) of the diode shall be 300% of the maximum impressed voltage on the diode or 400 volts, whichever is greater.
* Diodes shall be configured into a full-wave bridge assembly. Diodes shall be sized to carry an average current of no more than 55% of the manufacturer’s recommended maximum current rating.
* Heat sinks shall be sized to keep diode case temperatures less than 100° C at rated rectifier output and at maximum rated ambient temperature.
* Diodes shall be overload protected by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.
* Diodes shall be equipped with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly sized to provide protection against secondary over-voltage surges.
  + 1. AC Circuit Breakers

Input overload and short circuit protection shall be provided by magnetic trip circuit breakers. The circuit breaker shall be sized to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load and must trip at 125 percent and above.

* + 1. Surge Protection

Separate AC and DC surge protection shall be provided by means of high energy Metal Oxide Varistors rated at 500 joules on D.C. output and 1000 joules on the AC input.

* + 1. Electrical Panels

Electrical panels shall be minimum thickness of 0.187" NEMA Grade "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Rectifier front instrument panel identifications shall either be permanently silk-screened onto the panel or be 1/16” lamicoid (plastic laminate) adhesive labels permanently engraved with white lettering on a black background. The adhesive labels shall be mechanically affixed to the panel via stainless steel rivets or screws.

* + 1. Connection Hardware

All electrical hardware shall be copper or high conductivity brass, suitably sized, and finished with an electroless nickel plating for superior corrosion resistance. All connections shall be tightly secured with lock washers and nuts torqued to manufacturer's recommended specifications. All electrical connections shall use the “double nut” method to ensure that any compression of the panel material will not affect the electrical conductivity of the connection.

* + 1. Cathodic Protection Cabinet
* Mount transformer-rectifier unit, disconnect switch and anode junction panel in a single enclosure.
* Enclosure to be free standing, NEMA 3R, 36" wide x 48" high x 24" deep, 12 gauge, type 304 stainless steel with lifting eyes.
* Equip with single, louvered door with provisions for padlocking. Provide drip shield and inside insect screen.
* Include ground lug, sized for No. 6 AWG wire.
* Place stickers on all four sides that read "Danger, High Voltage, Keep Out."
* Provide permanent engraved nameplate with black letters on white background that reads "Cathodic Protection Cabinet, Property of the City of Dallas.”
  + 1. Rectifier Instrumentation
* Rectifier shall be equipped with separate analog ammeter and voltmeter.
* Meters shall be a minimum of 3-1/2" size, with a minimum scale length of 2-7/8".
* Meters shall be 0 - 50 millivolts full-scale deflection, taut-band movement with four-to-one swamping (i.e. internal meter resistance comprised of 25% winding resistance and 75% fully temperature compensated dropping resistor for superior, wide temperature range performance).
* Meter accuracy shall be + 2% full-scale deflection at 25° C., temperature compensated to 0.85% per 10 degrees C.
* Rectifier meters shall be scaled to have rated output no less than 70%, or greater than 85% of full-scale deflection.
* Meter shunts shall be panel-mounted Holloway type "SW" style, with an accuracy of ± 0.25%.
  + 1. Transformers

Transformers shall meet UL 506, Specialty Transformers and the following:

* Transformer designed as full isolation with separate isolated primary and secondary windings with a minimum efficiency of 95%.
* Transformer secondary shall be equipped with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Tap adjustment shall be by means of tap bars.
* Transformer materials and construction shall be rated for Class "H" operation (180° C). Insulation materials shall be further enhanced by dipping in thermosetting varnish and baking.
* Transformer shall be rated for a minimum dielectric strength of 2250 volts applied for one minute between the windings, and between the windings and the core.
  + 1. Potential Monitoring Connections

Two, five way binding posts shall be provided on the front of the rectifier instrument panel. One will be labeled “Reference” and one will be labeled “Structure”.

* + 1. Remote Monitoring Connection

The rectifier shall be provided with a terminal block for possible connection to a Corrpower remote monitoring unit. The terminal strip shall have two separate terminals each for monitoring of the rectifier DC output voltage and DC output current. Terminals for connecting to an internal interrupter coil (interrupt contactor to be supplied with rectifier), monitoring of structure potential, and monitoring of the rectifier AC shall also be provided.

* + 1. Miscellaneous
* All rectifiers shall be capable of operating from either a 115 or 230 volt, single phase, 60 hertz AC input.
* Cathodic Protection Rectifier shall be 100% quality control tested as outlined in this specification.
* During manufacture, the rectifier shall be subjected to frequent visual and performance testing to ensure a high degree of quality acceptance level.
* Rectifiers shall be subjected to 100% testing of the following rectifier electrical parameters:
* AC input voltage, current, apparent power and true power.
* DC output current, voltage and power.
* AC power factor.
* AC to DC conversion efficiency.
* Output ripple.
  1. **Anode Junction Panel**
     1. Enclosure

Mount the anode junction panel in the stainless steel rectifier enclosure as shown on the drawing. Provide positive terminal, 0.01 ohm type RS Holloway shunts, and a minimum 3/16” thick, NEMA Grade “XX” phenolic panel. For size and terminal configurations, see drawings.

* + 1. Positive Cable

Use single No. 4 AWG, conductor, seven strand copper with HMW/PE insulation.

# Negative Cables

* + 1. Cables

Rectifier negative cables shall be No. 4 AWG, single conductor, seven strand copper with medium density, HMW/PE insulation. The polyethylene shall conform to ASTM D 1248, Type I, Class C, Grade 5.

* + 1. Test Lead

The test lead shall be No. 12 AWG, solid copper wire with white, TW, THW, or THHN insulation and shall be of sufficient length to extend from the pipe connection to the rectifier without splicing.

**3.6 Reference Electrode**

* The electrode shall be equipped with No. 14 AWG stranded copper wire with blue HMW/PE insulation of suitable length to extend from near the pipe (see drawings) to the rectifier without splicing.
* The reference electrode shall be copper/copper sulfate Permacell Plus, double membrane, and ceramic cell in a geomembrane package, as manufactured by Corrpro or approved equal.

**3.7 Thermite Weld Equipment**

* Charges and Molds- Cadweld molds and charges shall be used. Charges and mold size shall be as specified by Erico for the specific surface configuration.
* For high strength steel pipelines, use only 15 gram Cadweld charges.
* Weld Coating- Coating for welds shall be Kop-Coat as manufactured by Carboline.
* Weld Cap- The coated weld shall be covered with a plastic weld cap.
  1. **AC Power Service**
* Products-All AC power components shall meet local power company requirements.
* Meter Base- Meter base shall be 120/240-volt, single phase, 100-ampere.
* Disconnect Switch- Provide fused disconnect in NEMA 1 enclosure. Supply with circuit breakers sized for 100 to 135 percent of the AC current flow at maximum rectifier output. Mount in cathodic protection cabinet with transformer-rectifier.
* Ground Rod- Ground rod shall conform to the requirements of the utility company having jurisdiction.
* Ground Wire and Clamp- Ground wire shall be bare, No. 6 AWG solid copper wire. Use a bronze, bolt-on ground rod clamp.
* Service Pole- Service Pole for rectifier shall be a 25 foot, Class 5, treated wood pole.
  1. **Power Supply Protection**

Cathodic protection transformer-rectifiers require extra protection from traffic and vandalism at specified locations.

* Fence- Ornamental iron fencing shall be installed where indicated on drawings. Fencing materials shall be as shown drawings.
* Bollards- Steel bollards shall be installed where indicated on drawings. Bollards materials shall conform to DWU Standard number 236.

**PART 4: INSTALLATION**

* 1. **Deep Anode**
* Permits- The Contractor will obtain well drilling permits as required by City, County and/or State agencies.
* Field Location- Location of the deep anodes are approximate. Exact placement shall be determined and verified in the field by the Contractor and the Dallas Water Utilities or its designated representative.
* Anode Hole Drilling-The anode hole shall be 8 inches diameter to a depth of 250 feet. Drilling shall be accomplished with rotary bit. Driller shall use standard techniques (i.e. trough and vacuum truck) to capture and contain the drilling fluids, mud and cuttings at the top of the hole. The driller shall select the type and consistency of drilling fluids to be consistent with soil characteristics. The drilling rig shall be leveled to provide a round, straight and plumb anode hole.
* Casing-Install an 8” diameter surface casing to a depth of 10 feet.
* Anode Hole Geological Logs- As the hole is drilled, the driller shall maintain a record describing the depth and type of geological formations encountered. Copies of the log shall be submitted as required by Section 2.3.
* Anode Hole Resistance Log- Record electric log of the hole using one of the anodes. The anode lead wire shall have been previously marked in five-foot increments. The anode lead wire shall be marked for a distance equaling or exceeding the maximum anticipated depth of the hole. As the anode is lowered into the hole, measure the resistance by impressing a minimum of 12-volts DC between the anode and a very well-grounded structure such as the AC power ground. Nilsson type soil resistance meters shall not be used to perform this test. A recommended 12-volt DC power source is a heavy-duty lead acid automobile battery. Lower the anode into the hole and at ten-foot increments, hold in place while the voltage and current output of the DC current source are measured and recorded. This information shall be recorded and submitted as required under Section 2.3.
* Vent Pipe Installation- The vent pipe (1-inch Allvent to the top of the coke breeze column) shall be installed in the hole with the first anode. One-inch PVC non-perforated pipe will be installed from the top of the coke breeze column to three

feet above the top of the hole. The bottom of the vent pipe shall be capped. The top of the vent pipe shall be capped throughout the anode and coke breeze backfill installation procedure to prevent intrusion of foreign material. Drilling mud shall not be allowed to enter in the vent pipe.

* Anode Installation- The deep anode shall consist of 10 – 1.25” x 48” long mixed metal oxide tubular anodes spaced at 10-foot intervals. The anodes shall be centered in the hole using anode centralizers. The anodes shall be installed by lowering individually into the hole by the lead wire. The lead wires shall be pre-marked for the nominal anode depth. The final depth shall be recorded with the first anode in the hole (i.e. the bottom anode) identified as anode number one (1). The anode lead wires shall not be damaged during handling or lowering into the hole. Under no circumstances shall the anode lead wires be clamped or pinched around another object while lowering. If the insulation for any anode lead wires are cut, broken, or nicked, the complete anode shall be rejected and shall be removed from the job site. Contractor shall replace all damaged anodes at no additional expense to Dallas Water Utilities
* Anode Column Coke Backfill- The coke backfill shall be slurried above-grade and then pumped into the hole after the anodes are installed. The coke shall be pumped from the bottom of the hole up using a pipe that is the length of the anode hole. The pipe used to pump the coke into the hole shall not be the vent pipe. The pipe shall be raised as the anode column is filled with coke. The pipe shall be removed from the hole after the coke installation is complete. A sufficient amount of backfill shall be used such that the coke breeze column will extend a minimum of five feet above the top of the uppermost anode and no closer than 30-feet from the top of the hole. Installation of the coke backfill shall be uniform with no voids around the anodes.
* Vent Pipe Conditions- The 1-inch diameter internal vent pipe shall terminate with a gooseneck fitting. The top end of the vent pipe shall be left open to allow gases from the anode hole to exit.
* Pea Gravel- Pea gravel shall be installed in the borehole from the top of the coke backfill to 5 feet below the bottom of the surface casing.
* Environmental Seal- A bentonite plug 10-feet in length shall be installed using AquaPlug or PermaPlug material. The plug shall extend 5 feet into the bottom of the casing and 5 feet below the bottom of the casing.
* Precautions- Contractor shall take all necessary precautions to avoid entrance of foreign matter into the hole, movement of soil strata, or collapsing of the hole during the progress of the work. Should movement of soil strata or collapse of the

drilled hole interfere with proper completion of the anode groundbed, Contractor will recover the wires, anodes and any vent pipe and ream or re-drill the hole.

* Mud and Cuttings- Drilling mud, cuttings and other waste shall be disposed of onsite in a manner which complies with the rules and regulations of the State, City and County.
  1. **Installation of Cathodic Protection Cabinet**
* Contents- The cathodic protection cabinet is to contain the transformer-rectifier, anode junction panel and disconnect switch.
* Codes- Comply with the latest edition of the National Electrical Code (NEC) and with all City of Dallas and local power company codes and standards.
* Mounting- Mount rectifiers on reinforced concrete pad as shown on the drawings. Place at elevation above the 100-year flood plain.
* Identification- Equip rectifiers with permanent engraved nameplates to identify the units as "Cathodic Protection Cabinet, Property of City of Dallas.”
* Conduit- Place all wiring to the rectifier in rigid galvanized steel conduit when run above grade.
* Use insulating bushings at the ends of all conduits
* Extend steel conduit 12 inches below grade.
* Electrical Service- Provide AC electrical service for each rectifier unit. Furnish and install the necessary wiring, conduits, wires, meter sockets, splice boxes and equipment to the service connection as required by the local power company.
* Completion- The installation is not considered complete until the AC and DC wiring is installed and the rectifier is capable of operating at full rated load. Install AC power such that the rectifier can be activated for test purposes. Leave the power off after test.
  1. **Cables and Test Lead**
* General- Connect the No. 4 AWG HMW/PE negative cable and No. 12 AWG test lead to the water transmission line and route to the cathodic protection panel. Route No. 4 AWG HMW/PE positive cable from junction box to transformer-rectifier.
* Excavation- Carefully excavate the water transmission line for wire and cable connection. The excavation on steel pipe can be anywhere along the line. For prestressed concrete cylinder pipe, a joint must be exposed for welding the "L Bracket" as shown on the drawings.
* Alternate Connection- As an alternate to direct connection to the pipe, where approved by the City, the Contractor may elect to connect the negative cable and test lead inside a concrete vault by welding a plate to the top of a flange, as shown on the drawings.
* Method- Attach negative cables and test leads to the water transmission lines by thermite welding at the location shown on the drawings.
* Preparation- Clean and dry the steel surface to which the negative cable is to be attached. Use a grinding wheel to remove all dirt, coating, oxide and mill scale from the surface. Use a solvent or file to remove oil and grease, if necessary. Clean the surface to bright metal. Repeat preparation for the test lead attachment. Remove approximately 1 inch of insulation from each end of the wires to be thermite welded to the steel surface, exposing clean, oxide-free copper.
* Welding- Thermite weld the negative cable and the lead as follows:
* Using the proper size thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface.
* Place the metal disk in the bottom of the mold.
* Remove the cap from the weld charge container and pour the contents into the mold. Squeeze the bottom of the weld charge container to spread ignition powder over the charge.
* Close the mold cover and ignite the starting powder with a flint gun. Firmly hold the mold in place until all of the charge has burned and the weld has cooled slightly.
* Remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.
* When the weld is secure, coat all bare metal and weld metal and cover with a thermite weld cap.
  1. **Permanent Reference Cell**
* Location- Locate the permanent reference cell near the negative pipeline connection as shown on the drawings.
* Placement- Remove the permanent reference cell from the shipping package and place below the springline and one foot away from the pipeline if in the excavation for the negative connection, and no more than three feet away if in a separate augured hole.
* Backfill- Backfill the reference electrode with six inches of select, native soil and compact by hand. Moisten soil with 5 gallons of water to achieve good compaction.
* Wiring- Run continuous lengths of the blue reference cell wiring, and the white test lead to the rectifier unit in the same trench as the negative cable. Do not nick or otherwise damage the wire insulation.

**4.5 Wire and Cable**

* Depth- Install all underground wires and cables a minimum of 36 inches below final grade with a minimum separation of 6 inches from other underground structures.
* Conduit- Place all DC positive cables, negative cables, test leads and permanent reference cell leads in rigid, galvanized steel conduit when above-grade. Extend the conduit 12 inches below grade.
* Bushings- Use insulating bushings at the ends of all conduits.
  1. **AC Power**
* Permit- Contractor is responsible for obtaining an electrical permit by a Licensed Electrician.
* Installation- The AC power and grounding assembly for the transformer-rectifiers, including weatherhead, conduit, meter loop and ground rod, shall comply with local, state and federal code.
* Power Supply- Contractor shall provide permanent AC service from the power company to the transformer-rectifiers.
* Account- Contractor shall transfer power company account to the City of Dallas at the end of the project. This is a requirement for project completion.
  1. **Power Supply Protection**

Cathodic protection transformer-rectifiers require extra protection from traffic and vandalism at specified locations.

* Fence- Ornamental iron fencing shall be installed where indicated on drawings. Fencing shall be constructed as shown drawings.
* Bollards- Steel bollards shall be installed where indicated on drawings. Bollards shall be constructed in accordance with DWU Standard number 236.

**4.6 Post-Installation Testing of the Cathodic Protection Systems**

* + - General- Inspect, energize, and adjust the cathodic protection as soon as possible after the equipment has been installed.
    - Commissioning- The commissioning of the cathodic protection system shall be performed by a Corrosion Engineer hired by the Contractor to achieve compliance with the referenced corrosion control standards set forth by NACE International and AWWA. The Corrosion Engineer shall be registered in the State of Texas as a Professional Engineer and, through experience and education, qualified in cathodic protection of prestressed concrete cylinder pipe.
    - Notice- Prior to native state and polarized potential testing, the Contractor shall give a minimum of 72 hours notice to Dallas Water Utilities to facilitate observation of the tests by its designated representative.
    - Method- The Corrosion Engineer shall:
* Measure native state pipe-to-soil potentials at all test stations, permanent reference cells, and locations of exposed pipe prior to energizing the cathodic protection system.
* Measure foreign line potentials, prior to energizing the cathodic protection system.
* Energize the cathodic protection system and adjust the DC current output such that the pipe-to-soil potentials near the cathodic protection current source (either transformer-rectifier or sacrificial anodes) is approximately -900 millivolts to a copper sulfate electrode (CSE). Record the DC voltage and current of the power supply.
* Allow sufficient time for the pipeline to polarize.
* Using synchronized current interrupters in all rectifiers influencing the test point, cycle the power supplies “On” and “Off”.
* Record “On” and “Instant Off” potentials at all water pipeline test stations, permanent reference cells, locations of exposed pipe, casings and foreign pipelines.
* Adjust the cathodic protection power supplies to achieve a minimum 100 millivolts of polarization without any “Instant Off” potentials more negative than -900 millivolts CSE.
* Record all adjustments of the DC power supplies.
* Verify that interference does not exist with foreign pipelines. Perform joint tests and mitigate any interference detected.

# After initial energizing, perform a walk-through inspection with Dallas Water Utilities or its designated representative to verify that all corrosion control components have been installed in accordance with project drawings and specifications.

# A punch list of outstanding work identified during walk-through inspection shall be made. Once Contractor has completed all work on punchlist, pipeline will be allowed to polarize for 30 days before final testing. Final testing and adjustment shall be performed after 30-day polarization period.

# During find testing, adjust the system to achieve 100 millivolts polarization with no polarized potential more negative than -900 millivolts CSE.

# Deficiencies discovered during final testing shall be repaired at Contractor’s expense and at no additional cost to Dallas Water Utilities. Should additional testing be required after final testing, cost of additional testing shall be paid by Contractor and will be charged at a rate of $1,500 per day.

# Equipment- All cathodic protection testing instruments shall be in proper working order and calibrated according to factory specifications.

# Report- A written report shall be submitted in accordance with Section 1.05, Submittals. Included shall be all test data, interference test results, resistance and geologic logs, the rectifier O&M Manual and the As-Built Drawings.

**PART 5: METHOD OF MEASUREMENT AND PAYMENT**

Payment for Impressed Current Cathodic Protection System as specified in this section shall be incidental and inclusive in the applicable unit price bid item.

**\*\*END OF SECTION\*\***

1. [↑](#footnote-ref-1)
2. [↑](#footnote-ref-2)
3. [↑](#footnote-ref-3)
4. [↑](#footnote-ref-4)