SECTION 26 42 00
CATHODIC PROTECTION

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies complete galvanic sacrificial anode type cathodic protection systems for underground steel structures. The section also includes devices to electrically isolate the system being protected.

B. The services required include planning, installation, adjusting and testing of a cathodic protection system, using sacrificial anodes for cathodic protection of the Steam lines and their connectors. The cathodic protection system shall include anodes, cables, connectors, corrosion protection test stations, and any other equipment required for a complete operating system providing the NACE criteria of protection as specified. Insulators are required whenever needed to insulate the pipes from any other structure

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

D. Section 33 63 00, STEAM ENERGY DISTRIBUTION: Coating on underground steel casings for steam distribution systems.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. The Contractor shall be regularly engaged in the installation and testing of cathodic protection systems. Contractor's personnel shall be experienced and shall be supervised by an engineer who is accredited as a Corrosion Specialist or Corrosion Protection Specialist by the National Association of Corrosion Engineers (NACE) International. All calculations, design and testing shall be performed by or supervised by the Corrosion Specialist or Engineer. All procedures shall conform to recommendations of NACE RP0169 unless specified otherwise.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Design Submittal: For cathodic protection system indicated to comply with performance requirements and design criteria, including analysis

data signed and sealed by the qualified corrosion engineer responsible for their preparation.

1. Conduct site tests necessary for design, including soil resistivity, close-interval potential surveys, testing during construction, interference testing, and training of Owner's personnel.
2. Provide system design calculations, stating the maximum recommended anode current output density, and the rate of gaseous production, if any, at that current density.

C. Furnish catalog cuts and shop drawings of following items:

1. Anodes.
2. Cable and wire.
3. Test stations.
4. Terminal boxes.
5. Isolating flanges, unions, coatings, casing seals.
6. Exothermic welding devices.
7. Cable splice kits.
8. Layout drawings, wiring diagrams.
9. Test instruments.
10. Dielectric tape.
11. Test connection points.

D. Detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, results of system design calculations including soil-resistivity, installation instructions and certified test data stating the maximum recommended anode current output density and the rate of gaseous production if any at that current density. Detail drawings shall contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function properly as a unit.

E. Accreditation of Corrosion Specialists or Engineers by NACE International.

F. Test reports in booklet form tabulating all field tests and measurements performed, upon completion and testing of the installed system and including close interval potential survey, casing and interference tests, final system test verifying protection, insulated joint and bond tests, and holiday coating test. A certified test report showing that the connecting method has passed a 120-day laboratory test without failure at the place of connection, wherein the anode is subjected to maximum recommended current output while immersed in a three percent sodium chloride solution.

G. Operation and Maintenance Manual: Include the following:

1. Basic system operation, outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown.
2. Instructions for pipe-to-reference cell and tank-to-reference cell potential measurements and frequency of monitoring.
3. Instructions for dielectric connections, interference and sacrificial-anode bonds; and precautions to ensure safe conditions during repair of pipe, tank or other metallic systems. Instructions shall be neatly bound.
4. Locations of all anodes, test stations, and insulating joints.
5. Structure-to-reference cell potentials as measured during the tests required by "Field Quality Control" Article.
6. Recommendations for maintenance testing, including instructions for pipe-to-reference cell potential measurements and frequency of testing.
7. Precautions to ensure safe conditions during repair of pipe system.

H. Certifications:

1. Two weeks prior to final inspection, submit four copies of the following to the Contracting Officer’s Representative (COR):
   a. Certification by the Contractor that the cathodic protection system has been properly installed, adjusted and tested.
   b. Certified copies of all of the factory design and production tests, field test data sheets and reports for the assemblies.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. American Society for Testing and Materials (ASTM):

B8-04.....Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, or Soft

D1248-05.....Polyethylene Plastic Extrusion Materials for Wire and Cable

ASTM F 1182..... Anodes, Sacrificial Zinc Alloy

G57-06.....Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

C. American Society of Mechanical Engineers (ASME):

B16.5-03.....Pipe Flanges and Flanged Fittings: NPS ½ through 24

D. National Association of Corrosion Engineers (NACE) International :

RP0169-02.....Control of External Corrosion on Underground or Submerged Metallic Piping Systems

RP0285.....Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

PART 2 - PRODUCTS

2.1 ANODES

A. Type: Magnesium, factory-packed in cloth bag or box containing prepared backfill mixture, with lead wires.

B. Construction:

1. Alloy Specifications:

Element	Percent-(Option-1)	Percent-(Option-2)
Aluminum	5.0 - 7.0	0.010 Max.
Manganese	0.15 Min.	0.50 - 1.30
Zinc	2.0 - 4.0	0.05 Max.
Silicon	0.30 Max.	0.05 Max.
Copper	0.10 Max.	0.02 Max.
Nickel	0.003 Max.	0.001 Max.
Iron	0.003 Max.	0.03 Max.
Other	0.30 Max.	0.30 Max.
Magnesium	Remainder	Remainder

2. Core: Perforated galvanized steel, maximum 0.10-pounds per linear foot [0.148 kg per meter], one end accessible in a recess for lead wire connection.
3. Lead Wire: Number 12 solid copper, 10 feet [3m] long, Type HMWPE (high molecular weight polyethylene) insulation, ASTM D1248, Type 1, Class C, Category 5, Grade E5.
4. Lead Wire Attachment to Core: Anode lead wire shall be factory installed. Silver solder the lead wire to the anode core, and seal the soldered connection and recessed end of the anode with an dielectric sealing compound. Cover the connection with heat shrinkable tubing.
5. Packaging: Permeable cloth bag or box with backfill mixture completely surrounding anode 1/2 inch [15mm] minimum.
   a. Grain Size: Pass through 20-mesh screen -- 100 percent; retained by 100-mesh screen -- 50 percent.
   b. Components:

Ground Hydrated Gypsum	75 percent
Powdered Wyoming Bentonite	20 percent
Anhydrous Sodium Sulphate	5 percent

   c. Weight: Weight requirements are listed on the drawings. Listings refer to alloy weight only.
   d. Center the anode in the firmly packed backfill using spacers. Overall dimensions of the bagged 17pound anode.

2.2 INSULATED CABLE

A. Type: One conductor, stranded, annealed copper, Type HMWPE (high molecular weight polyethylene) insulation and jacket.

B. Service: Buried in corrosive soils. Header cable, test leads, bonding cable.

C. Construction:

1. Table:

MINIMUM THICKNESS OF INSULATION AND JACKET		
AWG-SIZE	NUMBER-OF-STRANDS	inches [mm]
No. 8	7	7/64 [2.8]
No. 6	7	7/64 [2.8]
No. 4	7	7/64 [2.8]
No. 2	7	7/64 [2.8]
No. 1	19	8/64 [3.2]
No. 1/10	19	8/64 [3.2]

2. Insulation: ASTM D1248, Type 1, Class C, Category 5, Grade E5.

3. Conductors: ASTM B8.

D. Lead wires terminating at a junction box or test station shall have a cable identification tag.

2.3 CABLE CONNECTIONS

A. Type: Connections between cables and pipes, casings or structures shall be exothermic fusion-welding process using copper oxide, aluminum and vanadium welding material in graphite molds. Connections between cables and between cables and leads shall be corrosion-resistant split bolts.

B. Insulation of Cable-to-Cable Connections: Epoxy-resin splice kits with two-part resin, mold, sealing mastic.

C. Coating of Cable Connections to Protected Structures: Field-applied coating similar to that on the protected structure.

2.4 TEST STATIONS

A. Type: Weatherproof, located at grade, or aboveground if so shown. Enclosed terminals for anode leads, test leads, and leads attached to protected system. Connection points for test instruments.

B. Construction:

1. Housing: The unit shall be of standard design, manufactured for use as a cathodic protection test station, complete with locking cover, terminal board, shunts, and brass or Type 316 stainless steel hardware. The terminal board shall be removable for easy access to wires. High-impact resistant plastic. Provide means to anchor housing below grade. Yellow color.

2. Terminal Board: High-impact resistant plastic board, cadmium or zinc-plated hardware, accessible from front and rear, sufficient terminals for all required connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anodes:

1. Excavate hole to a minimum 3 inches [75mm] larger than the packaged anode diameter. Install in native soil, 3 feet [900mm] minimum from protected structure, below centerline of protected structure, and at locations shown. Backfill shall be native soil. Install anodes adjacent to fuel tanks horizontally.
2. Do not lift or support anode by the lead wire. Where applicable, remove manufacturer's plastic wrap/bag from the anode. Exercise care to preclude damaging the cloth bag and the lead wire insulation.
3. Center the packaged anode in the hole with native soil in layers not exceeding 6 inches [150mm]. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 6 inches [150mm] above the top of the anode, pour not less than ten gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes shall not be backfilled prior to inspection and approval by the COR.

B. Cables and Anode Leads:

1. Burial: 2 feet [600mm] minimum below finished grade, 6 inch [150mm] minimum separation from other underground structures, backfill material in contact with cable free of rocks and debris. Cover the lead wire trench bottom with a 3 inch [75mm] layer of sand or stone free earth. Center wire on the backfill layer, do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 6 inches [150mm] deep, compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter and refuse in backfill.
2. Continuity Bonds: Use cable to connect adjacent protected structures, and protected structures separated by non-welded connectors. Provide 25 percent additional length as slack to allow differential movement of protected systems.
3. Connections: Provide clean, bright, bare metal surface at all connection points. Connect anode lead wire(s) to the test station terminal board(s. Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. Weld connections using exothermic kit(s) in accordance with the kit manufacturer's instructions. Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 2 pound [908g]

hammer. Cover connections with an electrically insulating coating. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.

4. Warning Tape: Install 6 inches [150mm] below grade, directly above cables.

C. Test Stations: Provide test stations as follows:
   1. At all insulating joints.
   2. At both ends of casings.
   3. Where the pipe connects to a dissimilar metal pipe.

D. Anchor terminal board firmly 2 feet [600mm] minimum above grade for above grade units. Connect all anodes and protected structure to the test stations.

E. Dielectric Insulation:
   1. General: Provide complete dielectric insulation between protected and unprotected systems and between protected systems and structures which could ground the cathodic protection. Required insulation points include all pipe entrances to buildings, manholes, and pits.
   2. Flanges: Install in locations open to view after completion of construction. Provide insulating gaskets, insulating sleeves on all bolts, insulating washers under bolt heads and nuts.
   3. Unions: Install in locations open to view after completion of construction. Unions not permitted in pipe sizes over 50 mm (2 inches).
   4. Wall Penetration Seals: Install in space between pipes and wall sleeves at building and manhole walls.
   5. Coatings: Completely coat all pipe or conduit areas that are in contact with concrete.

3.2 FIELD QUALITY CONTROL

A. Provide system with a calculated design life exceeding 40 years.

B. Pre-construction Survey: The Corrosion Specialist shall perform a soil resistivity survey using the Wenner Four-Pin Method as described in ASTM G57. Survey entire length of proposed protected system at the structure depth. Also survey native-state structure-to-soil potential, soil pH, and presence of stray currents.

C. Calculations: The Corrosion Specialist shall perform engineering calculations to verify the design of the system shown. The calculations shall follow a format published by a recognized corrosion expert. Inform the Government of any recommended changes in the system design shown.

D. Field Inspections During Construction: The corrosion specialist shall inspect the work at least twice to ascertain that there is no grounding,

short circuits, coating damage, and that installation is in accordance with requirements.

E. Final Inspection:

1. Performed by Corrosion Specialist; witnessed by COR.
2. Test Instruments:
   a. Digital Volt-Ammeter with impedance of 7-10 mega-ohms/volt.
   b. Saturated copper-copper sulfate reference electrode.
   c. Other instruments as required.
3. Procedures: Conform to NACE RP0169.
4. Test Results Required for Acceptance:
   a. Potential of minus 0.85 volt between protected structure and reference electrode.
   b. Minimum shift of minus 300 millivolts upon application of protective current. Voltage measured between protected structure and reference electrode.
   c. Minimum shift of minus 100 millivolts upon interruption of protective current. Voltage measured between protected structure and reference electrode.
   d. Amperage value sufficient that anode life 40 years can be calculated. Provide calculations.
5. Test Report: Submit a complete report to COR showing all test measurements, calculations, list of instruments used. All structure-to-electrolyte measurements, including initial potentials and anode outputs, shall be recorded on applicable forms. Identification of test locations, test station and anode test stations shall coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor shall locate, correct, and report to the COR any short circuits encountered during the checkout of the installed cathodic protection system.
6. One Year Warranty Period Testing: The Contractor shall inspect, test, and adjust the cathodic protection system for one yearto ensure its continued conformance with the criteria outlined below. The performance period for these tests shall commence upon the completion of all cathodic protection work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the cathodic protection system by the COR. Copies of the One Year Warranty Period Cathodic Protection System Field Test Report, including field data, and certified by the Contractor's corrosion engineer shall be submitted to the COR.

3.4 AS-BUILT DRAWINGS

Provide one set of reproducible drawings showing dimensioned locations of all anodes, cables, test stations, and also anode weights. Provide identification of test stations and anodes keyed to test reports.

3.5 INSTRUCTION

During the warranty testing and at a time designated by the COR, make available the services of a technician regularly employed or authorized by the manufacturer of the Cathodic Protection System for instructing Government personnel in the proper operation, maintenance, safety, and emergency procedures of the Cathodic Protection System. The period of instruction shall be not less than one but not more than two 8-hour working day. Conduct the training at the jobsite or at another location mutually satisfactory to the Government and the Contractor. The field instructions shall cover all of the items contained in the operation and maintenance manual.

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