

**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 tanks and piping. 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 steam lines, 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. Any pipe crossing the steam pipe shall have a test station.

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 23 10 00, FACILITY FUEL SYSTEMS: Coating on underground steel oil tanks, and secondary containment for underground tanks and piping systems.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

1.3 QUALITY ASSURANCE

- A. 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 Cathodic Protection Specialist by the National Association of Corrosion Engineers (NACE) International.
- B. Cathodic protection for underground metal storage tanks shall be designed in accordance with NACE RP0169. Cathodic protection for underground metal piping tanks shall be designed in accordance with NACE RP0285.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS. Submit sufficient information to demonstrate compliance with drawings and specifications.

1. Design Submittal: For cathodic protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the corrosion engineer responsible for their preparation.
 - a. Conduct site tests necessary for design, including soil resistivity, close-interval potential surveys, testing during construction, interference testing, and training of Owner's personnel.
 - b. Provide system design calculations, stating the maximum recommended anode current output density, and the rate of gaseous production, if any, at that current density.
2. Furnish catalog cuts and shop drawings for the following items:
 - a. Anodes.
 - b. Cable and wire.
 - c. Test stations.
 - d. Terminal boxes.
 - e. Isolating flanges, unions, coatings, casing seals.
 - f. Exothermic welding devices.
 - g. Cable splice kits.
 - h. Layout drawings, wiring diagrams.
 - i. Test instruments.
 - j. Dielectric tape.
 - k. Test connection points.
3. Detail drawings consisting of a complete list of equipment and material and complete wiring and schematic diagrams, as well as any other details required to demonstrate that the system will function properly.
4. Designer's accreditation as a Corrosion Specialist or Cathodic Protection Specialist by NACE International.
5. 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.

6. Operation and Maintenance Manual:
 - a. Basic system operation.
 - b. Instructions for dielectric connections, interference and sacrificial-anode bonds; and precautions to ensure safe conditions during repair of pipe, tank or other metallic systems.
 - c. Locations of all anodes, test stations, and insulating joints.
 - d. Structure-to-reference cell potentials.
 - e. Recommendations for maintenance testing, including instructions for pipe-to-reference cell potential measurements and frequency of testing.
 - f. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
7. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the cathodic protection system conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the Cathodic protection system has been properly installed and adjusted.

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):

B8-11.....	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
B843-07.....	Magnesium Alloy Anodes for Cathodic Protection
D1248-12.....	Polyethylene Plastic Extrusion Materials for Wire and Cable
F1182-07.....	Anodes, Sacrificial Zinc Alloy
G57-12.....	Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

C. American Society of Mechanical Engineers (ASME):

B16-98.....Pipes and Fittings

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

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

RP0285-02.....Corrosion Control of Underground Storage Tank
Systems by Cathodic Protection

PART 2 - PRODUCTS

2.1 ANODES

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

B. Construction:

1. Alloy Specifications:

Element	Percent of Weight
Aluminum	0.010 Max.
Manganese	0.50 - 1.30
Zinc	0.05 Max.
Silicon	0.50 Max.
Copper	0.02 Max.
Nickel	0.001 Max.
Iron	0.03 Max.
Other	0.30 Max.
Magnesium	Remainder

2. Core: Galvanized steel.

3. Lead Wire: Factory installed, No. 12 solid copper, 3 M (10 feet) long, with TW or THWN insulation.

4. Lead Wire Attachment to Core: Silver solder the lead wire to the anode core, and seal the connection with an epoxy sealing compound. Dielectric material shall extend past the connection and cover the lead wire insulation by not less than 12 mm (1/2 inch).

5. Packaging: Permeable cloth bag or box with backfill mixture completely surrounding anode 12 mm (1/2 inch) minimum.

a. Components:

Hydrated Gypsum	75 percent
Powdered Bentonite	20 percent

Anhydrous Sodium Sulphate	5 percent
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b. Center the anode in the firmly packed backfill using spacers.

2.2 INSULATED CABLE

A. Single conductor, stranded, annealed copper, Type HMWPE (high molecular weight polyethylene) insulation.

B. Construction:

1. Thickness of insulation:

AWG-SIZE	mm (inches)
No. 8	2.8 (7/64)
No. 6	2.8 (7/64)
No. 4	2.8 (7/64)
No. 2	2.8 (7/64)
No. 1	3.2 (8/64)
No. 1/0	3.2 (8/64)

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

3. Conductors: ASTM B8.

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

2.3 CABLE CONNECTIONS

A. Connections between cables and tank, pipes, casings, or structures shall be exothermic welding process. 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 CABLE AND WIRE IDENTIFICATION TAGS

A. Laminated plastic material with black letters on a yellow background. Print letters and numbers a minimum of 5 mm (3/16 inch) in size.

Provide identifier legend in accordance with the drawings.

2.5 TEST STATIONS

A. Type: Weatherproof, located at grade, or aboveground if so shown on the drawings. Enclosed terminals for anode leads, test leads, leads attached to protected system, and 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 stainless steel hardware.
2. Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic. Insulated terminal boards shall have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper bus bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections shall be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes). Conductors shall be permanently identified by means of tags to indicate termination. Each conductor shall be color coded as follows:

Anode lead wire - black

Structure lead wire - white

Reference electrode lead wire - red

2.6 PERMANENT REFERENCE ELECTRODES

- A. Permanent reference electrodes shall be copper copper-sulfate, silver silver-chloride, zinc specifically manufactured for underground use, [32 mm (1-1/4 inch) diameter, by 255 mm (10 inches) long, plastic tube with an ion trap to minimize contamination of the cell, and a minimum surface sensing area of square centimeters (square inches). The cell shall be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer. Provide cells with No. 10 cable of sufficient length to extend to the test station junction box without splicing. Reference electrodes shall have a minimum 15 year life, and stability of plus or minus 5 millivolts under 3 microampere load.

2.7 DIELECTRIC TAPE

- A. Vinyl plastic electrical tape, 0.18 to 0.25 mm (7 - 10 mils) thick, pressure-sensitive adhesive.

2.8 WARNING TAPE

- A. 50 mm (2 inches) wide, detectable with metal detector, mylar-encased aluminum, orange color, imprinted "Cathodic Protection Cable Below" or similar.

2.9 DIELECTRIC INSULATION

- A. Rubber-based, 3 mm (0.125 inch) thick.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anodes:

1. Excavate hole to a minimum 75 mm (3 inches) larger than the packaged anode diameter. Excavate lead wire trench to 24 inches) deep. Install in native soil, 900 mm (3 feet) minimum from protected structure, below centerline of protected structure, and at locations shown. Backfill shall be native soil. Install anodes adjacent to fuel tanks vertically.
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 150 mm (6 inches). Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 150 mm (6 inches) 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 COTR.

B. Cables and Anode Leads:

1. Burial: 600 mm (2 feet) minimum below finished grade, 600 mm (6 inches) 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 75 mm (3 inches) 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 150 mm (6 inch) deep, and compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter and refuse in backfill. Place cable warning tape within 18 inches of finished grade, above cable and conduit.
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) directly to the protected structure(s) by use of exothermic welds. 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 908 g (2 pound) hammer. Cover connections with an electrically insulating coating which is compatible with the existing coating on the structure. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.
 4. Warning Tape: Install 150 mm (6 inches) below grade, directly above cables.
- C. Test Stations: Provide test stations and permanent reference electrodes as follows:
1. At 305 M (1000 foot) intervals.
 2. At all insulating joints.
 3. At both ends of casings.
 4. Where the pipe crosses any other metal pipes.
 5. Where the pipe connects to an existing piping system.
 6. Where the pipe connects to a dissimilar metal pipe.
- D. Anchor terminal board firmly 600 mm (2 feet) 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.

F. Permanent Reference Electrode Calibration and Installation:

1. Provide copper copper-sulfate, silver-silver chloride, or zinc reference electrode(s).
2. Prior to installation, soak the prepackaged reference electrode in a container of potable water for 30 minutes.
3. Calibrate the permanent reference electrode in the presence of the COTR by measuring the potential difference between the permanent reference electrode and an independent (portable) calibrated reference electrode placed in the water adjacent to the permanent reference electrode. Potential differences between the two electrodes of the same generic type should not exceed 10 millivolts when the sensing windows of the two electrodes being compared are not more than 2 mm (1/16 inch) apart but not touching. Zinc permanent reference electrodes should be within the range of 1000 to 1150 millivolts when calibrated with an independent (portable) calibrated copper-copper sulfate reference electrode with the two electrodes being not more than 2 mm (1/16 inch) apart but not touching. Permanent reference electrodes not within these potential differences shall be removed and replaced at the Contractor's expense. Prior to completely backfilling over reference electrodes, again verify the accuracy of the reference electrode. The testing provision shall also apply to replacement reference electrodes as well.

3.2 RECONDITIONING OF SURFACES

- A. Restoration of Sod: Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. Preserve sod and topsoil carefully and replace after the backfilling is completed. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding.
- B. Restoration of Pavement: Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course shall have a maximum aggregate size of 40 mm (1-1/2 inches). Prime base course with liquid asphalt, ASTM D 2028, Grade RC-70 prior to paving. Match base course thickness to existing but shall not be less than 150

mm (6 inches). Asphalt aggregate size shall be 13 mm (1/2 inch), asphalt cement shall conform to ASTM D 3381, Grade AR-2000. Match asphalt concrete thickness to existing but shall not be less than 50 mm (2 inches). Repair portland cement concrete pavement, sidewalks, curbs, and gutters using 20.67 MPa 3,000 psi concrete conforming to Section 03 30 00, CAST-IN-PLACE CONCRETE. Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.3 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. 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 COTR.
 - 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 COTR 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 COTR 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 semi-annually for one year, 4 interim inspections total, to 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 COTR. 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 COTR.

3.4 AS-BUILT DRAWINGS

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

3.5 INSTRUCTION

- A. During the warranty testing and at a time designated by the COTR, 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 two but not more than four hours. The field instructions shall cover all of the items contained in the operation and maintenance manual.

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