SECTION 13 47 13 – CATHODIC PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes passive cathodic protection systems that use magnesium anodes to protect iron and steel piping.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design, supervise, test, and inspect the installation of cathodic protection systems, including comprehensive engineering analysis by a qualified professional engineer or a person certified as qualified by NACE International, hereinafter referred to as NACE, if such licensing or certification includes suitable experience in corrosion control on buried or submerged metallic piping systems and metallic tanks, using performance requirements and design criteria indicated.

1. Design cathodic protection for pipelines according to NACE RP0169.

B. Survey site and determine soil or water corrosivity (resistivity), current requirements, potential surveys, stray currents, and water chemistry/corrosivity (pH).

C. Select anodes and accessories relevant to level of protection. Design anodes for an estimated life of 50 years before replacement.

D. Cathodic protection systems shall provide protective potential that complies wpith referenced NACE standards. Insulators are required if needed to insulate protected metals from other structures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For cathodic protection. Include plans, evaluations, sections, details, and attachments to other work.

1. Detail locations of cathodic protection equipment, devices, and outlets, with characteristics and cross-references to products.
2. Include calculations and details of anode designs.
3. Include labeling and identifying scheme for wires, cables, and test boxes.

C. Delegated-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.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, and coordinating connections to piping.

B. Qualification Data: For qualified professional engineer. Submit evidence of current license, corporate authorization (if applicable) of the engineering business, and NACE certifications.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: In addition to items specified in Section 017823 "Operation and Maintenance Data," 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.

1.6 QUALITY ASSURANCE

A. Corrosion Engineer Qualifications: A qualified professional engineer who has education and experience in cathodic protection of buried and submerged metal structures and has NACE accreditation or certification as a Corrosion Specialist or Cathodic Protection Specialist.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect anodes from exposure to rain and direct sunlight.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace permanent reference electrodes that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 50 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MAGNESIUM ANODES, TYPE II

A. Comply with ASTM B 843.

B. Chemical composition as percent of weight shall be as follows:

1. Aluminum: 0.010 maximum.
2. Manganese: 0.50 to 1.3.
3. Zinc: 0.05 maximum.
4. Silicon: 0.50 maximum.
5. Copper: 0.02 maximum.
6. Nickel: 0.001 maximum.
7. Iron: 0.03 maximum.
8. Other Impurities: 0.05 each; 0.3 maximum total.
9. Magnesium: Remainder.

C. Anode Core: Galvanized steel with anode wire silver-soldered to the core. Connection shall be recessed and epoxy insulated for 600-V rating. Connection shall be covered with heat-shrinkable tubing, and insulation shall be extended over connection.

D. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.

E. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

1. Hydrated Gypsum: 75 percent.
2. Bentonite Clay: 20 percent.
3. Anhydrous Sodium Sulfate: 5 percent.

2.2 MAGNESIUM/MANGANESE ALLOY ANODES

A. Chemical composition as percent of weight shall be as follows:

1. Aluminum: 0.01 maximum.
2. Manganese: 0.50 to 1.3.
3. Copper: 0.02 maximum.
4. Nickel: 0.001 maximum.
5. Iron: 0.03 maximum.
6. Other Impurities: 0.05 each; 0.3 maximum total.
7. Magnesium: Remainder.

B. Bare Anode Weight: 40 lb, not including core, and a nominal length of 60 inches.

C. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and

NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.

D. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

1. Hydrated Gypsum: 75 percent.
2. Bentonite Clay: 20 percent.
3. Anhydrous Sodium Sulfate: 5 percent.

2.3 PERMANENT REFERENCE ELECTRODES

A. Copper/copper sulfate (Cu/CuSO4), suitable for direct burial. Electrode shall be guaranteed by supplier for 30 years' service in the installed environment.

2.4 WIRE AND CABLE

A. Anode Header Cable: Single-conductor, Type HMWPE, insulated cable specifically designed for direct-buried dc service in cathodic protection installations.

1. Conductor: Stranded, annealed, uncoated copper, not less than No. 8 AWG, complying with ASTM B 3 and ASTM B 8.
2. Insulation: High-molecular-weight polyethylene, complying with NEMA WC 70/ICEA S-95-658.
3. Minimum Average Thickness of Insulation: 110 mils for Nos. 8 through 2 AWG, and 125 mils for Nos. 1 through 4/0 AWG; rated at 600 V.
4. Connectors: exothermic welds.

B. Conductors and Cables: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Bonding Conductors for Joint and Continuity Bonds: Not less than No. 8 AWG, stranded, Type THWN copper conductors.
2. Flexible Pipe Coupling Bonds: Flexible copper straps with electrical resistance equal to No. 1/0 AWG stranded copper wire and with five holes for five exothermic welds to pipe.
3. Test Wires: No. 12 AWG, Type THWN copper conductors.
4. Resistance Wires: No. 16 or No. 22 AWG nickel-chromium wire.
5. Cables for Installation in Conduit: Type THWN copper conductors.

2.5 TEST STATIONS

A. Plastic Test Stations: Flush-mounted type, manufactured of high-impact-resistant PVC or polycarbonate with watertight conduit connections and cover and removable terminal board having at least five terminals.

B. Test Station Mounting Enclosures:

1. Non-Traffic-Area Boxes: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

2. Traffic-Area Boxes: Comply with requirements in Section 260543 "Underground Ducts and Raceways for Electrical Systems." Boxes shall have cast-iron covers with a welded bead legend "CP TEST."

2.6 SEALING, POTTING, AND DIELECTRIC COMPOUNDS

A. Sealing and Dielectric Insulating Compound: Comply with NACE RP0188. Black, rubber based, soft, permanently pliable, tacky, moldable, and unbacked; 0.5 inch thick.

B. Potting Compound: Comply with NACE RP0188. Cast-epoxy, two-package type; fabricated for this purpose and covered with heat-shrinkable tape.

C. Pressure-Sensitive, Vinyl-Plastic Electrical Tape: Comply with UL 510.

2.7 EXOTHERMIC WELDING MATERIALS

A. Exothermic Weld Kits: Specifically designed by manufacturer for welding materials and shapes required.

B. Exothermic Weld Caps: Dome of high-density polyethylene, 10-mil minimum thickness, filled with mastic and containing a tunnel portion to separate lead wire from exothermic weld.

2.8 COATING REPAIR MATERIALS

A. Touchup Coating Materials: Comply with requirements in Section 099600 "High-Performance Coatings" for coating systems for touchup of factory-applied coatings.

B. Adhesive-Applied Coating Materials: Coating materials shall be compatible with factory-applied coating system.

1. Nominal thickness of coating materials shall be not less than 60 mils, plus or minus 5 percent.
2. Coating materials shall be one of the following supplied by factory-applied coating system manufacturer:

    a. Polyvinyl-chloride, pressure-sensitive, adhesive tape.
    b. High-density polyethylene/bituminous rubber compound tape.
    c. Butyl rubber tape.
    d. Coal-tar epoxy.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with ANSI/IEEE C2 and NFPA 70.

B. Make connections to ferrous pipe using exothermic welding.

C. Coat welds with the coating repair material and apply an exothermic weld cap.

3.2 MAGNESIUM ANODE INSTALLATION

A. Install magnesium anodes at locations that clear obstructions. Install at least 36 inches and no more than 10 feet from pipe to be protected. Install in augered holes with top of anode a minimum of 36 inches below finished grade. In soils that will collapse into augered holes, use casing of galvanized sheet steel.

B. Install anodes in a dry condition after plastic or waterproof protective covering has been completely removed from water-permeable permanent container that houses anode metal. Do not use anode-connecting wire for lowering anode into hole. Backfill annular space around anode with fine earth in 6-inch layers; compact each layer using hand tools. Do not strike anode or connecting wire during backfilling and compacting. After backfilling and compacting to within 6 inches of finished grade, pour approximately 5 gal. of water into each filled hole. After water has been absorbed by earth, complete backfilling to finished level.

C. If rock strata are encountered before achieving specified augured hole depth, install anodes horizontally at depth at least as deep as bottom of pipe to be protected.

D. Install anodes spaced as indicated, connected through a test station to the pipeline, allowing slack in connecting wire to compensate for movement during backfill operation.

E. For tank protection, connect groups of anodes to collector cable. Make contact, through a test station, with tank to be protected.

F. Do not use resistance wires to reduce current output of individual or group anodes.

3.3 INSTALLATION OF REFERENCE ELECTRODES

A. Install directly beneath the buried metallic component being protected.

3.4 CABLE AND WIRE INSTALLATION

A. Install conductors, except anode wires, in PVC conduit with waterproof PVC junction boxes. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for conduit and its installation.

B. Anode Wire Installation: Cover trench bottom for the anode wire with 3-inch layer of sand or stone-free earth. Center wire on backfill layer and do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 6 inches deep, and compact each layer. Use clean fill, free from roots, vegetable matter, and refuse. Place cable underground-line warning tape within 18 inches of finished grade, above cable and conduit.

C. Bonding Conductors: Install conductors on metallic pipe and tanks, to and across buried flexible couplings, mechanical joints, and flanged joints except at places where insulating joints are specified. Welded and threaded joints are considered electrically continuous and do not require bonding.

1. Install at least two bonds between parts requiring bonding.
2. Bonding conductors must contain sufficient slack for anticipated movement between structures. Bonding conductors across pipe joints shall have not less than a 4-inch slack for pipe expansion, contraction, and soil stress.
3. Connect bonding conductors to pipe, coupling follower rings and coupling middle ring or sleeve. Connect bonding conductors with exothermic welds.

D. For wire splicing, use compression connectors or exothermic welds.

3.5 TEST STATIONS

A. Install test stations as follows:

1. At 1000-foot intervals.
2. At insulating joints.
3. At both ends of casings when casing material is included in the cathodic protection system.
4. Where pipe crosses other metal pipes.
5. Where pipe connects to existing piping system.
6. Where pipe connects to dissimilar metal pipe.
7. At each tank component.

B. Install test stations on backfill complying with requirements for trench bottom fill for anode wires unless otherwise indicated.

C. Terminate test conductors on terminal boards and install a spare set of test leads at each testing location.

3.6 PIPE JOINTS

A. Insulating Flange Sets: Cover flanges with sealing and dielectric compound.

B. Insulating Unions: Install electrical isolation at each building entrance and at other locations indicated on approved Delegated-Design Drawings. Cover unions with sealing and dielectric compound.

3.7 INSULATING PIPE SLEEVES

A. Install insulating sleeves between metallic piping and metal buildings, hangers, supports, and other metal structures. Completely surround the metallic pipe for the full length of the steel contact and effectively prevent contact between the cathodically protected metallic pipe and other metallic structures. Support insulating sleeve to prevent damage to coating and to accommodate relative movement, vibrations, and temperature differentials.

3.8 DISSIMILAR METALS

A. Underground Dissimilar Piping: Coat insulating joint and pipe at joints of dissimilar piping material with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of joint.

B. Underground Dissimilar Valves: Coat dissimilar ferrous valves and pipe with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of valve.

C. Aboveground Dissimilar Pipe and Valves: If dissimilar metal pipe joints and valves are not buried and are exposed only to atmosphere, coat connection or valve, including pipe, with sealing and dielectric compound for a minimum distance of three pipe diameters on both sides of junction.

3.9 COATINGS

A. Field Joints: Apply adhesive-applied coating system in a thickness to achieve corrosion protection equal to adjacent factory-applied coating.

3.10 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify anode wires and anode header cables with marker tape.
2. Identify underground wires and cables with underground-line warning tape.
3. Identify text boxes with engraved, laminated acrylic or melamine label, permanently attached to text box.

3.11 FIELD QUALITY CONTROL

A. Comply with NACE RP0169 and NACE RP0285.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.

D. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:

1. Static Pull Test: Choose, at random, one completed anode of each type for this destructive test. Demonstrate that anode wire connections have enough strength to withstand a minimum tensile load of 300 lb. If test fails, replace all anodes and repeat test at another randomly selected anode.
2. Insulation Testing: Before anode system is connected to pipe, test insulation at each insulating joint and fitting. Demonstrate that no metallic contact, or short circuit, exists between the two insulated sections of pipe. Replace defective joints or fittings.
3. Bonding Tests: Test for electrical continuity across all bonded joints. Repair or add additional bonds until electrical continuity is achieved.
4. Baseline Potentials: After backfilling of pipe and anodes is completed, but before anodes are connected to pipe, measure the static potential of pipe to soil. Record initial measurements.
5. Anode Output: Measure electrical current as anodes or groups of anodes are connected to pipe. Use a low-resistance ammeter. Record current, date, time, and location of each measurement.
6. Pipe-to-Reference Electrode Potential Measurements: On completion of installation of entire cathodic protection system, make electrode potential measurements according to NACE RP0169, using a copper/copper-sulfate reference electrode and a potentiometer-voltmeter, or a dc voltmeter with an internal resistance (sensitivity) of not less than 100,000 ohms per volt and a full scale of 1 or 2 V. Make measurements at same locations as those used for baseline potentials. Record voltage, date, time, and location of each measurement, using one of the following two methods:

a. 0.85 V Negative Voltage: With cathodic system in operation, measure a negative voltage of at least minus 0.85 V between pipe and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe.
b. 100-mV Polarization Voltage: Determine polarization voltage shift by interrupting protective current and measuring polarization decay. An immediate voltage shift will occur if protective current is interrupted. Use voltage reading, after immediate shift, as base reading from which to measure polarization decay. Measure at least a minimum polarization voltage shift of 100 mV between pipe and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe.

F. Location of Measurements for Piping: For coated piping or conduit, measure from reference electrode in contact with the earth directly over pipe. Measure at intervals not exceeding 400 feet. Make additional measurements at each distribution service riser, with reference electrode placed directly over service line.

G. Location of Measurements for Tanks: For underground tanks, measure from reference electrode located as follows:

1. Directly over center of tank.
2. At a point directly over tank and midway between each pair of anodes.
3. At each end of tank.

H. Interference Testing: Test interference with cathodic protection from any foreign pipes and tanks in cooperation with Owner of foreign pipes and tanks. Report results and recommendations.

I. Stray Current Measurements: Perform at each test station. Mitigate stray currents due to lightning or overhead ac power transmission lines as provided for in NACE standards.

J. Inspect coatings; comply with NACE RP0188. Repair imperfections of factory-applied coatings as specified in "Coatings" Article.

1. Use electronic holiday detectors to detect coating imperfections.
2. All damage to the protective coating during transit and handling shall be repaired before installation.
3. Repair factory-applied coatings to have equal or better corrosion resistance than the factory-applied coating system. Field-repair material shall be of the type approved by, and shall be applied as recommended by, manufacturer of the coating material.

3.12 ADJUSTING

A. Adjust cathodic current using resistors as recommended by corrosion engineer who prepared the Delegated-Design Submittal in Part 1.

B. During the first year after Substantial Completion, test, inspect, and adjust cathodic protection system every three months to ensure its continued compliance with specified requirements.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cathodic protection system.

END OF SECTION 13 47 13