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GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM

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GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASTM INTERNATIONAL (ASTM)

ASTM A194/A194M	(2022) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B843	(2018) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)

ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0177	(2019) Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE SP0188	(1999; R 2006) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE SP21424	(2018) Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation and Monitoring

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-2704	(2004) Engineering and Design -- Cathodic Protection Systems for Civil Works Structures

UNDERWRITERS LABORATORIES (UL)

UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

A PDF or similar file of 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 water-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. Include in the detail drawings all details required to demonstrate that the system has been coordinated and will function properly, as specified and shown. Include in the detail drawings complete wiring and schematic diagrams to illustrate the test coupon scheme and any other details required to demonstrate that the system has been coordinated and will function properly as a unit.

Isolation flange kits

Anode junction boxes, bonding boxes, and test stations

Joint bonds

Contractor's Modifications; G

A PDF or similar file of detail drawings showing proposed changes in location, scope of performance indicating any variations from, additions to, or clarifications of contract drawings. Show proposed changes in anode arrangement, anode size and number, anode materials and layout details, mounting details, and any other pertinent information to proper installation and performance of the system.

SD-03 Product Data

Equipment; G

An itemized list of equipment and materials (in PDF or similar file)including item number, quantity, and manufacturer of each item. The list must be accompanied by a description of procedures for each type of testing and adjustments. Installation of materials and equipment must not commence until this submittal is approved.

~~Qualifications~~

~~Equipment; G~~

Anodes; G

Anode junction boxes, bonding boxes, and test stations

Dielectric unions

~~Wires~~

~~Cable and wire~~

Casings, isolation, and seals

Shunts

Permanent reference electrodes; G

Spare Parts

Spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than six months prior to the date of beneficial occupancy. The data must include a complete list of parts, special tools, and supplies, with current unit prices and source of supply. Two spare anodes of each type must be furnished.

SD-06 Test Reports

Tests and Measurements; G

Test reports in a PDF format tabulating all field tests and measurements performed, upon completion and testing of the installed system and including close interval potential survey, interference tests, and final system test verifying protection.

Contractor's Modifications; G

Final report regarding Contractor's modifications. The report, in PDF format must include structure-to-electrolyte measurements throughout the affected area, indicating that the modifications improved the overall conditions. The following special materials and information are required: installation and testing procedures, and equipment; coating material; system design calculations for anode number, life, and parameters to achieve protective potential; bonding and waterproofing details; exothermic weld equipment and material.

SD-07 Certificates

Cathodic Protection System; G

Proof that the materials and equipment furnished under this section conform to the specified requirements contained in the referenced standards or publications. The label or listing by the specified agency will be acceptable evidence of such compliance.

"Corrosion Expert" Qualifications; G

Evidence of qualifications for a "corrosion expert."

a. The Corrosion Expert's name and qualifications must be certified in writing to the Contracting Officer's representative prior to the start of construction.

b. Certification must be submitted giving the name of the firm, the number of years of experience, and a list of not less than five (5) of the firm's installations three (3) or more years old that have been tested and found satisfactory.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual; G

Cathodic Protection System; G

Training Course; G

Cathodic Protection System, Data Package 5; G

SD-11, Closeout Submittals

Initial Cathodic Protection System Field Testing; G

1.3 MAINTENANCE MATERIAL SUBMITTALS

1.3.1 Spare Parts

After approval of shop drawings, furnish spare parts data for each different item of material and ~~equipment~~equipment specified. The data must include a complete list of parts, special tools, and supplies, with current unit prices and source of supply.

After approval of ~~shop~~as-built drawings, furnish revised spare parts for any changes made from original submittal. One spare anode of each type must be furnished. In addition, supply information for material and equipment replacement for all other components of the complete system, including anodes, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. Furnish one reference electrode on a hand reel with ~350 feet of conductor and one digital voltmeter that can be used in the maintenance of this CP system. Demonstrate use of furnished equipment in actual tests during the training course. Provide a description of equipment of the pipe-to-soil protected structure and foreign structures at electrical isolation between the utility supplier and the facility piping.

1.4 QUALITY CONTROL

1.4.1 Drawings

Detailed drawings must be provided showing location of anodes, test coupons, coupon test stations, permanent reference cells, and bonding. Locations must be referenced to two permanent facilities or mark points.

1.4.2 Regulatory Requirements

Obtain the services of a corrosion expert to design, supervise, inspect, and test the installation and performance of the cathodic protection system. The term "corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic structures.

1.4.3 "Corrosion Expert" Qualifications

The corrosion expert must be accredited or certified by NACE International, as a CP-4 CP Specialist or be a NACE International certified Corrosion Specialist or a registered professional engineer who has certification or licensing that includes education and experience in CP of the type of CP system being installed. The corrosion expert must have not less than five years of experience in the type of CP for buried or submerged metallic structures under this contract. Submit evidence of qualifications of the corrosion expert including their name and qualifications certified in writing to the Contracting Officer or the Contracting Officer's Representative. Certification must be submitted

giving the name of the firm, the number of years of experience, and a list of not less than five of the firm's installations, three or more years old, that have been tested and found satisfactory.

1.4.4 Services of "Corrosion Expert"

~~The "corrosion expert" must make a minimum of three visits to the project site. The first of these visits will include obtaining soil resistivity data, acknowledging the type of pipeline coatings to be used and reporting to the contractor the type of CP required (GACP or ICCP). Once the submittals are approved and the materials delivered, the "corrosion expert" will revisit the site to verify the materials meet submittal requirements, ensure the contractor understands installation practices and that the contractor is capable and qualified to complete the installation.~~

~~The "corrosion expert" will be available (but not necessarily be onsite the entire time) during the installation of the CP system to answer questions, approve any changes or additions required during construction, or to provide recommendations as required. The third visit is to complete the training and demonstrations to applicable personnel on proper testing and maintenance techniques and to complete testing the installed CP systems to ensure it has been installed properly and meets adequate CP criteria. An additional visit is required if the One-Year-Warranty-Period-Testing is required.~~a. The Contractor must obtain the services of a "corrosion expert" to supervise, coordinate, inspect, and test the installation and performance of the cathodic protection system. "Corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of submerged metallic surfaces. Such a person must be certified by NACE International as a NACE certified Corrosion Specialist or a NACE certified Cathodic Protection (CP) Specialist or be a registered professional corrosion engineer who has certification or licensing that includes education and experience in corrosion control of piping systems with 5 years experience in corrosion control on metallic surfaces of this type under this contract.

b. The "corrosion expert" must closely coordinate their work and the work of their installers with the coating contractors and other contractors doing work. During the fabrication phase, the "corrosion expert" must also ensure that all mounting bolt or stud threads are properly taped and/or otherwise covered prior to painting (in order to insure future good electrical connections). Consequently, the "corrosion expert" must visit the project site where the pipe work is being accomplished in order to assure that the cathodic protection work is properly coordinated and installed. The "corrosion expert" must coordinate with the contractor(s) as often as necessary to ensure all cathodic protection requirements are met. The "corrosion expert" must visit the project site or pipe work site to coordinate, plan, and assure that cathodic protection anode mounting stud or bolt installers and fabrication contractors understand the work necessary to be accomplished during this phase. The "corrosion expert" must assure that the anode stud or bolt installers fully understand where the components are to be welded to the pipe and that they understand the correct procedures to follow. The personnel conducting this work must have at least one anode of each type to be installed at the project fabrication work site in order to assure that the anodes will

correctly fit onto the equipment at each required location.

c. The "corrosion expert" must provide inspection, guidance, and direction to the contractor's cathodic protection system installation personnel as required to ensure proper completion of the installation. All components, equipment, and supplies required to complete the installation must be provided by the contractor. The "corrosion expert" must make as many visits to the project site as are necessary to properly accomplish the cathodic protection system installation. The first of these visits must occur prior to the beginning of work on the facility water supply piping. This visit must include obtaining water resistivity data, and gathering any other information necessary from the site in order to properly coordinate with the contractor and plan the installation of the cathodic protection system. This visit must take place prior to the beginning of any fabrication work and, as stated above. During this visit the "corrosion expert" must acknowledge the type of structure coatings to be used and coordinate the coating system with the cathodic protection system installation, and report to the Contractor any problem areas encountered. The cathodic protection system specified in these specifications and shown on the Contract Drawings is based on the use of a well bonded, dielectric coating system; consequently, if any other coating system is planned to be utilized, which is not compatible with this cathodic protection installation, then the "corrosion expert" must notify the government immediately. If a conductive coating system, or other coating system that is not compatible with cathodic protection, is selected or specified for application, then the Government has the option to withdraw these cathodic protection requirements from the contract and the Contractor will credit the Government for the work not yet accomplished. Also, during this visit, or a prior visit, the "corrosion expert" must perform a close interval "native" potential survey on the submerged portions of the piping, as specified in this section; "native" readings must be taken at all locations as that specified herein for ON potential measurements.

d. After the submittals are approved and the materials delivered; and after the "corrosion expert" has already visited the site in order to coordinate, plan, and supervise, as necessary, all anode mounting bolt or stud layout and installation work; and after all pipe coating work is completed; the "corrosion expert" must visit the project site to inspect all cathodic protection anode mounting locations, as well as perform an inspection of the pipe coating integrity to assure that the CP systems are installed properly and that the coatings are applied properly in order to correlate with the CP systems to form a complete and operable corrosion control system. During this visit the "corrosion expert" must ensure the contractor understands best installation practices and laying out the components. The "corrosion expert" must also explain and assure the anode installer understands the amount and locations of plastisol required to be removed from each type of anode. Assuring that the installers understand best installation practices, the laying out of the components must be explained during both the pipe fabrication work visit(s) and at the visits to the project site after the piping has been fabricated in order to properly plan and complete the cathodic protection installation.

e. Another visit (or visits) to the project site must take place prior to piping being buried. During this time, the corrosion expert must

verify that all anodes are properly installed and all plastisol has been properly removed. The "corrosion expert" must also ensure that all anodes make good electrical contact with the structure and that all remaining exposed mounting straps, bolts, nuts are coated in accordance with these specifications and the drawings.

f. An additional visit (or visits) must involve the final acceptance testing of the cathodic protection systems. The "corrosion expert" must supervise installation, activation, and testing of all site cathodic protection.

1.5 DELIVERY, STORAGE AND HANDLING

Storage area for corrosion materials will be designated by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. If materials are not stored in a building, tarps or similar protection must be used to protect material from inclement weather. Resack and add backfill to packaged anodes that are damaged as a result of improper handling or exposure to rain.

1.6 WARRANTY

Provide equipment items that are supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

a. The Contractor must furnish and install a complete, operating, sacrificial anode cathodic protection system in complete compliance with NFPA 70, in compliance with the Contract Drawings, in accordance with the recommendations of the manufacturer, in accordance with standard construction practice, and as approved by the Contracting Officer's representative to conform with the minimum requirements of this contract. The services required include planning, installation, adjusting and testing of a cathodic protection system, using sacrificial anodes for cathodic protection of the submerged metallic surfaces of the normally buried portions of the facility water supply piping, or as shown on the drawings. The cathodic protection system must include anodes, studs (or bolts used as studs), nuts, and any other equipment as shown on the drawings and/or as described in these specifications, and as required for a complete operating system providing the NACE criteria of protection as specified. The drawings indicate the extent and arrangement of the anodes. Anodes must be delivered to the location designated by the Contracting Officer's representative and stored at location as specified herein. The Contractor must assure that their Corrosion Expert, as described below, fully coordinates all their work in order to assure that all cathodic protection work required during pipe fabrication work, and before pipe painting, is accomplished.

b. All phases of pipe fabrication, including decisions on when to install the various cathodic protection components, must be fully coordinated with the "corrosion expert" required herein.

2.1.1 Corrosion Control System Design

~~The~~A corrosion expert must design a complete and operational sacrificial anode cathodic protection system for underground metallic pipes and pipeline components, in accordance with EM 1110-2-2704, NACE SP0169, and NFPA 70, and as specified herein. The design must include the number, location, and arrangement of the anodes, permanent reference electrodes, test stations, and junction boxes, wiring diagram, details of electrical bonding and isolation, and any other pertinent information to ensure proper installation and performance of the system. Include system commissioning and testing plans. The design must be approved by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

~~2.1.1.1 Contractor's Modifications~~

~~The specified system is based on a corrosion protection system with magnesium sacrificial anodes. The Contractor may modify the cathodic protection system after review of the project, site verification, and analysis, if the proposed modifications include the anodes specified and will provide better overall system performance. The modifications must be designed and approved by the corrosion expert. Submit a detailed description and drawings of the proposed changes in scope of performance indicating any variations from, additions to, or clarifications of the design. The modifications must be approved by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.~~

2.1.1.1 Contractor's Modifications

The specified system is based on a complete system with magnesium sacrificial anodes. The Contractor may modify the cathodic protection system after review of the project, site verification, and analysis, if the proposed modifications include the anodes specified and will provide better overall system performance. The modifications must be fully described, be approved by the Contracting Officer's representative, and must meet the following criteria. With cathodic protection applied, the proposed system must achieve a minimum structure-to-electrolyte potential of minus 850 millivolts with reference to a saturated copper-copper sulfate reference cell contacting the electrolyte. Voltage drops other than those across the structure-to-electrolyte boundary must be considered for valid interpretation of these voltage measurements as described in NACE SP0169. Placement of the reference electrode in close proximity to the structure must not be considered in this contract as adequate for elimination of voltage drops other than those across the structure-to-electrolyte boundary since the electrode would have to be close to a coating holiday (the structure is coated). The Contractor must take resistivity measurements of the water in the vicinity of the buried pipe surface. The cathodic protection system must produce sufficient current and voltage in order to produce a minimum of minus 850 millivolts potential (considering IR drop) between the structure being tested and the reference cell. This potential must be obtained over 95 percent of the submerged metallic area. The anode system must be designed for a life of twenty-five (25) years of continuous operation.

2.1.2 Design Requirements

2.1.2.1 Electrical Isolators

Isolators are required to isolate the pipes —from any other structure. Provide isolators at all locations where the pipes contact any other metallic structure. Provide locations and detailed drawings of required installations. Include any requirements for lightning protection, test stations, surge protection, or other requirements and include locations and details in design drawings.

~~2.1.2.2 Anode and Bond Wires~~

~~Provide magnesium anodes with an unpackaged weight of 20 pounds at uniform distances along the metallic pipelines. Provide the number of anodes required to achieve minus 850 millivolts "instant off" potential on the metallic pipeline surface and at the same time not provide ovrevoltage above 1200 millivolts "instant off." Route the anodes through test stations. Provide these anodes in addition to anodes for the pipe under concrete slab and casing requirements. For each cathodic system, provide metallic components and structures that are electrically continuous by installing bond wires between the various structures. Bonding of existing buried structures may also be required to preclude detrimental stray current effects and safety hazards. Return stray current to its source without damaging structures intercepting the stray current. Provide electrical isolation of underground facilities in accordance with acceptable industry practice. All tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.~~

2.1.2.2 Anode and Bond Wires

The total number of anodes, of each type specified and indicated, must be provided and installed on the described piping as described in these specifications. Anodes of the type indicated must be located where shown on the drawings. For each cathodic protection system, the metallic components and structure surfaces to be protected must be made electrically continuous. This will be accomplished by installing bond wires between the various structure surfaces as, and if necessary. Bonding of existing submerged structures may be required to preclude detrimental stray current effects and safety hazards. Provisions must be included to return stray current to its source without damaging structures intercepting the stray current. The electrical isolation of submerged facilities in accordance with acceptable industry practice must be included under this section. All tests must be witnessed by the Contracting Officer's representative.

~~2.1.2.3 Surge Protection~~

~~Install approved sealed weatherproof lightning and surge arrestor devices across isolation flanges or fittings installed in underground piping. Provide gapless, self-healing, solid state type arrestor. Provide number 4 AWG copper lead wires with High Molecular Weight Polyethylene (HMWPE) insulation. Lightning arrestors are not required for isolation flanges on metallic components used on non-metallic piping systems.~~

2.1.2.3 Non-metallic Pipe System

In the event pipe other than metallic pipe is approved and used in lieu of

metallic pipe, protect ~~all~~ metallic components of this pipe system per expert recommendations and standard practice~~with CP~~. Submit detailed drawings of CP for each component to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager for approval within 45 days after date of receipt of notice to proceed, and before commencement of any work.

2.1.2.4 Coatings

Provide coatings for metallic components as required for metallic fittings. Complete and test protective coating on each metallic component (such as valves, hydrants and fittings). Provide coating as required for underground metallic pipe. Each test must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Select, apply, and inspect coatings as specified in these specifications. The use of non-metallic pipe does not change other requirements of the specifications. Submit any deviations due to the use of non-metallic pipe for approval.

~~2.1.2.5 Tracer Wire~~

~~When a non-metallic pipeline is used to extend or add to an existing metallic line, exothermic-weld No. 8 AWG copper wire with THHN insulation to the existing metallic line and run the length of the new non-metallic line. Use this wire as a locator tracer wire and to maintain continuity to any future extensions of the pipeline.~~

~~2.1.2.6 Drawings~~

~~Submit detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, contractor's modifications, results of system design calculations including soil-resistivity, installation instructions and certified test data showing location of anodes and stating the maximum recommended anode current output density. Include in the detail drawings complete wiring and schematic diagrams, isolation fittings, test stations, permanent reference electrodes and bonding and any other details required to demonstrate that the system has been coordinated and will function properly as a unit. Reference locations to two permanent facilities or mark points. Provide one electronic digital copy and digital photos of the completed installation.~~

~~2.1.2.7 Summary of Services Required~~

~~Include the following scope of services:~~

~~a. Close-interval potential surveys,~~

~~b. CP Installation System,~~

~~c. System testing,~~

~~d. Casing corrosion control,~~

~~e. Interference testing,~~

~~f. Training,~~

~~g. Operating and maintenance manual,~~

~~h. Isolation testing and bonding testing.~~

2.1.2.5 Summary of Services Required

The scope of services must include, but is not limited to, the following:

a. Close-interval potential surveys (grid as described)

b. Cathodic Protection Systems' planning,installation, drawings, etc.

c. System testing

d. Interference testing

e. Preparation and provision of all reports/documentation

2.1.2.6 Tests of Components

Perform a minimum of four tests at each metallic component in the piping system. Two measurements must be made directly over the anodes and the other two tests must be over the outer edge of the component, but at the farthest point from the anodes. Provide a field drawing showing the component, the structure, all components of the CP system and their relationship to each other. Also provide a narrative describing how the CP system will work and the testing at each component. Components requiring CP must include but not be limited to the following:

a. Pipes beneath the floor slab or foundations.

~~c~~ b. Shutoff valves.

~~d~~c. Metallic pipes extended from aboveground locations.

~~e~~d. Connectors or change-of-direction devices.

~~f~~e. Metallic pipe components or sections.

~~g~~f. Backflow preventers.

~~i~~h. Casings.

~~2.1.2.7 Electrical Potential Measurements~~

~~Make all potential tests at a minimum of 10 foot intervals witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Provide submittals identifying test locations on separate drawings, showing all metal to be protected and all CP equipment. Distinguish and identify test points, equipment, and protected metal.~~

2.1.2.7 Electrical Potential Measurements

For all surfaces that are submerged or buried during testing, all potential tests must be made at a minimum grid of 5 foot horizontal

intervals across and 3 foot vertical intervals. These measurements must be witnessed by the Contracting Officer's representative. Submittals must identify test locations on separate drawing, showing all metal to be protected and all cathodic protection equipment. Test points, equipment, and protected metal must be easily distinguished and identified.

2.1.2.8 Typical Metallic Components on Non-metallic Systems

2.1.2.8.1 Metallic Components

Provide the number of anodes required to achieve minus 850 millivolts "instant off" potential on the metallic area and at the same time not provide overvoltage above 1200 millivolts "instant off." As a minimum, the galvanic anode unpackaged weight must be 20 pounds. Locate the galvanic anodes on each side of the metallic component and route through a test station.

~~2.1.2.8.2 Fire Hydrants~~

~~Provide fire hydrant pipe components with a minimum of two anodes. These galvanic anodes must have an unpackaged weight of20 pounds.~~

2.1.2.8.2 Pipe Beneath Concrete Slab

Pipe beneath concrete slab must have a minimum of 2 galvanic anodes. These galvanic anodes must have an unpackaged weight of 20 pounds. Pipe beneath concrete slab must have 2 permanent reference electrodes located beneath the slab. Locate one permanent reference electrode where the pipe enters the concrete slab. Route all conductors to a test station.

2.1.2.8.3 Valves

Protect each valve with a minimum of 2 galvanic anodes. The galvanic anode must have an unpackaged weight of 20 pounds.

2.1.2.8.4 Metallic Pipe Component or Section

Protect each section of metallic pipe with a minimum of 2 galvanic anodes. The galvanic anodes must have an unpackaged weight of 20 pounds.

2.1.2.8.5 Connectors or Change-of-Direction Devices

Protect each change-of-direction device with a minimum of 2 galvanic anodes. The galvanic anode must have an unpackaged weight of 20 pounds.

2.1.2.9 Metallic Component Coating

Coatings for metallic components will be required for metallic fittings as indicated. These metallic fittings will include fire hydrants, tees, elbows, and valves. Coatings must be selected, applied, and inspected as specified in the coating specifications referenced and be compatible with the structure being protected. All coatings must be in accordance with all applicable Federal, State, and local regulations. Unbonded coatings must not be used with CP.

2.1.2.10 Location of Test Stations

Provide test stations of the type and location shown and post mount. Provide buried isolation joints with test wire connections brought to a

test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations as follows:

a. At 1,000-foot intervals or less.

b. Where the pipe or conduit crosses any other metal pipe.

c. At both ends of casings under roadways and railways.

d. Where both sides of an isolation joint are not accessible above ground for testing purposes.

2.1.2.11 Electrical Isolation of Structures

a. As a minimum, provide isolating flanges or unions at the following locations:

(1) Connection of new metallic piping or components to existing piping.

(2) Pressure piping beneath floor slab to a building.

b. Provide isolation at metallic connection of all lines to existing system and where connecting to a building. Additionally, provide isolation between foreign pipes that cross the new lines within 10 feet. Install isolation fittings, including isolating flanges and couplings, aboveground or in a concrete pit.

2.1.2.11.1 Isolation Joint Testing

An isolator checker or insulation tester will be used for isolation or insulating joint (flange or dielectric) electrical testing.

2.1.2.11.2 Underground Structure Coating

This coating specification takes precedence over any other project specification and drawing notes, whether stated or implied, and also applies to the pipe supplier. Variance in coating quality is not allowed by the contractor or Base Construction Representative without the written consent of the designer. All underground metallic pipes to be cathodically protected must have a high quality factory-applied coating. This includes all carbon steel, cast-iron and ductile-iron pipes. Select, apply, and inspect coatings as specified. If non-metallic pipes are installed, coat all metallic fittings on pipe sections in accordance with this specification section.

2.1.2.11.3 Field Joints

Coat all field joints with materials compatible with the pipeline coating compound. Apply the joint coating material to an equal thickness as the pipeline coating. Do not use unbonded coatings for these buried metallic components. This includes the elimination of all unbonded polymer wraps or tubes. Once the pipeline or vessel is set in the trench, conduct an inspection of the coating. This inspection must include electrical holiday detection. Repair any damaged areas of the coating. The Contracting Officer or the Contracting Officer's Representative, Technical Expert or Project Manager must be asked to witness inspection of the

coating and testing using a holiday detector.

2.1.2.11.4 Inspection of Pipe Coatings

Any damage to the protective coating during transit and handling must be repaired before installation. After field coating has been applied, inspect the entire pipe using an electric holiday detector in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector must be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Upon detection, immediately repair all holidays in the protective coating. Occasional checks of holiday detector, operation will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Provide all labor, materials, and equipment necessary for conducting the inspection.

~~2.1.2.11.5 Protective Coating for Aboveground Piping System~~

~~Provide finish painting conforming to the applicable paragraph of Section 09 90 00.00 28 PAINTS AND COATINGS and as follows:~~

2.1.2.11.5 Ferrous Surfaces

Touch-up shop-primed surfaces with ferrous metal primer. Solvent-clean surfaces that have not been shop-primed. Surfaces that contain loose rust, loose mill scale, and other foreign substances must be mechanically-cleaned by power wire-brushing and primed with ferrous metal primer. Finish primed surface with two coats of exterior oil paint and vinyl paint.

2.1.3 Performance Requirements

The design must allow for synchronized interruption of all applied current.

2.1.3.1 Criteria of Cathodic Protection

The design must allow for synchronized interruption of all applied current. All galvanic anode leads, or header cables, must be connected to the protected structure through test stations or junction boxes and must never be connected directly to the protected structure.

a. Determination of the on and polarized (instant off) potentials must be made with the protective current applied to the pipeline for a minimum of 4 days. Polarized potentials may be determined using a coupon test station (Error-Free (IR Free) test station). Polarized potentials must be determined by interrupting all the current being applied to the structure or coupon.

b. The potential measurements for the native measurement and the polarized potential must be made with the reference electrode at the same exact location. The polarization decay measurements must also be made with the reference electrode at the same exact location as the polarization potential.

c. The polarization decay measurements will be the difference between the polarized potential and a voltage measurement made 48 hours after the interruption of protective current.

2.1.3.1.1 Steel

A negative polarized potential of 0.85 volts (850 millivolts) or more negative. The voltage must not be more negative than a negative polarized potential of 1.200 volts (1200 millivolts).

2.2 EQUIPMENT

2.2.1 Corrosion Rate Monitoring

Corrosion probes must be designed, manufactured and procured specifically for the application and matched to the structure being protected. Manufacturer must match or be compatible with previously installed rate monitoring equipment in use at the installation.

~~2.2.2 Solid State Decoupler (SSD)~~

~~SSDs must be designed, manufactured, and procured specifically for the application and must exceed the modeled AC steady-state current and fault conditions. SSDs must be installed with a protective ground-based enclosure to secure the cable connections and prevent electrical hazards.~~

~~Characteristic~~	~~SSD~~
~~AC steady-state current, rms~~	~~45A~~
~~AC fault current, rms. at 0.5s~~	~~1.2 to 5 kA~~
~~Lightning current, 8x20micros, peak~~	~~75-100 kA~~
~~Hazardous location certification~~	~~Division 2, Zone 2~~
~~Rain Proof, IP66~~	~~Yes~~
~~Submersible, IP68 or NEMA 6P~~	~~Yes~~

2.3 COMPONENTS

2.3.1 Test Stations

2.3.1.1 Post Top Mounted

NEMA ICS 6. Metallic or non-metallic with terminal board, a minimum of 6 terminal posts and lockable lid. A non-metallic enclosure must be high impact strength molded plastic. The unit must be of standard design, manufactured for use as a CP test station, complete with cover, terminal board, shunts, and brass or Type 304 or 316 stainless steel hardware. The terminal board must be removable for easy access to wires. The test station must be mounted atop 6 foot long polyethylene conduit with

anchor. Terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes).

2.3.2 Shunts for Test Stations and Junction Boxes

Provide 0.1 or 0.01 ohm, 2 or 8 ampere repectively as appropriate at each location, accuracy plus or
minus one percent, polycarbonate circuit board type, color coded for value recognition, red for 0.1 ohm shunt and yellow for 0.01 ohm shunt, with nickel-plated brass posts and standard 0.25 inch inch holes on 1 inch centers to fit test stations and terminal boards manganin wire type.

2.3.3 Junction Box Enclosures

NEMA ICS 6, Type 4X enclosure with Type 304 or 316 stainless steel hinges and latched cover and padlocked hasp. Enclosure must be of painted steel construction with terminal board. Knockout for conduit must be the size and location as per submitted drawings.

2.3.3.1 Nameplates

Provide nameplate in accordance with ASTM D709. Provide laminated plastic nameplates for each enclosure as specified or as indicated on the drawings. Each nameplate inscription must identify the function. Nameplates will be melamine plastic, 0.125 inch thick, white with black center core. Surface will be matte finish. Corners will be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 25 inch by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.3.4 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic 1/4 inch thick with dimensions as indicated. Insulated terminal boards must have the required number of terminals (one terminal required for each conductor). Install solderless copper lugs and copper buss bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections will be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, reference electrodes and coupons).

2.4 MATERIALS

2.4.1 Magnesium Anodes

At a minimum, the total number of bolted on magnesium slab anodes, as described herein and as shown on the drawings, must be provided. The anodes must be installed at the locations as shown on the drawings and/or as described in these specifications. Magnesium anodes must comply with all standards within ASTM B843.

2.4.1.1 Plastisol Coated Slab Anode Composition

Magnesium slab anodes must meet the H-1, Grade B, alloying standard. All slab anodes must have the manufacturer's supplied plastisol coating, which must be only removed in areas as described herein and/or as shown on the drawing details. All Magnesium slab type anodes as indicated on the

drawings must conform to ASTM B 843 and to the following analysis (in percents) unless otherwise indicated:

Aluminum	5.3-6.7%
Manganese	0.15-0.7%
Zinc	2.5-3.5%
Silicon, max.	0.30%
Copper, max.	0.05%
Nickel, max.	0.003%
Iron, max.	0.003%
Other impurities - total, max.	0.30%
Magnesium	Remainder

The Contractor must furnish spectrographic analysis on samples from each batch or heat of anodes used on this project.

2.4.1.2 Dimensions and Weights

The following dimensions and weights of anodes are not all inclusive and are presented as examples, various manufacturers may have additional sizes not included in the following table:

a. Bare anode weight: 20 pounds.

Typical Magnesium Anode Size (may be round, square, or D shaped)

Nominal Weight Bare		Approximate Size						Packaged Weight		Nominal Packaged Dimensions			
		Width		Height		Length				Diameter		Length	
kg	lbs	mm	inch	mm	inch	mm	inch	kg	lbs	mm	inch	mm	inch
	1		1.75		1.75		8		5		3.25		9
	3		3.5		3.75		5		8		6		10
	5		3.5		3.75		8.5		17		6		12
	9		2.75		3		27	15.9	35		5.5		32
	9		3.5		3.75		14		27		6		17
	17		2.75		2.75		50.25		60		6		55
	17		3.5		4		25.75		45		6.5		29
	20		2.75		3.75		59.75		70		5		66
	32		3.5		3,75		45.25		91		6.5		53
	32		5.5		5		20.5		70		8		28

Typical Magnesium Anode Size (may be round, square, or D shaped)													
Nominal Weight Bare		Approximate Size						Packaged Weight		Nominal Packaged Dimensions			
	40		3.5		3.75		59.75		96		6.5		66
	48		5.5		5.75		31		100		8		38
	60		4		4		60		125		7		64

2.4.1.3 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially-prepared quick-wetting backfill and contained in a water permeable cloth or paper sack. Anodes must be centered by means of spacers in the backfill material.

The backfill material will have the following composition, unless otherwise indicated:

Material	Approximate Percent by Weight
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

~~2.4.2 Galvanic Anodes~~

~~2.4.2.1 Magnesium Anodes~~

~~Install magnesium anodes on the pipe system. See Paragraph METALLIC COMPONENTS ON NON-METALLIC SYSTEMS AND TYPICALS for additional anodes under slab.~~

~~2.4.2.1.1 Anode Composition~~

~~Anodes must be of high-potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not made from scrap metal. Magnesium anodes must conform to ASTM B843 and to the following analysis (in percent) otherwise indicated:~~

~~Aluminum~~	~~0.010 percent~~
~~Manganese~~	~~0.50 to 1.30 percent max~~
~~Zinc~~	~~0.05 percent max~~
~~Silicon~~	~~0.05 percent max~~

Copper	0.02 percent max
Nickel	0.001 percent max
Iron	0.03 percent max
Other impurities	0.05 each or 0.3 percent max total
Magnesium	Remainder

2.4.2.1.2 Dimensions and Weights

The following dimensions and weights of anodes are not all inclusive and are presented as examples, various manufacturers may have additional sizes not included in the following table:

a. Bare anode weight: 20 pounds.

Typical Magnesium Anode Size (may be round, square, or D shaped)													
Nominal Weight Bare		Approximate Size						Packaged Weight		Nominal Packaged Dimensions			
kg	lbs	Width		Height		Length		kg	lbs	Diameter		Length	
		mm	inch	mm	inch	mm	inch			mm	inch	mm	inch
	1		1.75		1.75		8		5		3.25		9
	3		3.5		3.75		5		8		6		10
	5		3.5		3.75		8.5		17		6		12
	9		2.75		3		27	15.9	35		5.5		32
	9		3.5		3.75		14		27		6		17
	17		2.75		2.75		50.25		60		6		55
	17		3.5		4		25.75		45		6.5		29
	20		2.75		3.75		59.75		70		5		66
	32		3.5		3,75		45.25		91		6.5		53
	32		5.5		5		20.5		70		8		28
	40		3.5		3.75		59.75		96		6.5		66
	48		5.5		5.75		31		100		8		38
	60		4		4		60		125		7		64

2.4.2.1.3 Packaged Anodes

Provide anodes in packaged form with the anode surrounded by specially-prepared quick-wetting backfill and contained in a water

~~permeable cloth or paper sack. Anodes must be centered by means of spacers in the backfill material.~~

~~The backfill material will have the following composition, unless otherwise indicated:~~

~~Material~~	~~Approximate Percent by Weight~~
~~Gypsum~~	~~75~~
~~Bentonite~~	~~20~~
~~Sodium Sulfate~~	~~5~~
~~Total~~	~~100~~

2.4.2 Test Boxes and Junctions Boxes

If necessary, boxes must be outdoor type conforming to UL 514A.

2.4.3 Wire and Cable

2.4.3.1 Anode Lead Wire

Anode lead wires must be No. 12 AWG solid copper wire, not less than 10 feet long, without any splices, complying with NFPA 70, and must conform to the requirements of Section 26 05 19.10 25, INSULATED WIRE AND CABLE

~~2.4.3.2 Anode Lead Wire~~

~~Wire must be No. 12 AWG solid copper wire, not less than 10 feet long, without any splices, complying with NFPA 70, Type Thermoplastic Heat and Water-resistant Nylon-coated (THHN) Rubber Heat (resistant) Wire (RHW) RHW-USE insulation. Connecting wires for magnesium anodes will be factory installed with the place or emergence from the anode in a cavity-sealed flush with a dielectric sealing compound.~~

2.4.3.2 Anode Header Cable

Anode header cable must be No. 4 AWG stranded copper wire, without any splices, complying with NFPA 70, and must conform to the requirements of Section 26 05 19.10 25, INSULATED WIRE AND CABLE.

2.4.3.3 Structure (Negative) Cable

Structure (negative) cable must be No. 2 AWG stranded copper wire, without any splices, complying with NFPA 70, and must conform to the requirements of Section 26 05 19.10 25, INSULATED WIRE AND CABLE.

2.4.3.4 Test Wires

Test wires must be No. 12 AWG stranded copper wire, without any splices, complying with NFPA 70, and must conform to the requirements of Section 26 05 19.10 25, INSULATED WIRE AND CABLE

~~2.4.3.5 Anode Header Cable~~

~~Cable for anode header and distribution will be No. 4 AWG stranded copper wire with type CP HMWP, 7/64 inch thick insulation, 600-volt rating.~~

~~2.4.3.6 Structure (Negative) Cable~~

~~Structure connecting wire must be No. 2 AWG stranded copper wire with type CP high molecular weight insulation, 7/64 inch thick insulation, 600 volt rating. Copper conductors conforming to ASTM B3 and ASTM B8.~~

~~2.4.3.7 Test Wires~~

~~Test wires must be No. 12 AWG stranded copper wire with NFPA 70 Type Thermoplastic Wire (TW) or RHW or polyethylene insulation. Copper conductors conforming to ASTM B3 and ASTM B8.~~

2.4.3.5 Joint and Continuity Bonds

Bonds must be provided across any electrically discontinuous connections and all other structures with other than welded or threaded joints that are included in this cathodic protection system. Unless otherwise specified in the specifications, bonds between structures with other than welded or threaded joints must be No. 8 AWG stranded copper cable, with polyethylene insulation and conform to the specification soutlined in Section 26 05 19.10 25, INSULATED WIRE AND CABLE. Bonds between structures must contain sufficient slack for any anticipated movement between structures. Bonds must be attached by exothermic welding. Exothermic weld areas must be insulated with coating compound and approved, and witnessed by the Contracting Officer's representative. Continuity bonds must be installed as necessary to reduce stray current interference. Additional joint bonding must be accomplished by the Contractor where the necessity is discovered during fabrication work or testing or where the Contracting Officer's representative directs that such bonding be done. There must be a minimum of two continuity bonds between each structure and other than welded or threaded joints. The Contractor must test for electrical continuity across all metallic surfaces of the piping. The Contractor must provide bonding as required and as specified above until electrical continuity is achieved. Bonding test data must be submitted for approval.

~~2.4.3.6 Joint and Continuity Bond Cables~~

~~Provide bonds across joints or any electrically discontinuous connections in the piping, and other pipes and structures with other than welded or threaded joints included in this CP system. Unless otherwise specified, bonds between structures and across joints in pipe with other than welded or threaded joints must be with No. 4 AWG stranded copper cable with polyethylene insulation. Bonds between structures must contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints must contain a minimum of 4 inch of slack to allow for pipe movement and soil stress. Bonds must be attached by exothermic welding. Exothermic weld areas must be insulated with coating compound and approved by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Continuity bonds must be installed as necessary to reduce stray current interference. Additional joint bonding must be done where determined during construction or testing or as directed. Joint bonding must include excavation and backfilling. There must be a minimum of 2 continuity bonds between each structure and other than welded or threaded joints. Electrical continuity must be tested across joints with other than welded or threaded joints and across metallic portions of sewage lift stations and water booster stations. Copper conductors conforming to ASTM B3 and ASTM B8.~~

2.4.3.6 Resistance Bond Wires

Resistance bonds must be adjusted for minimum interference while achieving the criteria of protection. Alternate methods may be used when approved.

~~2.4.3.7 Polyethylene Insulation~~

~~Polyethylene insulation must comply with the requirements of ASTM D1248 and of the following types, classes, and grades:~~

2.4.3.7 Cable and Wiring Insulation

Cable and wiring insulation must conform to the requirements of Section 26 05 19.10 25, INSULATED WIRE AND CABLE.

2.4.4 ~~Cable and wire~~Cable and Wire Identification Tags

~~Stainless steel material with engraved letters. Print letters and numbers a minimum of 3/16 inch in height. Provide identifier legend .~~Provide cable and wiring identification tags in accordance with requirements within Sections 26 05 00.00 25, COMMON WORK RESULTS FOR ELECTRICAL and 26 05 19.10 25, INSULATED WIRE AND CABLE.

2.4.5 AC Mitigation Materials

If required, AC mitigation materials typically consist of a mitigation material either zinc ribbon or copper cable, interconnecting coated copper cables, solid state decouplers to control the AC current flow and test stations.

2.4.6 Backfill Material

The backfill material must have the following composition, unless otherwise indicated:

Material	**Approximate Percent by Weight**
Gypsum	75
Bentonite	20
Sodium Sulfate	5
Total	100

2.4.7 Permanent Reference Electrodes

Permanent reference electrodes must be copper/copper-sulfate specifically manufactured for underground use. Must never need recharging, maintenance, or recalibration. Must have impregnated membrane which keeps electrode electrolytes from drying out or getting the reference electrode electrolyte contaminated. Must have ion trap to prevent reference electrode damage from hydrogen sulfide or excess chloride ions. The electrode will be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer. Provide electrodes with No. 12 AWG, RHW-USE cable of sufficient length to extend to the test station or junction box without splicing. Reference electrodes will have a minimum

20-year life, stability of plus or minus 5 millivolts under 3 microamp load. The manufacturer must calibrate the PRE to 316 mV plus or minus 10mV referenced to a standard hydrogen electrode (SHE) and provide a calibration certificate detailing the results of the calibration. Procedures for evaluating the accuracy annually must be included in the Operation and Maintenance Manual.

2.4.8 Pavement Inserts

Pavement insert must be a non-metallic flush type test station without terminal board, and must allow a copper/copper sulfate reference electrode to contact the electrolyte beneath the pavement surface. Provide traffic valve box capable of withstanding H-20 traffic loads.

2.4.9 Coupons

Coupons must match the material of the structure, with 2 integrated connection(s) with electrical wire(s) and be designed, manufactured and procured for use as a corrosion coupon, IR-Free reference electrode, or AC reading electrode.

2.4.10 Isolation Flange Kits

Provide full-faced gaskets, isolating sleeves and washers, and steel washers. Provide isolation flange kits rated for operation at the rated pressure and temperature.

2.4.10.1 Gaskets

ASME B16.21. Neoprene faced phenolic or laminated phenolic material .

2.4.10.2 Isolating Washers and Sleeves

Two sets 1/8 inch laminated phenolic. Isolating washers must fit within the bolt facing on the flange over the outside of the fabric reinforced phenolic sleeve.

2.4.10.3 Washers

Steel, cadmium plated, to fit within the bolt facing on the flange.

2.4.11 Steel Flanges and Bolting

2.4.11.1 Steel Flanges

ASME B16.5, 150 lb..

2.4.11.2 Bolting

ASTM A307, Grade B for bolts; ASTM A194/A194M, Grade 2 for nuts. Dimensions: ASME B18.2.1 for bolts, ASME B18.2.2 for nuts. Threads: ASME B1.1, Class 2A fit for bolts, Class 2B fit for nuts. Bolts must extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.4.12 Dielectric Unions

ASME B16.39, Class 150 for dimensional, strength, and pressure requirements. Insulation barrier must limit galvanic current to one

percent of the short-circuit current in a corresponding metallic joint. Provide insulating material impervious to water.

2.4.13 Isolation and End Seals

2.4.13.1 Casing Isolator/Centralizer

High density (linear), injection molded virgin Polyethylene positive electrical isolation, high abrasion resistance and low coefficient of friction.

2.4.13.2 End Seals

Ethylene Propylene Diene Monomer (EPDM) Neoprene rubber end seals, thickness of 1/8 inch or more, with 2 Stainless Steel Pipe Clamps per end seal, 1/8 inch thick and 1/2 inch wide or more.

2.5 ACCESSORIES

2.5.1 Conduit

~~UL 6, rigid galvanized steel, Outlet boxes: UL 514A and fittings UL 514B, threaded hubs. Non-metallic conduit must conform to NEMA TC 2~~Conduit must conform to the requirements of Section 26 05 00.00 25, COMMON WORK RESULTS FOR ELECTRICAL.~~.~~

2.5.2 Joint, Patch, Seal, and Repair Coating

~~Sealing and dielectric compound must be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Compound will be applied as recommended by the manufacturer, but not less than 1/2-inch thick. Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to UL 510.~~Sealing and dielectric compound must be a black, rubber based compound that is soft, permanently pliable, tacky, moldable, and unbacked. Compound must be applied as recommended by the manufacturer, but not less than 1/2-inch thick. Coating compound must be cold-applied coal-tar base mastic.

~~2.5.3 Underground Splices~~

~~Provide splices with a compression connector on the conductors, and insulation and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.~~

~~2.5.3.1 Cast-Type Splice~~

~~Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.~~

~~2.5.3.2 Gravity-Poured Splice~~

~~Gravity-poured method must employ materials and equipment contained in and approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.~~

~~2.5.3.3 Heat Shrinkable Splice~~

~~Provide heavy wall heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which must be applied by a clean burning propane gas torch.~~

2.5.3 Electrical Isolation of Structures

2.5.3.1 Electrically Isolating Pipe Joints

Electrically isolating pipe joints will be of a type that is in regular factory production.

2.5.3.2 Electrically Isolating Couplings

Electrically isolating couplings will be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals will be of a type that is in regular factory production made for the purpose of electrically isolating the carrier pipe from the casing and preventing the incursion of water into the annular space.

~~2.5.4 Electrical Insulating Coating~~

~~Heat-shrinkable tape or conformable watertight sealant having dielectric strength not less than 15 kV for a 1/8 inch thick layer.~~

~~2.5.5 Buried Cable Warning and Identification Tape~~

~~Polyethylene tape, manufactured for warning and identification of buried cable and conduit. Tape must be 3 inches wide, Yellow in color and read "Caution Buried Cable Below" or similar. Color and lettering must be permanent and unaffected by moisture or other substances in backfill materials.~~

2.5.4 Electrical Connections

Electrical connections must be as shown on Contract Drawings or in accordance with Sections 26 05 00.00 25, COMMON WORK RESULTS FOR ELECTRICAL and 26 05 19.10 25, INSULATED WIRE AND CABLE. In order to ensure good electrical connections, good metal to metal contact must be achieved in all locations where the anodes are bolted to the structures.

~~2.5.5 Electrical Connection to Structures~~

~~2.5.5.1 Exothermic Welds~~

~~Electrical connections to metallic structures must be made using exothermic welds in strict accordance with the manufacturer's recommendations.~~

~~2.5.5.2 Electrical-Shielded Arc Welds~~

~~Electrical-shielded arc welds must be approved for use on steel pipe by shop drawing submittal action.~~

~~2.5.5.3 Brazing~~

~~Brazing will be as specified by manufacturer using specialized equipment~~

~~designed for that purpose.~~

~~2.5.6 Electrical Tape~~

~~Pressure-sensitive vinyl plastic electrical tape and rubber insulated tape must conform to UL 510.~~

~~2.5.7 Exothermic Weld Kits~~

~~Exothermic weld kits specifically designed by the manufacturer for exothermic welding wires to metallic surfaces. Molds must be for specific type of metallic structure (steel, cast iron), specific diameter of pipe or metallic surface and specific size (AWG)and type of wire (solid, stranded).~~

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Non-Destructive Testing of Anodes

Contractor must perform the tests in the presence of the Contracting Officer or the Contracting Officer's Representative. One anode of each type will be chosen at random for non-destructive testing and will be submerged in a container of fresh water for about 30 minutes. Contractor must then measure the anode-to-water potential difference between a calibrated copper/copper sulfate reference electrode. Potential differences must generally be within the following ranges:

Anode Type	**DC Volts to Calibrated Cu/CuSO4 Reference Electrode**
High Potential Magnesium	More Negative than Negative 1.65 Volts DC
Standard Magnesium	More Negative than Negative 1.4 Volts DC

Failure of the test anode to conform to this specification can be cause for rejecting all anodes from the same lot as the test anode. The contractor must mark all rejected anodes on the ends with a 6 inch high "X" using yellow spray paint. The contractor must replace any rejected anodes at the contractor's expense. The destructive testing provision must also apply to replacement anodes as well.

PART 3 EXECUTION

3.1 CRITERIA OF PROTECTION

Acceptance criteria for determining the adequacy of protection on a submerged metallic structure must be in accordance with NACE SP0169 and as specified below.

3.1.1 Iron and Steel

a. Prior to final acceptance testing of the cathodic protection system, the "corrosion expert" must devise a test procedure utilizing unpainted test coupons. The "corrosion expert" must clearly describe by narrative and drawing details their testing plan and submit it to the Contracting Officer's representative for approval prior to the beginning of any structural or mechanical steel work. The "corrosion expert" or contractor, if possible, must obtain the test coupons from the steel supplier that provides the steel for the pipe (or, some of

the left over, if any, steel that used to accomplish the fabrication on the pipe or a similar steel from the same supplier if none of the steel used is available). The coupons may be utilized on a temporary basis for acceptance performance testing purposes or the "Corrosion Expert" may incorporate the test coupons and necessary test stations into the cathodic protection system for permanent installation by the contractor and for future use in operational testing. A minimum of four test coupons must be used for the pipe. Test leads must be routed from the piping to a test station and from each coupon to a test station. The test leads routed from each coupon must be routed in such a manner as to enable disconnection of the coupons from the structure; thus, totally removing the coupon from under the influence and protection of the magnesium anodes (disconnection accomplished at the test station). Since the anodes will be bolted to the piping, the coupons will not be able to be electrically connected to the pipe and must be only connected to the pipe via test leads routed through a test station (in order to allow for disconnecting of the coupons). As specified herein, the "corrosion expert" must take baseline (or native) readings on the pipe; these native readings must be taken as specified herein and at the same locations specified for the potential measurements required for the piping. The "corrosion expert" must also take baseline (or native) measurements at the test coupons after the pipe and coupons are buried but prior to connection of the coupons to the piping. These base readings must be recorded and submitted to the Contracting Officer's representative.

b. For acceptance testing, the cathodic protection system must meet the minimum criteria defined below.

c. A negative voltage of at least 0.85 volt as measured between the structure and a saturated copper-copper-sulfate reference electrode contacting the electrolyte. Determination of this voltage is to be made with the protective current applied ("ON" potentials) and after the cathodic protection system has been in operation for a minimum of 72 hours. Voltage drops other than those across the structure-to-electrolyte boundary must be considered for valid interpretation of this voltage measurement as described in NACE SP0169. In this contract, placing the electrode in close proximity to the painted surface will not be considered adequate as "consideration of voltage drops other than those across the structure-to-electrolyte boundary." The "corrosion expert" must establish that voltage drops other than those across the structure-to-electrolyte boundary (i.e., IR drop) have been properly considered by utilizing the following methodology. After the native readings (as described above) are taken at each coupon location and at the specified locations on the piping, the "corrosion expert" or their installers must connect the coupons to the piping, which also places them under cathodic protection. After the coupons have been under the influence of the cathodic protection system for a minimum of 72 hours, the "instant off" reading of each coupon must be measured and recorded by disconnecting each coupon from the piping segment. Each "instant off" reading must be a minimum of minus 850 millivolts at each test coupon location. These "instant off" measurements obtained at each coupon location must be utilized to establish the IR drop (voltage drops other than those across the structure-to-electrolyte boundary). The coupon "instant-off" readings must be properly applied and correlated with the required "ON" potential readings across the piping in order to substantiate that the "ON" readings meet the potential requirements described herein after voltage drops other than those across the structure-to-electrolyte

boundary have been considered. A minimum of minus 850 millivolts polarized potential between the submerged surface being tested and the reference cell must be achieved over 95 percent of the submerged area of the structure. Adequate number of measurements (potential measurement grid is defined in these specifications) must be obtained over the entire structure to verify and record achievement of minus 850 millivolts (polarized potentials). This potential must be obtained over 95 percent of the total submerged metallic area without the potential exceeding minus 1100 millivolts (after consideration of voltage drops other than those across the structure-to-electrolyte boundary).

d. If a minus 850 millivolt "instant off" measurement cannot be obtained at each test coupon, the "corrosion expert" may utilize the following test procedure at the test coupons, if submitted to and approved by the Contracting Officer's representative prior to testing.

e. A minimum polarization voltage shift of 100 millivolts as measured between the test coupon and a saturated copper-copper sulfate reference electrode contacting the electrolyte near the coupon. This polarization voltage shift must be determined by interrupting the protective current (by disconnecting the coupon from the structure) and measuring the polarization decay. When the coupon lead is disconnected and the protective current is interrupted, an immediate voltage shift should occur. The voltage reading, after the immediate shift (this reading will be defined herein as being the same reading as the "instant off" reading described above and must be the second reading displayed on the digital voltmeter being used for measurements; this terminology will be utilized below), must be used as the base reading from which to measure polarization decay. Measurements achieving 100 millivolts decay must be made at each test coupon location. Alternatively, the "instant off" measurements can be compared to the native readings taken prior to initial connection of coupons to the structure. If the "instant off" reading is compared to the corresponding native reading of each specific coupon, it must be a minimum of 100 mV more negative with respect to the copper-copper-sulfate reference cell than the native reading. The "instant off" measurements must be made after the coupons have been connected to the structure and the cathodic protection system has been in operation for a minimum of 72 hours.

3.2 SAFETY PRECAUTIONS AND HAZARDOUS LOCATIONS

Any personnel performing operations that will generate heat, sparks, or flame in hazardous locations must first perform adequate safety precautions. A trained responsible person must ensure the area is safe to perform the operation. Required actions include ensuring adequate ventilation before work starts, air monitoring, and a fire watch must be provided and remain for 30 minutes after the operation is completed. A minimum of 20 pound ABC type fire extinguisher must be available and must be inspected before each use. Equipment being used must be inspected and used in accordance with manufacturer recommendations. Combustibles that are in the work area(s) must be moved or if they cannot be moved, be covered with fire retardant welding blankets. When performing exothermic welding, properly sized charges and inspection of the structure condition must be accomplished to ensure a safe operation.

3.3 INSTALLATION

3.3.1 Excavation and Trenching

Perform trenching and backfilling in accordance with Section 31 00 00.00 25 EARTHWORK. In the areas of the anode beds, all trees and underbrush will be cleared and grubbed to the limits shown or indicated. In the event rock is encountered in providing the required depth for anodes, determine an alternate approved location and, if the depth is still not provided, submit an alternate plan to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Alternate techniques and depths must be approved prior to implementation.

3.3.2 Anode Excavation

Excavate hole to a minimum 3 inches larger than the packaged anode diameter.

3.3.3 Lead Wire Trench

Excavate lead wire trench to 24 inches deep.

~~## 3.4 ANODES AND LEAD WIRE~~

~~### 3.4.1 Anode Installation~~

~~Unless otherwise authorized, installation must not proceed without the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Locations may be changed to clear obstructions with the approval of the corrosion expert and approval of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Anodes will be installed in sufficient number and of the required type, size, spacing, and depth to obtain a uniform current distribution over the surface of the structure. The anode system will be designed for a life of 25 years of continuous operation. Anodes must be installed as indicated and in a dry condition after any plastic or waterproof protective covering has been completely removed from the water permeable, permanent container housing the anode metal. The anode connecting wire must not be used for lowering the anode into the hole. The annular space around the anode must be backfilled with fine earth in 6 inch layers and each layer must be hand tamped.~~

~~#### 3.4.1.1 Single Anodes~~

~~Single anodes, spaced as shown, will be connected to the pipe or connected through a test station to the pipeline, allowing adequate slack in the connecting wire to compensate for movement during backfill operation.~~

~~#### 3.4.1.2 Group of Anodes~~

~~Groups of anodes, in quantity and location shown, must be connected to an anode header cable. The anode header cable must make contact with the structure to be protected only through a test station. Anode lead connection to the anode header cable must be made by an approved crimp connector or exothermic weld and splice mold kit with appropriate potting compound.~~

3.4 ANODE INSTALLATION

3.4.1 Anode Installation, General

Unless otherwise authorized, installation of anodes must be after painting and piping work has been completed (except for the installation of the anode stud bolts, which must be accomplished prior to painting of the piping). Anodes of the size specified must be installed as indicated and at the locations shown. Locations may be changed to clear obstructions with the approval of the Contracting Officer's representative. Anodes must be installed in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution over the surface of the structure.

3.4.2 Anode Stud Bolt and Slab Anode Installation Procedure

During fabrication, but prior to painting, stud bolts (bolts welded to the piping structure as detailed on the shop drawings) for the magnesium slab anodes must be provided and installed in accordance with the drawing details and in the locations shown and indicated on the drawings. However, prior to installation of the stud bolts, the supplier of the specific anodes to be purchased by the contractor and installed must be consulted in order to assure that the dimensions shown on the drawing details are in agreement with the requirements of their specific anodes (the contractor's corrosion expert must coordinate these requirements with the anode supplier). Additionally, the corrosion expert must assure that the correct mounting bolts, nuts, washers, and other materials are ordered in order to properly mount the specific anodes that are to be installed. As required elsewhere in this specification section, prior to welding the mounting bolts to the piping surface, at least one anode of each type to be installed must be on-site in order to ensure that it can be properly mounted to the mounting bolts in the locations of which they are to be welded. After bolts are welded to the pipe and prior to painting the piping, wrap the threads with tape to prevent the pipe coating material from adhering to the threads. After the pipe painting is completed and just prior to installation of the anodes, remove the tape from the bolts. Before mounting the anodes, remove the epoxy coating from the area adjacent to the mounting holes to insure good electrical contact between the anode strap, bolt, and nut. After each anode is installed, remove the plastisol coating from the surface of the anode per manufacturer recommendations. Then check the continuity between the anode and structure. Discontinuous anodes are to be loosened and any excess epoxy removed from the straps as required to achieve continuity. After anode installation on bolts, all exposed steel surfaces (including bolts, nuts and washers) must be thoroughly cleaned and painted using paints and coatings prescribed for the pipe. Care should be taken to not paint any of the magnesium anode material.

3.4.3 Installation Details

Details must conform to the requirements of this specification. Any details shown on the drawings are for reference only.

3.4.4 Underground Pipe Joint Bonds

Underground pipe having other than welded or threaded coupling joints must be made electrically continuous by means of a bonding connection installed across the joint.

3.4.5 Anode Junction Boxes

Provide junction boxes and mark each of the wires terminating in each box.

3.4.6 Bonding Boxes

Provide structure bonding boxes in locations where the protected structure crosses or comes into close proximity to other metal structures that are unprotected or protected by its own electrically isolated CP system(s).

~~3.5 INSTALLATION DETAILS~~

~~3.5.1 Anode Installation~~

~~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. Center the packaged anode in the hole with native soil in layers not exceeding 6 inches. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 6 inches above the top of the anode, pour at least ten gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes must not be backfilled prior to inspection and approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.~~

~~3.5.2 Lead Wire Installation~~

~~Cover the lead wire trench bottom with a 3 inch 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 exceedingsix inches deep. 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.~~

~~3.5.2.1 Lead Wire Connections~~

~~Connect anode lead wire(s) to the test station terminal board(s). Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.~~

~~3.5.2.2 Metallic Underground Pipeline Connection~~

~~To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes, if required, all anode lead wires must be connected to a test station and buried a minimum of 24 inches in depth. The cable must be No. 10 AWG, stranded copper, polyethylene or RHW-USE insulated cable. The cable must make contact with the structure only through a test station. Resistance wire must be installed between the cable and the pipe cable, in the test station, to reduce the current output, if required. Anode connections, except in the test station, must be accomplished by exothermic welding, and must be insulated by means of at least three (3) layers of electrical tape; and all lead wire connections must be installed in a moisture-proof splice mold kit and filled with epoxy resin. Lead wire-to-structure connections must be accomplished by an exothermic welding process. All welds must be in accordance with the manufacturer's recommendations. A backfill shield filled with a pipeline mastic sealant and material compatible with the coating must be placed over the weld connection and be of such diameter as to cover the exposed metal adequately. Anodes must be~~

~~installed at a minimum of 8 feet and a maximum of 10 feet from the structure to be protected.~~

~~Contractor must take proper safety precautions prior to and during welding to live pipelines. Contractor must notify the activity Fuel Office via the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of three days before performing exothermic welding to live lines. Exothermic welding must be conducted with product flowing through the pipeline to eliminate vapor spaces within the pipe and to dissipate the heat on the pipe. Exothermic weld charges for connections to live lines must be limited to a maximum 15 gram charge to prevent burning through the pipe wall. Exothermic weld connections must be spaced a minimum of6 inches apart. In the event of an unsuccessful weld, the new weld location must be located a minimum of 6 inches from the unsuccessful weld and any other existing welds. Contractor must obtain the services of a certified safety professional to approve the contractor's exothermic welding safety procedures. Results of this consultation must be included in the Contractor's Daily Report.~~

~~3.5.3 Underground Pipe Joint Bonds~~

~~Underground pipe having other than welded or threaded coupling joints must be made electrically continuous by means of a bonding connection installed across the joint.~~

~~3.5.4 Anode Junction Boxes~~

~~Provide junction boxes and mark each of the wires terminating in each box.~~

~~3.5.5 Bonding Boxes~~

~~Provide structure bonding boxes in locations where the protected structure crosses or comes into close proximity to other metal structures that are unprotected or protected by its own electrically isolated CP system(s).~~

~~3.5.6 Test Stations and Permanent Reference Electrodes~~

~~Test stations will be post mounted. Provide buried isolation joints with test wire connections brought to a test station. Reference all test stations with GPS coordinates. Unless otherwise shown, locate other test stations and permanent reference electrodes as follows:~~

~~a. At 1000 foot intervals.~~

~~b. At all isolation joints.~~

~~c. At both ends of casings.~~

~~d. Where the pipe crosses any other metal pipes.~~

~~e. Where the pipe connects to an existing piping system.~~

~~f. Where the pipe connects to a dissimilar-metal pipe.~~

~~Do not fill the bottom of the test station with concrete unless otherwise specified. Do not place rubbish, scrap or other debris into the test station.~~

~~3.5.7 Permanent Reference Electrode Verification~~

~~Verify permanent reference electrodes against a calibrated portable electrode in the presence of the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager before installation. Verify in a non-metallic container of water. Permanent electrode must measure a reference potential agreeing with that measured by the portable electrode within plus or minus 0.010 volts when the sensing windows of the two electrodes being compared are not more than 1/6 inch apart but not touching. Remove permanent reference electrodes not within this potential range from the construction site by the end of the day and replace at the contractor's expense. The testing provision applies to replacement permanent reference electrodes as well.~~

~~3.5.7.1 Field Drawings~~

~~Complete a field drawing of Permanent Reference Electrode locations. Submit copy with daily report to the government.~~

3.5 ELECTRICAL ISOLATION OF STRUCTURES

3.5.1 Isolation Fittings

Isolating fittings, including isolating flange kits, dielectric unions and couplings, must be installed aboveground, or within manholes, wherever possible. Where isolating joints must be covered with soil, they must be fitted with a proper joint cover specifically manufactured for covering the particular joint, and the space within the cover filled with hot coal-tar enamel or hot petrolatum wax. Isolating fittings in lines entering buildings must be located at least 12 inch above grade of floor level, when possible. Isolating joints must be provided with grounding cells to protect against over-voltage surges or approved surge protection devices. The cells must provide a low resistance across isolating joint without excessive loss of cathodic current.

3.5.2 Dielectric Unions

Work piping into place without springing or forcing. Apply joint compound or thread tape to male threads only. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Cover unions with an electrically insulating coating.

3.5.3 Joint Bonds

Provide joint bonds on metallic pipe to and across buried flexible couplings, mechanical joints, flanged joints and joints not welded or threaded to provide electrical continuity. Connect bond wire(s) to the structure(s) by use of exothermic weld kit(s). Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. Weld connections using exothermic kits 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 hammer. Cover connections with an electrically insulating coating which is compatible with the existing coating on the structure.

3.5.4 Casings, Isolation, and Seals

Where the pipeline is installed in a casing under a roadway or railway,

isolate the pipeline from the casing, and seal the annular space against intrusion of water.

3.6 FIELD QUALITY CONTROL

Field tests must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative 5 days prior to performing each field test. Quality control for the cathodic protection system must consist of the following:

a. Initial field testing by the contractor upon construction.

b. Government Field Testing after contractor initial field test report submission.

c. Warranty period field testing by the contractor.

d. Final field testing by the contractor after one year of service.

3.6.1 Tests and Measurements

3.6.1.1 Native Potentials

Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five (5) working days prior to each test. Base potential tests: At least one week after installation and backfilling of the pipe and installation of the anodes, but before connection of anodes to the structure, measure base (native) structure-to-electrolyte potentials of the pipe and any casings. Perform measurements at anode junction boxes, test stations and other locations suitable for test purposes (such as service risers or valves), at intervals not exceeding 100 feet with readings at each end point and the midpoints as a minimum. The locations of these measurements must be identical to the locations specified for potential measurements with anodes connected. Use the same measuring equipment that is specified for measuring protected potential measurements.

3.6.1.2 Protected Potentials

Systems must be tested and inspected by the contractor's corrosion engineer in the presence of the Contracting Officer or the Contracting Officer's Representative. Notify the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager a minimum of five working days prior to each test. At least one week after native potential testing and connection of anodes to the structure, measure protected structure-to-electrolyte potentials. The locations of these measurements must be identical to the locations specified for native potential measurements. Use the same measuring equipment that is specified for measuring protected potential measurements. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Contractor must correct and retest, at the contractor's and Technical Expert's expense, deficiencies in the materials and installation observed by these tests and inspections.

3.6.1.3 Isolation Testing

Before the anode system is connected to the pipe, an isolation test must be made at each isolating joint or fitting. This test will demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the pipe. Any isolating fittings installed and found to be defective must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.6.1.4 Isolation Tester

An Isolation Tester designed and manufactured for use in CP, using the continuity check circuit, must be used for all isolating joint (flange) electrical testing. Testing must conform to the manufacturer's operating instructions. Test must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. An isolating joint that is good will read full scale on the meter. If an isolating joint is shorted, the meter pointer will be deflected or near zero on the meter scale. Location of the fault will be determined from the instructions, and the joint must be repaired.

3.6.1.5 Anode Output

As the anodes or groups of anodes are connected to the pipe, current output will be measured with an approved clamp-on milliammeter, calibrated shunt with a suitable millivoltmeter or multimeter, or a low resistance ammeter. (Of the three methods, the low-resistance ammeter is the least desirable and most inaccurate. The clamp-on milliammeter is the most accurate.) The values obtained and the date, time, and location must be recorded.

3.6.1.6 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire CP system in operation, electrode potential measurements must be made using a copper/copper sulfate reference electrode and a potentiometer-voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements must be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements must be recorded. No less than eight (8) measurements will be made over any length of line or component. Additional measurements will be made at each distribution service riser, with the reference electrode placed directly over the service line.

3.6.1.7 Casing Tests

Before final acceptance of the installation, the electrical isolation of carrier pipe from casings must be tested and any short circuits corrected.

3.6.1.8 Holiday Test

Any damage to the protective coating during transit and handling must be repaired before installation. After field-coating has been applied, the entire pipe must be inspected by an electric holiday detector with impressed current in accordance with NACE SP0188 using a full-ring, spring-type coil electrode. The holiday detector will be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective coating must be repaired upon

detection. Occasional checks of holiday detector potential will be made by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection must be furnished by the contractor. The coating system must be inspected for holes, voids, cracks, and other damage during installation.

3.6.1.9 Stray Current Measurements

Before final acceptance of the installation, stray current tests must be performed on any foreign pipes in close proximity to the installed anodes. A full report of the tests giving all details must be made.

3.6.1.10 Induced AC Testing

Before final acceptance of the installation, induced AC Voltage tests must be performed on the pipes near high AC Voltage infrastructure and where crossing above ground and underground AC transmission systems. A full report of these tests must be included in the final testing reports with all details and data taken. The touch potential of any testing over 5 volts must be reported to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager. Any touch potential over 10 Volts must be mitigated by effective mitigation techniques. Refer to NACE SP0177 and NACE SP21424.

3.6.1.11 Interference Tests

Before final acceptance of the installation, interference tests will be made with respect to any foreign pipes in cooperation with the owner of the foreign pipes. A full report of the tests giving all details must be made. Stray current measurements must be performed at all isolating locations and at locations where the new pipeline crosses foreign metallic pipes; results of stray current measurements must also be submitted for approval. The method of measurements and locations of measurements must be submitted for approval. As a minimum, stray current measurements must be performed at the following locations:

a. Connection points of new pipeline to existing pipeline.

b. Crossing points of new pipeline with other existing metallic pipelines.

3.6.1.12 Initial Cathodic Protection System Field Testing

a. Initial field testing must be completed by the contractor upon completion of construction. Field testing must be witnessed by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager or their designated representative. Advise the Contracting Officer or Contracting Officer's Representative 5 days prior to performing each field test. Field testing must include native and protected potentials, and anode current testing.

b. The Contractor must submit an initial field test report of the cathodic protection system. All structure-to-electrolyte measurements, including initial potentials, anode outputs, and other required testing must be recorded on applicable forms. Identification

of test locations, test station and anode test stations will coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor must locate, correct, and report to the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager any short circuits encountered during the checkout of the installed CP system.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Reconditioning of Surfaces

3.7.1.1 Concrete

Concrete must be 3000 psi minimum ultimate 28-day compressive strength with one inch minimum aggregate conforming to Section 03 31 01.00 25 CAST-IN-PLACE STRUCTURAL CONCRETE FOR CIVIL WORKS .

3.7.1.2 Restoration of Sod

Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed since it is estimated that no section of pipeline must remain uncovered for more than two (2) days. 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. Seeding must be done as directed, in all unsurfaced locations where sod and topsoil could not be preserved and replaced. The use of sod in lieu of seeding will require approval by the Contracting Officer or the Contracting Officer's Representative, Technical Expert and Project Manager.

3.7.1.3 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 must have a maximum aggregate size of 1 1/2 inches. Prime base course with liquid asphalt, ASTM D2028/D2028M, Grade RC-70 prior to paving. Match base course thickness to existing but must not be less than 6 inches. Asphalt aggregate size must be 1/2 inch , asphalt cement must conform to ASTM D3381/D3381M, Grade AR-2000. Match asphalt concrete thickness to existing but must not be less than 2 inches. Repair Portland cement concrete pavement, sidewalks, curbs, and gutters using 3,000 psi concrete conforming to Section 03 31 01.00 25 CAST-IN-PLACE STRUCTURAL CONCRETE FOR CIVIL WORKS . Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.7.2 Training

3.7.2.1 Instruction to Government Personnel

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 must be not less than four hours and not more than two 8-hour working days. Conduct the training at the jobsite or at another location mutually satisfactory to the government and the contractor. The field instructions will cover all of the items contained

in the ~~o~~Operation and ~~m~~Maintenance ~~m~~Manual.

-- End of Section --