ITEM NO. 819

Galvanic Anode Cathodic Protection

PART 1 GENERAL

819.1 DESCRIPTION

1. The WORK of this Section includes providing a complete galvanic anode cathodic protection system for the structures as outlined on the Drawings:
2. Electrical Isolation of above structures from adjacent metallic structures, reinforcing steel, structures of dissimilar metal, conduits, and all other metallic components that may impact the operation of the cathodic protection system.
3. Electrical bonding of all non-insulated, non-welded pipe or mechanical joints.
4. Installation of galvanic anodes and all other work described herein and on the Drawings
5. Testing of system during installation.
6. Cleanup and restoration of work site.
7. Testing of installation after installation and backfill (Final System Checkout).

819.2 REQUIREMENTS

1. If the products installed as part of this Section are found to be defective or damaged or if the WORK of this Section is not in conformance with these Specifications, then the products and WORK shall be corrected at the CONTRACTOR's expense.
2. Any retesting required due to inadequate installation or defective materials shall be paid for by the CONTRACTOR.
3. The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK as indicated, but without altering or modifying the CONTRACTOR's responsibilities under the Contract Documents.
4. The WORK also requires coordination of assembly, installation and testing between the pipeline contractor and any cathodic protection material supplier or subcontractor.

819.3 RELATED WORK SPECIFIED ELSEWHERE: The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Site Safety and Regulatory Requirements
2. Coatings
3. Piping
4. Excavation, Trenching, Backfilling, and Compacting
5. Cast-In-Place Concrete

819.4 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS: The WORK of this Section shall comply with the current editions of the following codes and standards:

1. American Society for Testing and Materials (ASTM)

B3	Standard Specification for Soft or Annealed Copper Wire
B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
B80	Magnesium-Alloy Sand Castings
B843	Magnesium-Alloy Anodes for Cathodic Protection.
C94	Standard Specification for Ready-Mixed Concrete
D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

D1785 Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
D2220 Standard Specification for Polyvinyl Chloride (PVC) Insulation for Cable and Wire
D3005 Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
D4388 Standard Specification for Nonmetallic Semi-conducting and Electrically Insulating Rubber Tapes

2. American Water Works Association (AWWA)
   C217 Application and Handling of Wax-Type Protective Coatings and Wrapper Systems for Underground Pipelines
3. National Association of Corrosion Engineers (NACE)
   SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
   SP0286 Electrical Isolation of Cathodically Protected Pipelines. RP0375 Wax Coating Systems for Underground Piping Systems
   M0497 Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
4. National Fire Protection Association
   70 National Electric Code
5. National Electrical Manufacturers Association (NEMA)
   TC2 Electrical Polyvinyl Chloride (PVC) Tubing and Conduit TC3 PVC Fittings
6. Underwriters Laboratories, Inc.
   83 Thermoplastic-Insulated Wires and Cables.
   486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   510 Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
   514 Outlet Boxes and Fittings.
7. Whenever the Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, the Drawings and these Specifications shall prevail.

819.5 GENERAL REQUIREMENTS

1. The Plans indicate the general arrangement of the cathodic protection facilities to be constructed. Where no dimensions are indicated on the Plans, the locations of cathodic protection test stations may be changed up to fifteen feet without the approval of the Engineer to avoid interference with other utilities and unforeseen obstacles. Where specific dimensions are shown on the Plans, or where proposed changes are greater than fifteen feet, written approval by the Engineer is required. Where applicable, materials and equipment shall bear evidence of UL approval and conform to the requirements of all applicable federal, state and local laws, codes, and regulations.

819.6 SUBMITTALS

1. The following shall be submitted to the ENGINEER prior to any equipment installation.
   a. Qualifications of the Contractor’s Corrosion Engineer and Corrosion Technician.
   b. Proposed alternate installation methods, proposed alternate testing methods.
   c. Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.
   d. Certification that the equipment and materials proposed and listed below, meet the Specifications and the intent of the Specifications.

(1) Magnesium Anodes and lead wire
(2) Pipe Lead, Anode Header and Bond Wire
(3) Connectors
(4) CP Test Stations
(5) Below Grade CP Test Boxes
(6) Pipe Flange Insulating Kits
(7) Coating for Buried Pipe Flanges and Fittings
(8) Alumino-Thermic Weld Kits
(9) Weld Coating
(10) Plastic Warning Tape
(11) Insulating Putty
(12) Rubber Splicing Tape
(13) Electrical Tape

e. Schedule including the expected start date and planned completion date.

2. The following shall be submitted to the ENGINEER after completion of the WORK.
   a. Wire connection testing.
   b. Insulating joint testing, before and after backfill.
   c. Casing insulator testing, before and after backfill.
   d. Joint bond testing, before and after backfill.
   e. System check-out report with certification by the Contractor's Corrosion Engineer stating that the testing criteria in these specifications have been met.
   f. Record Drawings shall be submitted and approved by the ENGINEER before the WORK is considered complete.

819.7 QUALITY ASSURANCE

1. The installation of the cathodic protection system's electrical components shall conform to the latest editions of: The National Electrical Code, applicable local codes, and the Standard Practices of NACE International Standard Practice SP0169.
2. Provide all materials, equipment, labor, and supervision necessary for the completion of all installations and testing.
3. Obtain the services of a Corrosion Engineer to inspect and test the installation of the cathodic protection system. The Corrosion Engineer shall be a Texas registered professional engineer and/or be certified by the National Association of Corrosion Engineers at the level of Corrosion Specialist or Cathodic Protection Specialist (i.e. NACE CP Level 4). Such a person shall have not less than five years experience inspecting and testing pipeline cathodic protection systems.
4. Obtain the services of a Cathodic Protection Technician to inspect and test the installation of the cathodic protection system. The Cathodic Protection Technician refers to a person certified by the National Association of Corrosion Engineers at the level of Cathodic Protection Technician (i.e. NACE CP Level 2). Such a person shall have not less than five years experience inspecting and testing pipeline cathodic protection systems.
5. Maintain record drawings for the cathodic protection system throughout the installation of the equipment. Properly identify all items of equipment and material. Show the exact locations of all buried wires, and CP test boxes using dimensional ties to existing structures or survey monuments.

PART 2 MATERIALS

819.8 GENERAL

1. Provide cathodic protection system materials and equipment that are new, undamaged, and in the original packaging marked with the manufacturer's name or trademark. The materials and equipment shall be of the manufacturer's latest standard design and shall be fully compatible to provide a complete and functional cathodic protection system.

819.9 MAGNESIUM ANODES

1. High Potential Magnesium Anode Alloy: Anodes shall be cast magnesium alloy ingots conforming to ASTM B843 as manufactured by the Dow Chemical Company, Federated Metals Company, Magnesium Corporation of America, or equal. The Open Circuit voltage of this alloy should be minimum 1.70 volt with respect to a copper sulfate reference electrode. The high potential magnesium alloy chemical composition shall be as shown below:

Component	Composition by Weight
Aluminum	0.01 percent maximum
Manganese	0.5 percent to 1.3 percent
Copper	0.02 percent maximum
Silicon	0.05 percent maximum
Nickel	0.001 percent maximum
Iron	0.03 percent maximum
Others, each	0.05 percent max. each
Magnesium	Remainder

2. Special Backfill Cloth Bag: Each magnesium anode shall be prepackaged in a permeable cloth bag and backfill. The backfill grains shall be such that 100 percent is capable of passing through a 100 mesh screen. The backfill shall be firmly packed around the anode by mechanical vibration to a density that will maintain the magnesium ingot in the center of the bag surrounded on average by at least one inch of backfill. The backfill shall have the following composition:

Gypsum	75 percent
Powdered Bentonite	20 percent
Anhydrous Sodium Sulfate	5 percent

3. Anode Core: The anode shall be cast with a galvanized steel wire, strip or rod core and shall be recessed at one end so that the core is accessible for the lead wire connection.
4. Anode Lead Wire Connections: The lead wire shall be connected to the anode core with silver solder. The connection shall be mechanically secure before soldering and shall have at least 1-1/2 turns of wire at the connection. The connection shall be insulated by filling the remainder of the recess with electrical potting compound. Unless otherwise shown on

5. the Plans, the anode lead wire shall be No. 12 AWG stranded copper wire with black HMWPE insulation. The anode wire shall be long enough to extend to the anode test box without any splices and provide for a minimum of 18 inches of slack within the test box.
6. Magnesium anode weight, alloy, total anode bag weight, and dimensions shall be as shown on the Plans.

819.10 PIPE LEAD, ANODE HEADER AND BOND WIRE

1. Use stranded copper wire. Wires with cut or damaged insulation are not acceptable and replacement of the entire lead will be required. Wires shall be sufficient length to extend from the point of installation on the pipeline to the appropriate corrosion monitoring test box without splices and provide for a minimum of 18 inches of slack within the test box.
2. Direct Buried CP Wires: Wires shall be stranded copper that conform to ASTM B3 and ASTM B8. All test wires and anode header/collector cable shall be minimum No. 10 AWG. Test wires and anode header/collector cable shall have HMWPE insulation specifically designed for cathodic protection service and suitable for direct burial in corrosive soil, conforming to ASTM D1248, Type I, Grade J3, Class C, Category 5 (HMW-PE Type CP). Wire insulation color shall be as shown on the Drawings.
3. Pipe Joint Bonding Wire: Wire shall be No. 4 AWG and shall have 7/64-inch thick HMWPE black insulation specifically designed for cathodic protection service and suitable for direct burial in corrosive soil, conforming to ASTM D1248, Type I, Grade J3, Class C, Category 5 (HMW-PE Type CP). Install bond wires at the minimum length required. Number of bonds per joint shall be as shown on the Drawings.

819.11 CONNECTORS

1. Split bolts shall be compact, high strength, high conductivity copper alloy, have free-running threads and easy to grip wrench flats. All current carrying bolts and hardware shall be copper alloy.
2. Cable connection lugs shall be constructed from high conductivity high strength copper alloy such as Ilsco Type SLU, Ilsco Type CP, or engineering approved equal. Cable connection lugs shall not have any aluminum or steel subcomponents. All current carrying bolts and hardware shall be copper alloy.

819.12 CP TEST STATIONS

1. Test stations shall not rust, corrode, shatter, peel, or absorb heat. Test stations shall be environmentally safe, resist attack from alkaline, acid, or organic compounds commonly found in soil and salt, herbicides, pesticides, and fertilizers. Test stations shall have dimensional and electrical stability from -20°F to 175°F and be stable under ultraviolet exposure.
2. Each CP Test Station shall include a cross-laminated phenolic terminal board with a minimum thickness of 1/4 inch. The terminal board shall contain individual lugs for each wire entering the test station or junction box.
3. Wire and cable identification markers. Provide a durable wire identification tag for each cable. Acceptable tags are military grade heat shrink labels with minimum dimensions of one-inch width and ¼-inch height. Print the labels per the job specific identification legend on the Drawings.

819.13 ANODE SHUNTS

1. The shunt resistance shall be such that a five Amp current causes a voltage drop of 50 millivolts (i.e. 0.010 ohms). Shunts shall be #12 AWG, 5-3/4 inch long manganin wire style such as the Holloway Type RS or engineering approved equal.

819.14 BELOW GRADE CP TEST BOXES

1. Provide an electrical pull box or concrete valve box for all below grade CP Test Stations. Generally, boxes shall be installed outside of any roads or parking lots. Where traffic loading of the boxes is required, they shall be designed to withstand H-20 traffic loads. Boxes shall be a minimum of 10-3/8 inches inside diameter, 12 inches deep, and have a cast iron cover. Covers for test stations shall have the words "CP TEST" cast or welded thereon. Letters shall be minimum 3/4 inches tall and 1/4 inch raised from the surrounding flat area. Use Christy Concrete Products, G5, or engineering approved equal.

819.15 PIPE FLANGE INSULATING KIT

1. For purposes of this specification, the terms "Pipe Flange Insulating Kit", "Insulated Flange", "Insulated Joint", and "Dielectric Flange" are used synonymously.
2. Pipe flange insulating kit materials shall be designated by the manufacturer as suitable for service at the operating temperatures and pressures specified in the piping specifications.
3. Flange insulating kits shall consist of a one piece, full-face, insulating gasket, an insulating sleeve for each bolt, insulating washers, and steel washers. For nominal pipe diameters up to and including 36 inches, provide one insulating washer and one steel washer on each side of the flange. For nominal pipe diameters greater than 36 inches, the insulating washers shall be installed sandwiched between a pair of matching steel washers on each side of the flange.
4. Insulating Gasket: Insulating gasket retainers shall be full face, Type E, NEMA G-10 epoxy glass retainers with a nitrile (Buna-N) rectangular cross section O-ring seal. Minimum total gasket thickness shall not be less than 1/8 inch. The gasket shall have the same outside diameter as the pipe flange. For cement mortar lined pipe, the gasket's inside diameter shall be one inch greater than the nominal pipe diameter. For epoxy lined pipe, the gasket's inside diameter shall be equal to the nominal pipe diameter. Dielectric strength shall be not less than 550 volts per mil, and compressive strength shall be not less than 50,000 psi. The manufacturer's name and date of manufacture shall be marked on both sides of the gasket with two-inch tall letters. The gasket shall be installed within six months of the date of manufacture. Use PSI Linebacker insulating gasket or engineer approved equal.
5. Insulating Sleeves: Provide full length, one piece, NEMA G-10 epoxy glass insulating flange bolt sleeves. Dielectric strength shall be not less than 400 volts per mil. The length of the insulating sleeves shall provide an air gap between the end of the insulating sleeve and inside surface of the stud bolt nut with a tolerance of 1/32 inch minimum and 1/8 inch maximum.
6. Insulating Washers: Insulating washers shall be NEMA G-10 epoxy glass with a minimum thickness of 1/8 inch. Dielectric strength shall not be less than 550 volts per mil, and compressive strength shall not be less than 50,000 psi. The insulating washer's inside diameter shall be sized to fit over the insulating sleeve's outside diameter.
7. Provide minimum 1/8-inch thick steel washers for placement over the insulating washers. The inside and outside diameter of the steel washers shall match those of the insulating washers. The steel washers must be able to freely rotate around the insulating sleeve. Attention must be paid to the fit between the steel washers and the insulating sleeve in order to avoid the washers twisting the sleeves when the flange bolts are torqued.
8. Flanged Coupling Adapter: Provide additional insulating washers at the harness lug plates as shown on the Drawings.
9. Provide four extra insulating sleeves and eight extra insulating washers for each insulating flange upon successful inspection of the insulating flange.

819.16 COATING FOR BURIED PIPE FLANGES AND FITTINGS

1. Apply a wax tape coating system where shown on the Drawings which conforms to AWWA C217 and consists of three parts: surface primer, wax-tape, and outer covering.
2. The primer shall be a blend of petrolatum, plasticizer, and corrosion inhibitors having a paste like consistency. It shall have a pour point of 100 degree F to 110 degree F and a flash point of 350 degree F. Use Trenton Wax-Tape Primer, or engineering approved equal.
3. The wax-tape shall consist of a synthetic-fiber felt, saturated with a blend of high melt microcrystalline wax, solvents, and corrosion inhibitors, forming a tape coating that is easily formable over irregular surfaces and which firms up after application. The tape shall have a saturant pour point between 125 degree F and 130 degree F and a dielectric strength equal to a minimum of 100 volts per mil. Tape thickness shall be 70 mils to 90 mils in six inch wide rolls. Use Trenton No. 1 wax-tape, or engineering approved equal.
4. The outer covering shall consist of two layers of a plastic wrapper. The plastic wrapper material shall consist of three 10-mil thick clear polyvinylidene chloride, high cling membranes wound together as a single sheet. Use Trenton Poly-Ply, or engineering approved equal.

819.17 ALUMINO-THERMIC WELD KITS

1. Exothermic weld material shall be a mixture of copper oxide and aluminum, packaged by size in plastic tubes as shown in the Plans. The materials shall be non-explosive and not subject to spontaneous ignition.
2. Exothermic weld material and accessories shall be Erico Products, Inc., ThermOweld® or engineering approved equal. Materials from different manufacturers shall not be mixed.

819.18 WELD COATING

1. Coating for all welds shall be a cold-applied, fast drying mastic consisting of bituminous resin and solvents. The minimum percentage of solids shall be 80 percent.

819.19 WELD CAPS

1. Weld caps shall be Royston Handy Cap, as manufactured by Royston Laboratories, Inc. Thermite Weld Cap, as manufactured by Phillips Petroleum Co., or engineering approved equal.

819.20 PLASTIC WARNING TAPE

1. Plastic warning tape for horizontal runs of buried leads in cable trenches shall be a minimum of four mils thick and six inches wide, inert yellow plastic film designed for prolonged use underground. The tape shall have the words, "CAUTION CATHODIC PROTECTION CABLE BELOW," or similar, clearly visible in repeating patterns along its entire length.

819.21 ELECTRICAL INSULATION PUTTY

1. Electrical insulation putty shall be of non-corrosive mastic adhesive rated to 600V, 32 to 176 degrees Fahrenheit. Putty shall be 3M Scotchfil Electrical Insulation Putty or engineering approved equal.

819.22 RUBBER SPLICING TAPE

1. Rubber splicing tape shall meet the requirements of ASTM D-4388 with a minimum thickness of 30 mils. Tape shall be Scotch Brand linerless rubber splicing tape, Model 130C

or approved equal.

819.23 ELECTRICAL TAPE

1. Vinyl electrical tape shall meet the requirements of ASTM D 3005 with a minimum thickness of 8.5 mils. Electrical tape shall be Scotch Brand Premium Vinyl Electrical Tape, Model Super 88 or approved equal.

819.24 CONCRETE

1. Concrete used for cathodic protection test station installations shall be normal weight concrete, in accordance with Section 03300 – Cast-in-Place Concrete.

PART 3 EXECUTION

819.25 INSTALLATION OF MAGNESIUM ANODES

1. Install anodes at the approximate locations shown on the Drawings.
2. If a minimum anode hole diameter is indicated on the Drawings, it is only applicable to drilled anode holes. The anode holes may be drilled with auger equipment, hydro-excavated, rotary bit/drilling mud equipment, or the anodes may be installed by conventionally excavated deep trenches at the option of the Contractor. Unless otherwise noted on the Drawings, vertical anodes (in drilled holes) may also be installed horizontally (in deep trenches). If installed horizontally, the depth of the horizontal anodes shall be equal to the lower depth of the vertical anode specification.
3. Anodes shall not be dropped in the hole or lowered by the copper wire. A separate non-metallic support line shall be used to lower the anodes. The support line can be abandoned in place for each anode hole or retrieved with the use of a release line.
4. After lowering the prepackaged anode into the anode hole, add a minimum of 30 gallons of potable water to the hole to fully saturate the powdered backfill (bentonite/gypsum/sodium sulfate) mixture around the anode. Allow a minimum of 30 minutes for the water to soak into the anode backfill mixture before backfilling the hole.
5. Backfill the anode hole with native soil in layers not exceeding six inches deep. Tamp each layer to remove voids.
6. Splice the anode leads onto anode header/collector cable using copper split bolt or crimp-type connectors. Make splices waterproof by:
   a. Smooth all irregular surfaces with electrical insulating putty
   b. Apply two layers of half lapped rubber splicing tape
   c. Apply two layers of half lapped vinyl electrical tape
7. Trench the anode collector/header wires in 1-in diameter SCH 40 PVC electrical conduit at a minimum of 2 feet depth to the corresponding Anode Test Station (ATS) as shown on the Drawings.

819.26 CP TEST STATION

1. For purposes of this specification, the terms “Cathodic Test Station”, “Cathodic Protection Test Station”, “Cathodic Test Box, and “CP Test Box” are used synonymously to refer to a group of test wires welded to a pipeline, casing, or tunnel which are trenched to an electrical junction box, flush mounted valve box, or flush mounted meter box.
2. Construct Test Stations to enable periodic cathodic protection system monitoring. Unless otherwise shown on the Plans, provide test stations at the following locations:
   a. Cased crossings - Provide a test station at all locations where cathodically protected pipelines run inside steel casings or steel reinforced tunnels to enable testing the integrity of electrical isolation between the pipeline and casing. Provide a pair of test wires welded to the pipeline and to the casing or

tunnel.

b. Insulated Flange - Provide a test station for insulated flanges or flanged coupling adapters where specified on the Drawings. Where insulated flanges are located inside vaults, flow control facilities, and pump stations, mount the test boxes on the exterior of these structures to enable cathodic protection monitoring without entering the structure. Provide a pair of test wires welded to the pipe on each side of the insulated flange, total four wires required. Test stations are not required at insulating flange installations at the Booster Station Pump Pad or the Surge Tank Pad at Old Pearsall Road Pump Station.

c. Magnesium Anode - Provide Anode Test Stations for all galvanic anode installations. Do not direct-connect anodes to the pipelines. Construct Anode Test Stations to enable monitoring of anode performance. Connect the anode header/collector cable(s) to a structure lead at the terminal board through a shunt to enable monitoring of protective current output.

3. All pipelines to be monitored with a Test Station shall have a minimum of two test wires welded to it.
4. Wherever possible, install Test Station boxes adjacent to vaults and other above-grade appurtenances.
5. Where flush mounted Test Stations are specified for a pipeline in a paved street, install the Test Station boxes in areas away from traffic hazards, such as in medians or behind curbs.
6. Where flush mounted Test Stations are specified provide a minimum of 18 inches of slack in all test wires to enable them to be removed from the box during periodic CP system testing.

819.27 WIRE-TO-PIPE CONNECTIONS ON BURIED PIPE

1. Weld the CP test wires to pipelines at the nearest pipe joint to the pipeline station indicated on the Drawings by either the exothermic welding or pin-brazing process.
2. Install the cables with sufficient slack so that the cable insulation and conductors will not be damaged during the pipe backfilling process.
3. For dielectrically coated steel pipelines, cover the welded connection with a polyethylene weld cap. Seal all around the weld cap and any other areas of exposed steel with a bitumastic coating or a two part high build fast cure epoxy coating.

819.28 WIRE-TO-PIPE CONNECTIONS ON EXPOSED PIPE

1. For wire-to-pipe connections inside vaults and other structures, exothermically weld the CP test wires to the pipe within one foot of the pipe-wall penetration, on the interior side. The welded connections shall be positioned so that the wires do not interfere with the installation or removal of flange bolts.
2. Paint the exothermically welded connection with a coating that matches material and color of the surrounding pipe coating.

819.29 EXOTHERMIC WELDS

1. Make wire connections to the pipeline or other structure with an exothermic weld process ("Cadweld", “ThermOweld”, or engineering approved equal), or pin-brazing process, per manufacturer’s recommendations.
2. Provide a minimum separation of six inches between multiple welds.
3. Remove a minimum amount of the existing coating required for placement of the weld tool on the steel structure. The steel surface must be completely clean and dry (near white metal surface preparation).
4. Test the weld integrity by striking it from the side with a two-pound hammer. If the weld

comes off, move away a minimum of three inches and repeat steps A through D.

5. After testing, apply weld coating.

819.30 PIPE JOINT BONDING WIRES

1. During installation of the pipe, electrically bond across all buried pipe joints which are not circumferentially welded as shown on the Drawings. Install bond wires across buried or submerged metallic in-line valves, flex couplings, bolted flanges, and fittings, except for insulated pipe flanges and monolithic insulating joints. Install bond wires using the minimum length required. For pipeline diameters less than 72 inches, a minimum of three No. 4 AWG copper bond wires are required for each bonded joint.

819.31 INSTALLATION OF INSULATING FLANGE MATERIALS

1. Install pipe flange insulating materials at the locations shown on the Drawings. Install pipe flange insulating materials in accordance with the manufacturer's recommendations and NACE recommended practice SP0286, "Electrical Isolation of Cathodically Protected Pipelines." Particular attention shall be paid to properly aligning the flanges prior to inserting the insulating sleeves around flange bolts. Prevent moisture, soil, or other foreign matter from contacting any portion of the insulating joint prior to or during installation. If moisture, soil, or other foreign matter contacts any portion of the insulating joint, disassemble the entire joint, clean with a suitable solvent and dry prior to reassembling. Follow the manufacturer's recommendations regarding the torquing pattern of the bolts and the amount of torque to be used when installing the flange insulating kit. As required, use only non-conductive lubricants such as Huskey 2000 Lubricating Paste & Anti-Seize compound, 3M Super 77 Spray Adhesive, and Triflow aerosol lubricant with Teflon additive, on the flange bolts or other flange components.

819.32 COATING OF BURIED PIPE FLANGES AND FITTINGS

1. Coat buried pipe flanges and fittings or elsewhere shown on the Drawings with a wax tape coating system in accordance with AWWA C217. The wax tape coating system shall extend over the adjacent pipe coating by a minimum 12 inches, or 18 inches away from the flange surface, whichever is greater.
2. The surfaces to receive the wax tape coating shall be clean and free of all dirt, grease, and other foreign material. Apply the primer by gloved hand or brush onto all exposed steel surfaces. Cut strips of wax tape and apply them by gloved hand around all bolts, nuts, and other irregular shapes so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed steel surfaces with a minimum wax tape thickness of 140 mils. Apply by hand two layers of polyvinylidene chloride, high cling membrane sheet over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the plastic wrap to the pipe with adhesive tape.

819.33 TESTING INSULATED PIPE FLANGES

1. The Contractor's Cathodic Protection Specialist, Corrosion Engineer, or Corrosion Technician shall test the electrical isolation effectiveness of each insulated pipe flange. The Contractor shall provide written notice of this testing to the Engineer a minimum of two days in advance. If the insulated pipe flange will be buried, it shall be tested for electrical isolation by the Contractor before the wax tape coating is applied and before it is connected to the pipeline. At the Engineer's option, SAWS may repeat this testing during or immediately after the installation of the insulating flange. Replace or repair any insulated

2. pipe flange that is determined not to be electrically effective. The effectiveness of insulating flanges shall be determined using the following test techniques in the order shown until one of the criteria is achieved or as otherwise directed by the Engineer.

   a. Electrical Potential Difference Test: Electrically bond the pipe on the vault or unburied side of the insulating flange to an electrical ground with a maximum resistance to remote soil of five Ohms. If the pipe on both sides of the insulating flange is mechanically connected to a minimum 50 feet of buried pipe, then the pipe does not need to be bonded to an electrical ground for this test. Measure the CP Potential of the pipe on both sides of the insulating flange using a copper/copper sulfate reference electrode. If the difference in CP Potentials is greater than or engineering approved equal to 400 millivolts, the insulating flange is providing adequate electrical isolation. If this criterion is not met, perform the Nilsson 400 Meter Direct Resistance Test to verify the effectiveness of the insulating flange.
   b. Direct Resistance Test: Measure the electrical resistance across the insulated flange using a 97 Hertz square wave null balancing ohmmeter such as the Model 400 Nilsson Soil Resistance Meter and the four-wire resistance technique. A standard handheld digital multi-test meter's ohmmeter circuit (e.g. Fluke 97 or Beckman HD110) is not suitable for properly making these resistance measurements. Perform this test by connecting the meter’s P1 and C1 terminals to one side of the insulating flange, using two wires, and then connecting the meter’s P2 and C2 terminals to the other side of the insulating flange, using two additional wires. Use vise grips or temporary exothermic welds to make the wire connections to the flange or pipe. The criterion for a pipe filled with water is a minimum measurement of five Ohms. The criterion for a dry or a partially filled pipe is a minimum measurement of 100 Ohms. If none of the applicable criteria are met, perform the Inductive Ammeter Direct Resistance Test to verify the effectiveness of the insulating flange.
   c. Inductive Ammeter Direct Resistance Test: Connect two separate wires via two separate connections to the pipe on both sides of the insulating flange. Use vise grips or temporary exothermic welds to make the wire connections. Use two pairs of test wires, one for current flow and one for voltage measurement. Using the first set of test wires, apply a minimum 12 volt DC electrical current across the insulating flange. Using the second set of test wires, measure the voltage across the insulating flange developed by the DC current flow. Use an inductive ammeter hoop (e.g. Swain hoop) clamped around the pipe immediately adjacent to the insulating flange to measure the change in DC current flow in the pipe, through the insulated flange. Calculate the electrical resistance across the insulating flange in Ohms by dividing the change in DC Volts by the change in DC Amps (i.e. Ohm's Law). The criterion for a pipe filled with water is a minimum measurement of five Ohms. The criterion for a dry pipe is a minimum measurement of 100 Ohms. If either of the applicable criteria is not met, perform the NACE Insulating Flange Leakage Test, per NACE SP0286, to verify the effectiveness of the insulating flange.
   d. NACE Insulating Flange Leakage Test: This test procedure shall conform to the "Leakage Test" described in the NACE Standard SP 0286, Section 8, "Field Testing and Maintenance", Figure 12. The test current used shall be between three and five DC Amps. The criterion for a pipe filled with water is a maximum “electrical leakage value” of 10 percent of the test current. The

criterion for a dry pipe is a maximum "electrical leakage value" of 5 percent of the test current.

3. Individual Flange Bolt Electrical Resistance Testing: For all insulated flanges to be buried and for all other insulating flanges that do not meet any of the previous minimum criteria, measure the electrical resistance of each flange bolt to both sides of the insulated flange using a Nilsson Model 400 Soil Resistance Meter and four-wire resistance technique. The measured resistance value for each flange through-bolt shall be a minimum of 1,000 Ohms, as measured from each bolt to both flanges. This criterion applies to flange through-bolts and does not apply to valve cap bolts. If lower resistance values are measured, remove, inspect, and replace all imperfect dielectric flange bolt sleeves and washers. If an insulated flange with threaded cap bolts passes the resistance tests for all the "through-bolts" yet fails the other previous tests, remove all the threaded cap bolts, inspect and replace all imperfect dielectric flange bolt sleeve and washer materials and retest.

819.34 ELECTRICAL ISOLATION TESTING BETWEEN PIPE AND STEEL REINFORCEMENT OR ENCASEMENT

1. Conduct testing to demonstrate that steel reinforcement in concrete structures and pipe encasements is not in contact with buried pipe. Correct all contacts detected between pipe and reinforcement or encasement.
2. The Contractor shall prepare written test procedures specifying the methods and equipment that will be used. Submit the proposed test method to the Engineer for approval a minimum of 30 days before the first concrete placement.
3. Isolation test methods may include measurements made between pipe and reinforcement or encasement for voltage difference, electrical resistance, or other parameters as required to prove electrical isolation. In no case shall an electrical resistance measurement made with a volt-ohm multimeter be accepted as a test procedure. In the event of a question regarding the electrical isolation of the pipe, the Engineer shall make the final determination.
4. Electrical isolation tests shall be conducted for each pipeline one day before placing concrete, the morning before concrete is placed, and immediately after the concrete is placed. The Engineer will witness the electrical isolation test conducted before the concrete is poured.

819.35 ELECTRICAL CONTINUITY TESTING OF PIPE WITH BONDED JOINTS

1. Conduct electrical continuity testing to demonstrate that all buried pipe joints (except insulated flanges) are either welded joints or have been electrically bonded across with No. 4 AWG stranded copper bond cables. The Contractor's Cathodic Protection Technician shall conduct the tests. The Engineer will witness the electrical continuity tests. The Contractor shall demonstrate to the Engineer's satisfaction that full electrical continuity has been achieved and shall make all required bond cable connections in the event that electrical continuity of the pipe is not achieved.
2. Perform electrical continuity tests at maximum spacings of 800 feet of pipe. Circulate a 12 volt electrical direct current through the pipeline. Use two pairs of test wires, one for current flow and one for voltage measurement. Measure the voltage difference developed by the DC current flow. Calculate the electrical resistance of the pipeline section in Ohms using Ohm's Law. The resistance test acceptance criterion is less than 150 percent of the calculated resistance value. The resistance value shall be calculated using the steel cross section area of the pipe, its length, and consideration for the joint bond cables at each bonded joint.
3. If other electrical continuity test methods are proposed, the Contractor shall prepare a written test procedure specifying the alternate method and equipment that will be used. A standard handheld digital multi-test meter's ohmmeter circuit (e.g. Fluke 87 or Beckman HD110) is not suitable for properly making these measurements. Submit in writing the alternate proposed test method to the Engineer for approval a minimum of 30 days before

the pipe laying begins.

819.36 CP TEST STATION TESTING

1. Testing of Completed Welds: Wire weld connections shall be inspected prior to backfilling. At the Engineer's direction, tests to verify the soundness of the welds shall be conducted by the Contractor. Tests for this purpose shall consist of striking the weld nugget with a two-pound hammer while steadily pulling on the wire. Note that the wire near the weld shall not be unnecessarily cold worked during installation or testing. Remove and reweld any welds that break loose or show signs of separating, as determined by the Engineer.
2. Wire Identification: Provide the Engineer 48 hours advance notice to verify that buried pipe lead wires and anode lead wires are properly identified with military grade shrink tubing prior to backfilling the wires and the welded wire-to-pipe connections.
3. Structure Wire and Anode Header/Collector Cable Integrity Tests: After the pipe is buried, the wire trenches are backfilled, and the cathodic test boxes are installed, the Engineer shall test each set of structure lead wires for electrical continuity to the pipe. If more than twice the theoretical resistance of the pipe lead wire lengths is measured, the Contractor shall excavate the pipe and replace the structure lead wires.

Wire Size	Resistance (Ohms/100 feet at 77 degree F)
No. 4 AWG	0.026
No. 6 AWG	0.041
No. 8 AWG	0.065
No. 10 AWG	0.104
No. 12 AWG	0.165
No. 14 AWG	0.262

819.37 CATHODIC PROTECTION SYSTEM ACTIVATION

1. Retain a NACE certified Level 2 Cathodic Protection Technician to perform the inspection testing. Perform tests under the direct supervision of a Texas registered professional engineer or a NACE certified Cathodic Protection Specialist or NACE certified Corrosion Specialist. Supervision is defined in this specification as requiring a minimum eight hours of onsite field work at the start of the inspections to work with the Cathodic Protection Technician to plan, direct, and verify the testing procedures and to provide troubleshooting as required.
2. Provide a minimum of five days advance notice to the Engineer before the cathodic protection activation will be performed to allow for coordination and observance of these tests.
3. Before beginning each day of testing, calibrate portable copper sulfate reference electrodes with respect to a master reference copper sulfate reference electrode.
4. Measure CP Native Potentials (i.e. baseline pipe-to-soil potentials) at all CP Test Stations. Measure CP Native Potentials on at all TS wires. Where two wires are attached to the same pipeline, measure and record the CP Native Potentials for both wires. If the potential measurements for the same pipeline differ by more than two millivolts, investigate the cause. See the previous paragraph titled "Pipe Test Wire Integrity Tests".
5. Measure the open-circuit anode-to-soil potentials of all magnesium anodes before they are connected to pipe wires at the Anode Test Stations. Verify minimum values of negative
6. 1.70 volts for high potential magnesium anodes. While making these measurements, place

7. the copper sulfate reference electrode in the soil directly over the anode holes.
8. Activate the cathodic protection system by connecting all the anode wires to the shunts

   inside the Anode Test Stations.
9. Measure CP "On Potentials" at the same locations where CP "Native Potentials" were previously measured.
10. Measure all anode currents at the Anode Test Stations by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet.
11. Perform a synchronously interrupted survey of the CP System at least two weeks after initial energization to allow for the development of the cathodic polarization process. Measure CP "On" Potentials and "Instant-Off" potentials at all Test Stations.
12. Furnish all test results including all CP Potential readings, electrical continuity test data, anode current readings, insulating flange test data, dates, and times. Reference all data to pipeline station numbers. Submit all data along with a letter report to the Engineer. The letter report shall include a description of the test methods, analysis of the data, and conclusions about the CP system's effectiveness. Submit all data in spreadsheet format compatible with Microsoft Excel. Submit data in both hard copy and computer disk format.

819.38 ACCEPTANCE CRITERION FOR STEEL PIPE WITH DIELECTRIC COATING

1. The operation of the cathodic protection system shall be tested to ensure that all portions of the pipeline are provided a full level of corrosion protection. The standards used to evaluate the CP potential measurements shall be in accordance with either of the two following NACE SP0169 criteria.
   a. 0.85 VOLT CP INSTANT-OFF or IR FREE POTENTIAL - A negative voltage of at least
   b. 0.85 volt as measured between the pipeline and a copper sulfate reference electrode contacting the soil directly over the pipeline. Determination of this voltage is to be made the instant the cathodic protection current is synchronously interrupted at all Anode Test Stations.
   c. 100 mV CP POLARIZATION SHIFT - A minimum polarization shift of 100 millivolts measured between the pipeline being protected from corrosion and a copper sulfate reference electrode contacting the soil directly over the pipeline. This minimum polarization shift shall be determined by synchronously interrupting all cathodic protection currents and measuring the polarization formation or decay. At the instant the cathodic protection current is interrupted ("instant off"), an immediate voltage shift will occur. The voltage reading just after the immediate shift shall be used as the base reading from which to calculate the polarization formation or decay.

-End of Specification-