SPECIFICATIONS
SECTION 13110
CATHODIC PROTECTION

PART 1 GENERAL

1.1 DESCRIPTION

A. Section includes requirements for a complete sacrificial cathodic protection system for pipelines.

1.2 QUALITY ASSURANCE

A. Materials:
   1. Following applicable Standards for corrosion control.
   2. Supplied by manufacturer regularly engaged in production of corrosion control materials.

B. Installer: Install test stations, insulating joints, anodes, and joint bonding under supervision of corrosion control technician or corrosion engineer experienced in corrosion control work.

C. Corrosion Control Testing: NACE International Certified Corrosion Specialist, Senior Corrosion Technologist, or corrosion engineer with at least 5 years experience in corrosion engineering to perform corrosion control testing.

1.3 SUBMITTALS

A. Submit following Section 01330.
   1. Catalog Data.
      a. Materials to be used for joint bonding, joint insulating, anodes, and reference cells.
      b. Thermite weld packages, including manufacturer's recommended cartridge and charge size for each application required.
   2. Catalog Data or Shop Drawings: Test stations.

B. Quality Assurance/Control Submittals.
   1. Certificates:
      a. Installer's qualifications.
      b. Corrosion control tester's qualifications, methods, and procedures for testing corrosion control system, including description of equipment and instruments to be used.

PART 2 PRODUCTS

2.1 MATERIALS

A. Wire.
   1. Bonding Wire: #2 or #4 AWG stranded copper wire rated at 600 volts with black high molecular weight polyethylene (HMWPE) insulation, length as shown on Standard Details.
   2. Test Lead Wires: #6 through #12 AWG stranded copper wire rated at 600 volts with THW, THHN, THWN, or HMWPE insulation. Wire sizes and insulation colors following Standard Details.
   3. Anode Header Wire: Stranded copper wire with black HMWPE insulation using #8 AWG for multiple galvanic anode installation and #4 AWG for impressed current anodes, unless otherwise noted on Drawings; length as required.

B. Exothermic (Thermite) Weld Materials.
   1. Thermite Weld Molds, Weld Powder, and Weld Metal Cartridges: Proper size and amounts for wire size, pipe size, and pipe material.
   2. Approved Manufacturers.
      a. Exothermic weld material:
         1) ERICO Products Inc.
         2) Continental Industries.
         3) Or equal.
      b. Ductile iron pipe:
         1) ERICO, Weld Metal Powder for Cast Iron 45 X F19.
         2) Or equal.
      c. Thermite weld caps:
         1) Royston Handy Caps (caps pre-filled with mastic).
         2) Thermite weld caps (empty caps to be field-filled with mastic).
         3) Or equal.

C. Terminations and Terminals.
   1. Wire Terminations for Bolted Connections: One piece bar lugs made of electrolytic grade copper bar stock and tin plated, assembled or fabricated before field delivery.
   2. Approved Manufacturers:
      a. ERICO Products, Inc., Type LA.
      b. Or equal.
   3. Terminals for Terminating Test Lead Wires in Test Boxes: One piece, burr-free, crimp-type, non-insulated brazed seam terminals made of annealed electrolytic copper, sized to match various wire and stud sizes.

D. Protective Coating Materials.
   1. Exothermic Welds: Bituminous, coal tar, petroleum wax, or petrolatum-based mastic or tape and primer.
   2. Approved Manufacturers:

a. Royston Laboratories.
b. Tapecoat Company.
c. Trenton Corporation.
d. Denso Incorporated.
e. Central Plastics Company.

E. Insulating Materials.
1. Flange Insulating Kit.
a. Flange Insulating Gasket: Full flange diameter, Type E, made of laminated phenolic with neoprene on each side of gasket with minimum total thickness of 1/8 inch.
1) Dielectric strength: Not less than 500 volts per mil.
2) Compressive strength: Not less than 24,000 psi.
3) Water absorption: Maximum 2.5%.
4) Approved manufacturers/suppliers:
a) Advance Products & Systems, Inc.
b) Central Plastics Company.
c) Pipeline Seal and Insulator, Inc. (PSI).
d) Or equal.
b. Insulating Flange Bolt Sleeves: High density polyethylene or spiral wrapped Mylar with dielectric strength not less than 1,200 volts per mil.
c. Insulating Flange Bolt Washers: High strength phenolic with minimum thickness of 1/8 inch, dielectric strength not less than 500 volts per mil, and compressive strength not less than 25,000 psi.
d. Steel Flange Bolt Washers for Placement over Insulating Washers: Minimum thickness of 1/8 inch and cadmium plated.
e. One Piece Combination Sleeve and Washer:
1) Only as noted on Drawings.
2) When noted, 1 piece sleeve and washer of molded acetal or nylon resin having minimum thickness of 1/8 inch.
a) Dielectric strength not less than 500 volts per mil.
b) Compressive strength not less than 15,000 psi.
2. Copper House Connections and Small Pipe Insulator.
a. Copper house connection insulator: Two brass parts and nylon dielectric bushing.
b. Insulator for other pipe 2 inch and smaller diameter: One piece threaded bushing made of nylon and sized to fit pipe.

F. Test Stations
1. Flush Mounted.
a. Tube: Following Standard Details.
b. Cast iron or high impact plastic collar with ribs.
c. Cast iron or high impact plastic locking lid: Blue with permanent identification marking "WSSC Test Station” to withstand AASHTO H-20 traffic loads and ultra violet rays.
2. Above Ground.

a. Weatherproof enclosure: Cast aluminum, galvanized steel, or high impact plastic, Lexan, Gyrlyn or equal.
b. Test box enclosure with locking waterproof cover: Fasten on pipe using non-rusting materials: stainless steel, galvanized steel, or cadmium plated steel fasteners.
c. Terminal block: Phenolic resin, plastic, micarta, Lexan, or Bakelite high dielectric material, with 7 terminals unless otherwise shown on Drawings.
d. Terminals: Nickel plated brass 1/4 inch threaded studs, nuts, and washers.
e. Shunt: 0.01 ohm with minimum of 6 ampere capacity in test stations with galvanic anodes following Drawings.

G. Reference Electrodes.
1. Zinc Reference Cell: Zinc bar in prepackaged backfill with test lead wire.
a. Contents: High purity zinc, 99.99 percent pure, meeting requirements of ASTM B418, Type II.
b. Size: Approximately 1.4 inches by 1.4 inches by 9 inches and weigh approximately 5 pounds.
c. Prepackaged Backfill:
1) 75 percent ground hydrated gypsum.
2) 20 percent powdered bentonite.
3) 5 percent anhydrous sodium sulfate.
4) In water permeable fabric sack with zinc bar centered in sack, weighing not less than 20 pounds.
d. Lead Wire: No. 12 AWG, 600 volts stranded copper wire with THW, THWN, or THHN green insulation, at least 25 feet long and silver soldered or exothermically welded to core of zinc bar.
2. Copper to Copper Sulfate Cell: In plastic tube in prepackaged backfill with test lead wire, with accuracy of ±5 millivolts and minimum design life of 15 years.
a. Contents: High purity copper element, 99.99 percent pure, inside a tube containing a super saturated solution of copper sulfate.
b. Prepackaged Backfill:
1) 75 percent ground hydrated gypsum.
2) 20 percent powdered bentonite.
3) 5 percent anhydrous sodium sulfate.
4) In water permeable fabric sack with zinc bar centered in sack, weighing less than 20 pounds.
c. Lead wire: No.12 AWG, 600 volts stranded copper wire with THW, THWN, or THHN red insulation, at least 25 feet long and crimped and soldered or brazed to copper element.

H. Anodes.
1. Magnesium bar in prepackaged backfill with test lead wire, in weights following Drawings.
2. Chemical Composition of Magnesium Anodes: Percent by weight.

	Standard	High Potential

Aluminum	5.0-7.0	0.010 Max.
Zinc	2.0-4.0	0.05 Max.
Manganese	0.150 Min.	0.50-1.30
Copper	0.100 Max.	0.020 Max.
Silicon	0.300 Max.	0.05 Max.
Iron	0.003 Max.	0.030 Max.
Nickel	0.003 Max.	0.001 Max.
Others	0.300 Max.	0.050 each or 0.300 Max Total.
Magnesium	Balance	Balance

3. Prepackaged Backfill:
   a. 75 percent ground hydrated gypsum.
   b. 20 percent powdered bentonite.
   c. 5 percent anhydrous sodium sulfate.
   d. In water permeable fabric sack with anode centered in sack.
4. Lead Wire: No. 12 AWG 600 volts solid copper wire with THW, THWN, or THHN white insulation, at least 15 feet long, and factory connected to core with silver brazing alloy with minimum silver content of 15 percent.

I. Detectable Warning Tape: Yellow Mylar encased aluminum foil, minimum of 6 inches wide, with imprinted words "CATHODIC PROTECTION”.

PART 3 EXECUTION

3.1 THERMITE WELDING OF WIRES

A. Thermite weld test lead and joint bond wires to ductile iron and steel pipe joints and fittings, except where limited use of lugs is permitted following Standard Details.
   1. This weld process may be specified for use on other metallic structures.

B. Select and use thermite welding equipment following equipment manufacturer's instructions and Standard Details.
   1. Use equipment and molds to accommodate wire size, metallic structure's shape, wire position of attachment (vertical or horizontal) and other criteria specified.
   2. Before a mold is used, remove and clean slag, dirt, and other foreign matter from mold.
   3. Use cartridge and charge size based on manufacturer's recommendations for specific application.
   4. Different charges are required for steel and ductile iron.

C. Surface Preparation:
   1. Surfaces with Little or No Coating:
      a. Cleaned to bare metal by grinding or filing area approximately 3 inches square to produce bright metal surface.
      b. Removed of coating, dirt, mill scale, oxide, grease, moisture, and other foreign matter from weld areas.

2. Surfaces with High Performance or Thick Coating: Cut 4 inch square window through coating and clean 3 inch square of surface to bright metal, avoiding damage to surrounding coating.

D. Preparation for Welding.
   1. Before welding, remove wire insulation as required to fit mold, avoiding damage to exposed copper wire.
   2. If wire is cut or nicked over half way through its diameter, cut off and strip new end.
   3. If manufacturer requires use of copper sleeve, crimp it securely to wire and remove excess wire protruding from end of sleeve.

E. Test Connection.
   1. After charge is set, remove mold and slag from weld area with welder's hammer.
   2. Strike top and sides of weld with hammer to test secureness of connection.
   3. If weld does not hold, remove scrap weld material, clean, and begin weld process again.
   4. After welding and before coating cleaned weld area, Engineer may test joint bond wires for electrical continuity.

F. Weld Caps.
   1. When weld passes test for soundness and electrical continuity, repair coating in weld area with petrolatum or petroleum wax mastic and weld cap placed over weld following Standard Details.
   2. Apply mastic to fill weld cap or pre-filled weld cap and cover exposed metal of structure and wire to minimum thickness of 1/4 inch.
      a. Repair damage to coating around weld area following coating manufacturer's recommendations.
   3. If weld cap will not fit due to physical space limitations, coat bare metal and wire in weld area with minimum 1/4 inch thickness of petrolatum or petroleum wax mastic.

3.2 BOLTED WIRE CONNECTIONS

A. Bolted wire connections for bonding purposes are permitted to bolts on valve body: Follow Standard Details and specified herein.

B. Connect wire to bolt on valve body that is closest to pipe centerline.
   1. After valve bolt is removed, clean valve surface under bolt head to bright metal.

C. Use prefabricated bar lug on bonding wire end that will connect to valve bolt.
   1. Size bar lughole to fit valve bolt, and make bolted connection following Standard Details.
   2. After bolted wire connection is completed, test joint bond wires for electrical continuity.
   3. After bond wire passes electrical continuity test, coat bar lug, exposed copper wire and valve metal cleaned to make connection with minimum 1/4 inch of petrolatum or petroleum wax mastic.

3.3 JOINT BONDING OF PIPE

A. Bond pipe joints and fittings to form electrically continuous pipeline following Drawings and Standard Details.

B. Wire.
   1. Size wire used for joint bonding according to pipe diameter and following Standard Details.
   2. Cut bond wire to shortest length practicable, including some slack, for given span.
      a. Locate bond wire welds on pipe and fittings following Standard Details.
      b. Horizontal welds are preferable, but where there is insufficient space on fitting, vertical welds will be permitted.
      c. Where multiple parallel bond wires are involved, space wires neatly and without wires crossing each other.
   3. Do not splice bond wires.
      a. Entirely replace bond wires broken during construction.
      b. Reweld loose weld connections.
   4. If insulation of bond wire is damaged between welds, repair insulation:
      a. Thoroughly clean damaged area and 6 inches either side of it.
      b. Wrap minimum of 1 overlapping layer of rubberized electrical tape around damaged area and extend at least 2 inches each side.
      c. Wrap 2 overlapping layers of plastic electrical tape around rubberized tape and extend at least 1 inch beyond rubberized tape at each end.

3.4 INSULATED JOINTS

A. Install insulated joints of type and at location following Drawings and Standard Details.

B. After insulated joint is completed, test and verify that joint is completely insulated.
   1. Coat entire joint including bolt ends and nuts with coating material specified herein.
   2. Fully coat minimum of 12 inches on each side of flange.
   3. Clean surface of flange and components and prepare surface following manufacturer’s recommendations.
   4. Apply uniform coat of primer to flange and all components.
   5. Apply filler mastic to all irregular surfaces of flange to provide smooth profile for tape application.
   6. Apply innerwrap to flange and all components in spiral fashion; minimum overlap 55 percent.
   7. Apply outerwrap to flange and all components in spiral fashion; minimum overlap 1 inch with sufficient tension to provide continuous adhesion of tape.
   8. Install test facilities at insulated flanges following Drawings.

C. For copper house connections and other small pipe, install connection insulator following Drawings.
   1. Locate insulator at copper pipe tie-in following Standard Details.

3.5 INSTALLATION OF TEST STATIONS

A. Location of Test Stations:
  1. Follow Drawings and Standard Details.
     a. Unless otherwise directed by Engineer, locate surface of concrete pad at finish grade.
  2. Identify test station with number following Drawings or Engineer furnished number.
     a. Paint number legibly inside test box lid or cover and on terminal block.
     b. Use permanent and weatherproof paint for metal or plastic surfaces.
  3. Immediately after installation in areas to be improved, protect and identify test station locations with 3 stakes extending at least 4 feet above existing grade, equally spaced around test station and wrapped with orange fluorescent flagging material within 6 inches from top of stakes.
  4. Situate pipe for pipe mounted test stations directly over pipeline.
     a. If this is not possible, locate at Engineer's direction.

B. Test Lead Wires.
  1. Install test lead wires without splices as shown on Standard Details and attach to pipe using exothermic welding method.
  2. Terminate test lead wires inside test box using proper sized crimp type connectors on wire ends.
     a. Connect each wire to terminal maintaining at least 18 inches slack in each wire at test station.
     b. Neatly coil slack wire in test station below terminal board.
  3. Locate wires on top and along pipe and at right angles to pipeline when wires depart for offset test stations.
     a. Protect wires from damage during backfilling operations with adequate slack and support.
  4. Place continuous yellow detectable warning tape directly over test lead wires, 12 inches to 18 inches below finished surface.
  5. Test each lead wire for continuity after backfill is completed.
     a. If test for continuity fails, repair or replace at Engineer's direction.
     b. After continuity is verified, connect each lead wire to terminal block in test station.

C. Reference Cells:
  1. Install reference cell following Standard Details or Drawings.
  2. Protect cloth sack with prepackaged backfill surrounding reference cell from tearing or damage.
  3. If damage occurs, provide new prepackaged reference cell.
  4. Test wire from reference cell for proper function.
     a. If reference cell is not functioning properly, repair or replace.
     b. After test cell is functioning properly, connect lead wire from reference cell to terminal block at test station.
     c. Do not attach other test lead wire to terminal that is used for reference cell.

D. IR Drop Lead Wires:
   1. Locate IR drop test stations following Drawings. Use wire size, type, and length following Standard Details.
   2. Locate long lead wires below springline of pipe and taped to pipe for protection, following drawings.

E. Foreign Pipeline:
   1. Provide test stations at foreign pipelines following Drawings and Standard Details.
   2. Notify owner of foreign pipeline at least 2 weeks before test station construction. Unless otherwise indicated only foreign pipeline owner or approved representative will be permitted to weld wires to foreign pipeline.

3.6 ANODE INSTALLATION

A. Locate anodes as shown on Drawings and Standard Details.
   1. Do not lift anode by lead wire.
   2. Protect cloth sack with prepackaged backfill surrounding anode from tearing or damage.
   3. If damage occurs, provide new prepackaged anode.
   4. After anode is in place, backfill around it with rock-free material and compact following Restoration Schedule on Drawings.
   5. After backfill is completed to at least 1 foot above anode, pour at least 15 gallons of water over anode, unless groundwater covers it.

B. Connect anode lead wire to terminal block at test station, or when shown on Drawings, directly to pipe by exothermic weld.

3.7 PLACING SYSTEM IN SERVICE

A. Accomplish final connections and place Cathodic Protection System in service specified under Corrosion Control Testing.

3.8 CORROSION CONTROL TESTING

A. Record methods and instruments used to perform required tests including all readings, measurements, and calculated resistances.

B. Minimum Equipment To Perform Corrosion Control Testing:
   1. DC ammeter with full scale ranges of 1, 10, and 100 amperes, accurate to within 1 percent of full scale. A millivolt meter with 1 percent of full scale accuracy and shunts may also be used.
   2. Voltmeter with minimum input resistance of 10 megohms, with DC low range of 200 millivolts full scale to DC high range of 100 volts full scale and accurate to within 1 percent of full scale.

3. Alternative to 1. and 2. above may be high impedance multi combination voltmeter-ammeter used with 100 ampere shunt, Miller B3A, or equal.
4. DC power supply with steady capacity of 50 amperes minimum, produced from portable cathodic protection rectifier, 6 or 12 volt automotive type wet cell batteries, or equal.
5. Test leads and clamps suitable for carrying test current, rated up to 75 amperes with lead wire length.
6. Adjustable resistors with sizes and capacities to handle desired outputs.
7. Safety switch rated for test current.
8. One pair of electrical probes for voltmeter.
9. Saturated copper-copper sulfate reference half cell.

C. Continuity testing.
   1. Submit records of joint bond resistance testing including:
      a. Instruments and equipment used, with sketch of test connections.
      b. Test amperages, voltages, and voltage changes during testing.
      c. Joint resistance, measured and calculated.
      d. Location of each test station, giving pipe station and street address.
   2. Calculate theoretical joint and bond resistances.
      a. Measure distance between test stations.
      b. Using Calculated Resistance Table included herein at end of Section, multiply measured distance by Resistance Per Foot (OHM) from table to obtain theoretical (or calculated) resistance.
      c. Measured resistance shall not exceed 10 percent of calculated resistance.

D. Test each insulating joint after assembly and prior to backfilling for insulation, using methods generally accepted in corrosion control engineering. Repair or replace defective or ineffective insulating joint.
   1. Submit records of insulated joint testing including:
      a. Test method and instruments used, with sketch of test connections.
      b. Location of insulated joint, giving pipe station and/or street address.
      c. Instrument readings of current, voltage, and calculated resistance.

E. After Backfill is Completed and Test Stations are in Place:
   1. Test and verify continuity and electrical isolation of pipeline.
   2. Measure pipe-to-soil potentials in close interval over-the-line survey, continuously at electrode spacing not to exceed 5 feet. Relate contact points of reference electrodes to pipeline stations and known pipeline appurtenances.
   3. Make sketch of each test station terminal board and test lead wire hookups.
   4. Make plan view sketch of each test station location with physical features and GPS coordinates as follows: Horizontal Control--MD State Plane Coordinates NAD83/91 to 0.01 foot accuracy, Vertical Control--NGVD29 to 0.01 foot accuracy.

F. For Pipeline with Cathodic Protection System, perform following:
   1. Before anode connection:
      a. Close interval pipe-to-soil potential survey.

b. Pipe-to-soil potential at each test station.
c. Reference cell-to-pipe potential at each test station.
d. IR drop calculations (K factor).
e. IR drop measurements - current flow and direction.
f. Anode potential.

2. At time of anode connection:
   a. Connect anodes to an appropriate test lead wire and shunt in each test station.
   b. Pipe-to-soil potential at each test station.
   c. Reference-to-pipe potential at each test station.
   d. IR drop measurements - current flow and direction.
   e. Anode current output.
3. Three to 4 weeks following anode connection (i.e., cathodic protection system activation):
   a. Close interval pipe-to-soil potential survey.
   b. Pipe-to-soil potential at each test station.
   c. Reference cell-to-pipe potential at each test station.
   d. IR drop measurements - current flow and direction.
   e. Anode current output.

G. For Pipeline without Cathodic Protection System, perform following:
   1. Close interval pipe-to-soil potential survey.
   2. Pipe-to-soil potential at each test station.
   3. Reference cell-to-pipe potential at each test station.
   4. IR drop calculations (K factor).
   5. IR drop measurements - current flow and direction.

H. At stations where foreign structures are interconnected, check for stray current.
   1. If stray current is revealed, identify source, if possible, and inform Engineer of findings.

PART 4 MEASUREMENT AND PAYMENT

4.1 TEST STATIONS

A. Measurement: By each complete in place.

B. Payment: At unit price for each as listed in Bid Schedule.
   1. Payment includes provisions to provide test stations, including but not limited to, joint bonding, insulating joints, lead wires, anodes and other necessary components to complete corrosion control system.

CALCULATED RESISTANCE TABLE

DUCTILE IRON PIPE

Diameter in Inches	Class	Resistance Per Foot (OHM)

CALCULATED RESISTANCE TABLE

DUCTILE IRON PIPE

Diameter in Inches	Class	Resistance Per Foot (OHM)
4	51	0.0000762
4	52	0.0000688
4	53	0.0000628
4	54	0.0000578
4	55	0.0000536
4	56	0.0000500
6	51	0.0000486
6	52	0.0000441
6	53	0.0000404
6	54	0.0000373
6	55	0.0000346
6	56	0.0000323
8	50	0.0000380
8	51	0.0000343
8	52	0.0000313
8	53	0.0000288
8	54	0.0000266
8	55	0.0000248
8	56	0.0000233
10	50	0.0000287
10	51	0.0000261
10	52	0.0000239
10	53	0.0000221
10	54	0.0000205
10	55	0.0000192
10	56	0.0000180
12	50	0.0000225
12	51	0.0000206
12	52	0.0000190
12	53	0.0000176
12	54	0.0000164
12	55	0.0000154
12	56	0.0000145
14	50	0.0000182
14	51	0.0000167
14	52	0.0000155

CALCULATED RESISTANCE TABLE

DUCTILE IRON PIPE

Diameter in Inches	Class	Resistance Per Foot (OHM)
14	53	0.0000144
14	54	0.0000135
14	55	0.0000127
14	56	0.0000119
16	50	0.0000155
16	51	0.0000143
16	52	0.0000132
16	53	0.0000123
16	54	0.0000115
16	55	0.0000109
16	56	0.0000103
20	50	0.0000118
20	51	0.0000109
20	52	0.0000101
20	53	0.0000095
20	54	0.0000089
20	55	0.0000084
20	56	0.0000079
24	50	0.0000093
24	51	0.0000087
24	52	0.0000081
24	53	0.0000076
24	54	0.0000071
24	55	0.0000067
24	56	0.0000064
30	50	0.0000073
30	51	0.0000066
30	52	0.0000061
30	53	0.0000056
30	54	0.0000052
30	55	0.0000049
30	56	0.0000046
36	50	0.0000055
36	51	0.0000050
36	52	0.0000045
36	53	0.0000041
36	54	0.0000038

CALCULATED RESISTANCE TABLE

DUCTILE IRON PIPE

Diameter in Inches	Class	Resistance Per Foot (OHM)
36	55	0.0000035
36	56	0.0000033
42	50	0.0000043
42	51	0.0000039
42	52	0.0000035
42	53	0.0000032
42	54	0.0000029
42	55	0.0000027
42	56	0.0000025
48	50	0.0000035
48	51	0.0000031
48	52	0.0000028
48	53	0.0000025
48	54	0.0000023
48	55	0.0000021
48	56	0.0000019
54	50	0.0000028
54	51	0.0000025
54	52	0.0000022
54	53	0.0000020
54	54	0.0000018
54	55	0.0000017
54	56	0.0000015

Joint Bond Wire Resistances

#2AWG Wire	0.000162 OHM Per Foot
#4AWG Wire	0.000259 OHM Per Foot

WSSC