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USACE / NAVFAC / AFCESA / NASA **UFGS-26 42 13.00 20 (April 2006)**

Preparing Activity: NAVFAC **Replacing without change UFGS-13110N (September 2000)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2012
****

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DIVISION 26 - ELECTRICAL

SECTION 26 42 13.00 20

CATHODIC PROTECTION BY GALVANIC ANODES

04/06

-- End of Section Table of Contents --

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SECTION 26 42 13.00 20

CATHODIC PROTECTION BY GALVANIC ANODES
04/06

****
NOTE: This guide specification covers the requirements for underground piping and buried or submerged structure cathodic protection systems using galvanic anodes systems.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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NOTE: The requirements for the cathodic protection systems should be determined by a corrosion engineer following the criteria, design, and installation recommendations included in the National Association of Corrosion Engineers (NACE) Standard SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems and others listed in the specification.
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NOTE: The following information should be on the drawings:

1. Location of all underground pipes and structures.

2. Locations of all anodes and test stations.

3. Locations of all flanges and unions.

4. Installation details for anodes and test stations.

5. Location of equipment.

6. Single-line diagrams elevations, limiting dimensions, and equipment ratings which are not covered in the specification.

7. Remote indicating or control requirements.
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
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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.

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.25	(2007) Standard for Buttwelding Ends
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B18.2.1	(2010) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2010) Standard for Square and Hex Nuts

ASTM INTERNATIONAL (ASTM)

ASTM A194/A194M	(2011) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM B418	(2009) Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B843	(2007) Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM C94/C94M	(2011b) Standard Specification for Ready-Mixed Concrete
ASTM D1248	(2005) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2028	(2010) Cutback Asphalt (Rapid-Curing Type)
ASTM D3381/D3381M	(2009a) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM F1182	(2007) Anodes, Sacrificial Zinc Alloy

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012) National Electrical Safety Code

NACE INTERNATIONAL (NACE)

NACE SP0169	(1992; R 2007) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0285	(2011) External Corrosion Control of

Underground Storage Tank Systems by Cathodic Protection

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA RN 1	(2005) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-I-1361	(1985; Rev C; Notice 1 1991) Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors and Transformers

UNDERWRITERS LABORATORIES (UL)

UL 44	(2010) Thermoset-Insulated Wires and Cables
UL 486A-486B	(2003; Reprint Feb 2010) Wire Connectors
UL 510	(2005; Reprint Apr 2008) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2004; Reprint Apr 2010) Metallic Outlet Boxes
UL 514B	(2004; Reprint Nov 2009) Conduit, Tubing and Cable Fittings
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 83	(2008) Thermoplastic-Insulated Wires and Cables

[1.2 RELATED REQUIREMENTS

Sections 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, [33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION], and, [26 20 00 INTERIOR DISTRIBUTION SYSTEM], apply to this section except as modified herein.

]1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Insulating flange sets

Anode junction boxes, bonding boxes and test stations

Joint bonds

SD-03 Product Data

Anodes[; G][; G, [_____]]

Anode junction boxes, bonding boxes, and test stations

Insulating flange sets

Dielectric unions

Wires

Cable and wire

Casings, insulation, and seals

Shunt resistors

Permanent reference electrodes[; G][; G, [_____]]

SD-07 Certificates

Qualifications of Corrosion Engineer[; G][; G, [_____]]

SD-10 Operation and Maintenance Data

Cathodic Protection System, Data Package 5[; G][; G, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11, Closeout Submittals

Initial Cathodic Protection System Field Test Report[; G][; G, [_____]]

One Year Warranty Period Cathodic Protection System Field Test Report[; G][; G, [_____]]

Final Cathodic Protection System Field Test Report[; G][; G, [_____]]

1.4 Services of Corrosion Engineer

The Contractor shall obtain the services of a corrosion engineer to supervise, inspect and test the installation of the cathodic protection system(s). Corrosion Engineer refers to a registered professional engineer with certification of licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person accredited or certified by the National Association of Corrosion Engineers at the level of Corrosion Specialist or Cathodic Protection Specialist. Such a person shall have not less than [three] [five] [_____] years experience in the cathodic protection of underground [storage tanks] or submerged structures. The contractor shall submit evidence of the qualifications of corrosion engineer to the Contracting Officer for review and approval.

PART 2 PRODUCTS

2.1 ANODES

[2.1.1 Magnesium

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NOTE: The chemical composition listed is for high potential anodes in accordance with ASTM B843. Should standard magnesium anodes be considered suitable, provide appropriate chemical composition.

Specify chemical composition which will provide adequate and economical service. Three different grades are generally available.
****

[ASTM B843] Chemical composition as follows:

Aluminum	[0.01] [_____] percent maximum
Manganese	[0.5 to 1.3] [_____] percent
Zinc	[0] [_____] percent [maximum]
Silicon	[0.05] [_____] percent [maximum]
Copper	[0.02] [_____] percent maximum
Nickel	[0.001] [_____] percent maximum
Iron	[0.03] [_____] percent maximum
Other Impurities	0.05 percent each, 0.3 percent maximum total
Magnesium	Remainder

a. Bare anode weight: [4.1] [7.72] [14.53] [_____] kg [[9] [17] [32] [_____] pounds] [not including core].

][2.1.2 [Cast] [Wrought] Zinc

[ASTM B418, Type [I] [II].] [ASTM F1182.] Bare anode weight: [2.2] [13.62] [_____] kg [5] [30] [_____] pounds [not including core].

][2.1.3 Aluminum

Chemical composition as follows:

Zinc	[4.5] [_____] percent maximum
Indium	[0.02] [_____] percent maximum
Silicon	[0.01] [_____] percent maximum
Aluminum	Remainder

Anode Weight [_____] kg [_____] pounds not including core.

]2.1.4 Anode Wires and Core

2.1.4.1 Anode Lead Wires

[UL 83, Type [TW] [THWN] [THHN]] [ASTM D1248, Type HMWPE (High Molecular Weight Polyethylene)] [UL 44, Type RHW], [solid] [stranded] copper conductors, not less than [No. 12] [_____] AWG, [3050] [6100] [_____] mm

[10] [20] [_____] feet long, [of sufficient length to extend to the accompanying junction box without splicing]. Anode lead wire shall be factory installed. [Silver solder the lead wire to the anode core, and seal the soldered connection and recessed end of the anode with an [asphaltic] [epoxy] dielectric sealing compound.] [Silver solder the lead wire to the protruding anode core, and completely seal the soldered connection with an [asphaltic] [epoxy] dielectric material.] Dielectric material shall extend past the connection and cover the lead wire insulation by not less than 15 mm 1/2 inch. [Cover the connection with heat shrinkable tubing.]

2.1.4.2 Anode Core

Iron [galvanized steel] rod [pipe] [strap] [_____], [3] [6.35] [12.7] mm diameter [_____] by [_____] [1/8] [1/4] [1/2] inch diameter [_____] by [_____].

2.1.5 Anode Backfill

Chemical composition as follows:

Hydrated gypsum:	75 percent
Bentonite clay:	20 percent
Sodium sulfate:	5 percent

Provide granular backfill with 100 percent passing through a 150 micrometers 100 mesh screen. Provide prepackaged anode in a cloth bag containing the anode and backfill. Center the anode in the firmly packed backfill using spacers. Overall dimensions of the bagged [7.72] [14.53] [_____] kg [17] [32] [_____] pound anode shall be [165 by 432 mm] [203 by 535 mm] [[_____] by [_____] mm] [6.5 by 17 inches] [8 by 21 inches] [[_____] by [_____] inches] with a total minimum weight of [20.4] [33.6] [_____] kg [45] [74] [_____] poundsnominal.

2.2 ANODE JUNCTION BOXES, BONDING BOXES, AND TEST STATIONS

2.2.1 Flush Mounted Type

NEMA ICS 6. Metallic or non-metallic with terminal board, [5] [8] [_____] terminal posts [and lockable lid]. A non-metallic enclosure shall be molded of glass filled polycarbonate and urethane coated or ABS plastic [and mounted on a 500 mm 18 inch length of PVC conduit]. The unit shall be of standard design, manufactured for use as a cathodic protection test station, complete with cover, terminal board, shunts, and brass or Type [304] [316] stainless steel hardware. The terminal board shall be removable for easy access to wires. [Provide traffic valve box capable of withstanding [H-20] [_____] traffic loads.] The cover shall have a cast in legend "CP TEST."

2.2.2 Post Top Mounted Type

NEMA ICS 6. Metallic or non-metallic with terminal board, [5] [8] [_____] terminal posts and lockable lid. A non-metallic enclosure shall be high impact strength molded plastic. The unit shall be of standard design, manufactured for use as a cathodic protection test station, complete with cover, terminal board, shunts, and brass or Type [304] [316] stainless steel hardware. The terminal board shall be removable for easy access to wires. The test station shall be mounted atop 1830 mm 6 foot long polyethylene conduit with anchor.

2.2.3 Wall Mounted Type

NEMA ICS 6, Type [3R] [4X] [_____] enclosure with [clamped cover] [Type [304] [316] stainless steel hinges and [clamped] [latched] cover] [and padlocked hasp]. Enclosure shall be of [galvanized steel] [painted steel] [aluminum] [fiberglass] [non-metallic] construction with terminal board and labeled with nameplate. Provide nameplate in accordance with Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS. Enclosure mounting posts shall be [galvanized steel pipe,schedule [40] [80] [_____]], [wood post, full length pressure treated with pentachlorophenol] [as indicated]. Mount enclosure 1066 mm 42 inches above finished grade [as indicated].

2.2.4 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic [3] [6] [_____] mm [1/8] [1/4] [_____] inch thick with dimensions as indicated. Insulated terminal boards shall 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 shall be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes). Conductors shall be permanently identified by means of plastic or metal tags, or plastic sleeves to indicate termination. [Each conductor shall be color coded as follows:

Anode lead wire:	black
Structure lead wire:	white
Sodium sulfate:	red

]

2.2.5 Shunt Resistors

[MIL-I-1361.] [0.01] [_____] ohm, [6] [_____] ampere, accuracy plus or minus one percent, manganin wire type.

2.2.6 Pavement Insert

Pavement insert shall be a non-metallic flush type test station without terminal board, and shall 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.]

2.2.7 Cast-In-Place Concrete

Flush mount type test stations, bonding boxes, and anode junction boxes shall be centered in a 460 by 460 by 102 mm 18 by 18 by 4 inch concrete slab. Concrete shall be 20 Mpa 3000 psi minimum ultimate 28-day compressive strength with 25 mm one inch minimum aggregate conforming to [ASTM C94/C94M] [Section 03 30 00 CAST-IN-PLACE CONCRETE].

2.3 PERMANENT REFERENCE ELECTRODES

Permanent reference electrodes shall be [copper copper-sulfate] [silver silver-chloride] [zinc] specifically manufactured for [underground] [marine] use, [32] [_____] mm [1 1/4] [_____] inch diameter, by [255] [_____] mm [10] [_____] inches long, [plastic [_____] tube with an ion trap to minimize contamination of the cell] [, and a minimum surface sensing area of [_____] square centimeters[_____] square inches]. [The cell shall be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer.] Provide cells with No. [10] [12] [_____] AWG, [RHW] [THHN] [_____] cable of sufficient length to extend to the [test station] [junction box] without splicing. Reference electrodes shall have a minimum 15 year life, stability of plus or minus 5 millivolts under 3 microamp load, and an initial accuracy of plus or minus 10 millivolts referenced to a calibrated portable reference electrode.

2.4 CABLE AND WIRE OTHER THAN ANODE LEAD WIRES

[UL 83, Type [TW] [THWN] [THHN]] [ASTM D1248, Type HMWPE (High Molecular Weight Polyethylene)], [UL 44, Type RHW], [solid] [stranded] copper conductor, color coded and sized (based on AWG). Copper wires shall conform to ASTM B3 and ASTM B8. Lead wires terminating at a junction box or test station shall have a cable identification tag. [Do not use bare copper wire for joint continuity bonds.] Refer to paragraph 2.1.4 [_____] for anode lead wires.

2.5 CABLE AND WIRE IDENTIFICATION TAGS

[Laminated plastic material with black letters on a yellow background] [[Brass] [Stainless steel] material with engraved letters]. Print letters and numbers a minimum of 5 mm 3/16 inch in size. Provide identifier legend [in accordance with the drawings] [_____].

2.6 WIRE CONNECTORS

UL 486A-486B. [_____] [Solderless copper lugs]

2.7 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.

a. 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.

Gravity poured method shall 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.

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

2.8 CONDUIT

[UL 6, rigid galvanized steel], [Outlet boxes: UL 514A and fittings UL 514B, threaded hubs]. [Metallic conduit and fittings to be PVC coated in accordance with NEMA RN 1, Type A40], [NEMA TC 2, Type EPC-40-PVC].

2.8.1 Buried Cable Warning and Identification Tape

Polyethylene tape, manufactured for warning and identification of buried cable and conduit. Tape shall be [75] [_____] mm [3] [_____] inches wide, [Yellow] [_____] in color and read "Caution Buried Cable Below" or similar. Color and lettering shall be permanent and unaffected by moisture or other substances in backfill materials.

2.9 INSULATING TAPE

UL 510.

2.10 INSULATING FLANGE SETS

****

NOTE: On projects having piping installed by Division 2, SITEWORK and/or Division 15, MECHANICAL, coordinate the requirements for flanges and unions with the appropriate section(s).

****

Provide full-faced gaskets, insulating sleeves and washers, and steel washers. Provide insulating flange sets rated for operation at the rated pressure and temperature.

2.10.1 Gaskets

****

NOTE: Do not use asbestos materials.

****

ASME B16.21. [Neoprene faced phenolic] [Laminated phenolic] material for operation at [_____] KPa, [232] [_____] degrees C [_____] psi, [450] [_____] degrees F.

2.10.2 Insulating Washers and Sleeves

Two sets 3 mm 1/8 inch [laminated phenolic] [_____] for operation at [232] [_____] degrees C [450] [_____] degrees F. Insulating washers shall fit within the bolt facing on the flange over the outside of the fabric reinforced phenolic sleeve.

2.10.3 Washers

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

2.11 STEEL FLANGES AND BOLTING

2.11.1 Steel Flanges

ASME B16.5, [668 N] [1335 N] [150 lb.] [300 lb.].

2.11.2 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 shall extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at the roof of threads.

2.12 DIELECTRIC UNIONS

****

NOTE: On projects having piping installed by Division 2, SITEWORK and/or Division 15, MECHANICAL, coordinate the requirements for flanges and unions with the appropriate section(s).

****

ASME B16.39, Class [1] [2] for dimensional, strength, and pressure requirements. Insulation barrier shall limit galvanic current to one percent of the short-circuit current in a corresponding metallic joint. Provide insulating material impervious to [water] [oil] [gas].

2.13 EXOTHERMIC WELD KITS

Exothermic weld kits specifically designed by the manufacturer for welding the types of materials and shapes provided.

2.14 ELECTRICALLY INSULATING COATINGS

[Heat-shrinkable tape] [Conformable water tight sealant having dielectric strength not less than 15 kV for a 3 mm 1/8 inch thick layer].

2.15 CASING INSULATORS AND SEALS

Casing insulators shall have a minimum [305] [_____] mm [12] [_____] inch band width, [constructed of heat fused plastic coated steel] [_____] and multi-segmented to attach firmly around the pipe. Casing end seals shall be S-shaped rubber seals with stainless steel straps.

PART 3 EXECUTION

3.1 INSTALLATION

[NFPA 70] [IEEE C2].

3.1.1 Anodes and Lead Wires

Provide [each] anode and lead wires as follows:

a. Excavate hole to a minimum 75 mm 3 inches larger than the packaged anode diameter, [_____] mm [_____] feet deep.

b. Excavate lead wire trench to [610] [_____] mm [24] [_____] inches deep, [_____] mm [_____] inches wide.

c. 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.

d. Center the packaged anode in the hole with native soil in layers not exceeding 150 millimeters 6 inches. Hand tamp each layer to remove voids taking care not to strike the anode lead wire. When the backfill is 150 millimeters 6 inches above the top of the anode, pour not less than ten gallons of water into the hole to saturate the anode backfill and surrounding soil. Anodes shall not be backfilled prior to inspection and approval by the Contracting Officer.

e. Cover the lead wire trench bottom with a 75 mm 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 exceeding 150 mm six inches deep, compact each layer thoroughly. Do not place tree roots, wood scrap, vegetable matter and refuse in backfill. Place cable warning tape within [450] [_____] mm [18] [_____] inches of finished grade, above cable and conduit.

f. Connect anode lead wire(s) [to the test station terminal board(s)] [directly to the protected 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 kit(s) in accordance with the kit manufacturer's instructions. Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure]]. Allow sufficient slack in the lead wire to compensate for movement during backfilling operation.

g. Connect structure leads to structure 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 kit(s) in accordance with the kit manufacturer's instructions.] Conform to the safety precautions of paragraph 3.1.2 [_____] when welding around fuel facilities. Check and verify adherence of the bond to the substrate for mechanical integrity by striking the weld with a 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure.] Connect structure lead wires to the test station terminal board(s).

3.1.2 Safety Precautions For Welding Around Fuel Facilities

Contractor shall take proper safety precautions prior to and during welding to live fuel pipelines [tanks]. Contractor shall notify the activity Fuel Office via the Contracting Officer a minimum of three days before performing exothermic welding to live fuel lines. Exothermic welding shall be conducted with fuel 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 fuel lines shall be limited to a maximum 15 gram charge to prevent burning through the pipe wall. Exothermic weld connections shall be spaced a minimum of 150 millimeters 6 inches apart. In the event of an unsuccessful weld, the new weld location shall be located a minimum of 150 millimeters 6 inches from the unsuccessful weld and any other existing welds. Contractor shall obtain the services of a certified Marine Chemist or Certified Industrial Hygienist [to monitor the construction site during exothermic welding work and certify that the area is free of flammable vapors and otherwise safe for work.] [to approve the contractor's exothermic welding safety procedures. Results of this consultation shall be included in the Contractor's Daily Report.]

3.1.3 Anode Junction Boxes

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

3.1.4 Bonding Boxes

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

3.1.5 Test Stations [and Permanent Reference Electrodes]

Provide test stations [and permanent reference electrodes] [as indicated.] as follows:

a. At [305] [_____] meters [1000] [_____] foot intervals.

b. At all insulating 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.

3.1.5.1 Permanent Reference Electrode Calibration and Installation

Provide [prepackaged] [copper copper-sulfate] [silver-silver chloride] [zinc] reference electrode(s) as indicated in the drawings. Prior to installation, soak the [prepackaged] reference electrode in a container of potable water for 30 minutes. Do not use seawater [except for silver-silver chloride electrodes intended for use in seawater]. Calibrate the permanent reference electrode in the presence of the contracting officer or his approved representative by measuring the potential difference between the permanent reference electrode and an independent (portable) calibrated reference electrode placed in the water adjacent to the permanent reference electrode. [Potential differences between the two electrodes of the same generic type should not exceed [10] [15] millivolts when the [sensing windows of the] two electrodes being compared are not more than 2 mm 1/6 inch apart but not touching.] [Zinc permanent reference electrodes should be within the range of minus 1000 to minus 1150 millivolts when calibrated with an independent (portable) calibrated copper-copper sulfate reference electrode with the two electrodes being not more than 2 mm 1/6 inch apart but not touching.] Permanent reference electrodes not within these potential differences shall be removed from the construction site by the end of the day and replaced at the contractor's expense. [Prior to completely backfilling over reference electrodes, again verify the accuracy of the reference electrode.] The testing provision shall also apply to replacement reference electrodes as well.

3.1.6 Insulating Flange Sets

[Provide insulating flange sets aboveground or within manholes as indicated]. [Locate insulating flanges on lines entering buildings at least 305 mm 12 inches above grade or floor level.] [Cut piping and provide flanges into place. Carefully align flange bolt holes and weld flange to pipe in accordance with ASME B16.25.] [Electrically isolate pipelines entering buildings from the structure wall either below or above ground with an electrically isolating wall sleeve.] Provide insulating flange sets into place without springing or forcing. Carefully install flange bolt sleeves to avoid damage to the sleeves. [Cover insulating flanges with an electrically insulating coating.]

3.1.7 Dielectric Unions

[Cut pipe ends square, remove fins and burrs, cut taper pipe threads in accordance with ASME B1.20.1.] Provide insulating unions as indicated. 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 shall not be permitted. Engage threads so that not more than three threads remain exposed. [Cover unions with an electrically insulating coating.]

3.1.8 Joint Bonds

Provide joint bonds on metallic pipe to and across buried flexible couplings, mechanical joints, flanged joints [except at places where insulating joints are specified] 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 908 gram 2 pound hammer. Cover connections with an electrically insulating coating [which is compatible with the existing coating on the structure].

3.1.9 Casings, Insulation, and Seals

Where the pipeline is installed in a casing under a roadway or railway, insulate the pipeline from the casing, and seal the annular space against intrusion of water.

3.1.10 Concrete

Concrete shall be 20 Mpa 3000 psi minimum ultimate 28-day compressive strength with 25 mm one inch minimum aggregate conforming to [ASTM C94/C94M] [Section 03 30 00 CAST-IN-PLACE CONCRETE].

3.1.11 Reconditioning of Surfaces

3.1.11.1 Restoration of Sod

Restore unpaved surfaces disturbed during the installation of anodes and wires to their original elevation and condition. Preserve sod and topsoil carefully and replace after the backfilling is completed. Where the surface is disturbed in a newly seeded area, re-seed the area with the same quality and formula of seed as that used in the original seeding.

3.1.11.2 Restoration of Pavement

Repair pavement, sidewalks, curbs, and gutters where existing surfaces are removed or disturbed for construction. Saw cut pavement edges. Graded aggregate base course shall have a maximum aggregate size of 40 millimeters 1 1/2 inches. Prime base course with [liquid asphalt, ASTM D2028, Grade RC-70] [_____] prior to paving. Match base course thickness to existing but shall not be less than 150 millimeters 6 inches. Asphalt aggregate size shall be 15 mm 1/2 inch [_____], asphalt cement shall [conform to ASTM D3381/D3381M, Grade AR-2000] [_____]. Match asphalt concrete thickness to existing but shall not be less than 50 millimeters 2 inches. Repair portland cement concrete pavement, sidewalks, curbs, and gutters using 20.67 MPa 3,000 psi concrete conforming to [ASTM C94/C94M] [Section 03 30 00 CAST-IN-PLACE CONCRETE.] Match existing pavement, sidewalk, curb, and gutter thicknesses.

3.2 FIELD QUALITY CONTROL

Field tests shall be witnessed by the Contracting Officer or his designated representative. Advise the Contracting Officer [5] [_____] days prior to performing each field test. Quality control for the cathodic protection system shall 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.

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NOTE: Additional testing may be required based upon the specific project or design. All tests listed below may not be required. Designer should consider the project requirements for selection of test procedures. Specify 30 days notice for large systems to allow the Government corrosion engineer to be on-site during the initial and final field testing of the cathodic protection systems.

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3.2.1 Testing

3.2.1.1 Non-Destructive Testing of Anodes

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

minus 1.0 to minus 1.15 Volts

High potential Magnesium	minus 1.65 to minus 1.75 Volts
Standard Magnesium	minus 1.4 to minus 1.5 Volts
Zinc	minus 1.0 to minus 1.15 Volts

[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 shall mark all rejected anodes on the ends with a 6" high "X" using yellow spray paint. Failed anodes shall be removed from the job site by the end of the day. The contractor shall replace any rejected anodes at his expense. The destructive testing provision shall also apply to replacement anodes as well.]

3.2.1.2 Destructive Testing of Anodes

Contractor shall perform the tests in the presence of the Contracting Officer. Contractor shall include the cost of an additional anode [of each different type] with the longest lead wire for the destructive test in his bid. One completed [prepackaged] anode of each type with lead wires shall be chosen at random for destructive testing and shall be submitted to a static pull test. Anode wire connections shall have sufficient strength to withstand a minimum tensile load of [136] [_____] kg [300] [_____] pounds. [The anode shall also be cut into sections and/or broken with a sledge hammer to verify conformance with this specification. Such items as anode-to-wire connection, complete encapsulation of the wire connector, and wire to anode electrical resistance shall be checked.] [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 shall mark all rejected anodes on the ends with a 6" high "X" using yellow spray paint. Failed anodes shall be removed from the job site by the end of the day. The contractor shall replace any rejected anodes at his expense. The destructive testing provision shall also apply to replacement anodes as well.]

3.2.1.3 Initial Cathodic Protection System Field Testing

Systems shall be tested and inspected by the Contractor's corrosion engineer in the presence of the Contracting Officer's corrosion protection engineer or an approved representative. Record test data, including date, time, and locations of testing and submit report to the Contracting Officer. Contractor shall correct and retest, at his expense, deficiencies in the materials and installation observed by these tests and inspections. Testing shall include the following measurements.

a. Base potential tests: At least [one week] [24 hours] [_____] after [backfilling of the pipe] [installation of structure to be protected] [initial operation of structures containing fluids] and installation of the anodes, but before connection of anodes to the structure, measure base (native) structure-to-electrolyte potentials of the [pipe [and casings]] [structure]. 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 [30] [120] [_____] meters [100] [400] [_____] feet [with readings at each end point and the midpoints as a minimum]. The locations of these measurements shall 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.

[For underground storage tanks, take a minimum of three measurements with the reference electrode located as follows:

(1) Directly over the longitudinal and transverse centerlines of the tank at intervals not exceeding the diameter of the tank and to a distance from the tank of two times the tank diameter.

(2) At points directly around the circumference of the tank.]

(a) Permanent reference electrode calibration: Verify calibration of the reference electrode by measuring the potential difference between the permanent reference electrode and an independent (portable) calibrated reference electrode placed in the soil or water adjacent to or as close as practicable to the permanent reference electrode. [Potential differences between the two electrodes of the same generic type should not exceed [10] [15] millivolts.] [Zinc permanent reference electrodes should be within the range of minus 1000 to minus 1150 millivolts when calibrated with a copper-copper sulfate reference electrode.] Permanent reference electrodes not within these potential differences shall be removed from the construction site by the end of the day and replaced at the contractor's expense. The testing provision shall also apply to replacement reference electrodes as well.

(b) Insulation joint testing: Perform insulation testing at each insulating joint or fitting [prior to burying the joint or fitting] before and after the connection of anodes to the pipe at [anode junction box] [test station]. Before connection, test using an insulation checker. After connection, test by measuring the potential shift on both sides of the insulating joint. These tests shall demonstrate that no metallic contact or short circuit exists between the two insulated sections of the pipe. Report and repair defective insulating flanges at the Contractor's expense.

(c) Electrical continuity testing: Perform electrical continuity testing for joint bonded pipe prior to backfilling of the pipe. [Circulate current through the pipe and compare the measured resistance to the theoretical resistance of the pipe and bond cables. The resistance measured shall not exceed 150 percent of the theoretical resistance.]

(d) Pipe casing testing: Before final acceptance of the installation, test the electrical insulation of the carrier pipe from casings and correct any short circuits.

(e) Anode-to-soil potential and anode output testing: Measure anode-to-soil potential of each anode with the anode disconnected [through the anode junction box]. After connecting the anodes to the pipe, measure current output of each anode [across the shunt installed].

(f) Protected potential measurement tests: With the entire galvanic protection system put into operation for at least [one week] [24 hours] [_____], measure potentials along the [pipeline [and at all casings]] [structure] using a portable [copper-copper sulfate] [silver-silver chloride] [and all permanent] reference electrodes and a voltmeter having an input impedance of not less than 10 megohm. The locations of these measurements shall be identical to the locations used for the base potential measurements.

(g) Interference testing: Perform interference testing with respect to any crossing and nearby foreign pipes in cooperation with the owner of the foreign pipes. The testing shall verify that the cathodic protection system does not have a deleterious effect on the foreign pipelines, and vice versa. Prepare a full report of the tests giving all details including remedial actions taken or recommendations to correct noted interference problems.

3.2.1.4 Initial Cathodic Protection System Field Test Report

The contractor shall submit a field test report of the cathodic protection system. All structure-to-electrolyte measurements, including initial potentials and anode outputs, shall be recorded on applicable forms. Identification of test locations, test station and anode test stations shall coordinate with the as-built drawings and be provided on system drawings included in the report. The contractor shall locate, correct, and report to the Contracting Officer any short circuits encountered during the checkout of the installed cathodic protection system.

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NOTE: The requirements of paragraph entitled "Government Field Testing" are required for cathodic protection projects in the NAVFAC LANT area. The designer should verify their applicability to projects outside the NAVFAC LANT area with the appropriate EFD corrosion program manager.

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3.2.1.5 Government Field Testing

The government corrosion [engineer, NAVFAC LANT Code 404] [program manager, NAVFAC LANT Code 1614C] shall review the Contractor's initial field testing report. Approximately four weeks after receipt of the Contractor's initial test report, the system will be tested and inspected in the Contractor's presence by the government corrosion [engineer, NAVFAC LANT Code 404] [program manager, NAVFAC LANT Code 1614C]. The Contractor shall correct, at his expense, materials and installations observed by these tests and inspections to not be in conformance with the plans and specifications. The Contractor shall pay for all retesting done by the government engineer made necessary by the correction of deficiencies.

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NOTE: For cathodic protection projects in the NAVFAC LANT area, select the appropriate NAVFAC LANT options for paragraphs entitled "One Year Warranty Period Testing" and "Final Field Testing."

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3.2.1.6 One Year Warranty Period Testing

The Contractor shall inspect, test, and adjust the cathodic protection system [quarterly] [semi-annually] [_____] for one year, [4] [2] [_____] interim inspections total, to ensure its continued conformance with the criteria outlined below. The performance period for these tests shall commence upon the completion of all cathodic protection work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the cathodic protection system by the Contracting Officer. Copies of the One Year Warranty Period Cathodic Protection System Field Test Report, including field data, and certified by the Contractor's corrosion engineer shall be submitted to the Contracting Officer, the activity, and the geographic Engineering Field Division corrosion [protection program manager] [engineer, NAVFAC LANT Code 404] [protection program manager, NAVFAC LANT Code 1614C].

3.2.1.7 Final Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures specified under, "Initial Field Testing of the Galvanic Cathodic Protection Systems". The Contractor shall inspect, test, and adjust the cathodic protection system after one year of operation to ensure its continued conformance with the criteria outlined below. The performance period for these tests shall commence upon preliminary acceptance for the cathodic protection system by the Contracting Officer. Copies of the Final Cathodic Protection System Field Test Report, certified by the Contractor's corrosion engineer shall be submitted to the Contracting Officer and the geographic Engineering Field Division corrosion [protection program manager] [engineer, NAVFAC LANT Code 404] [protection program manager, NAVFAC LANT Code 1614C] for approval, and as an attachment to the operation and maintenance manual in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.2.2 Criteria for Cathodic Protection

Conduct in accordance with [NACE SP0169] [NACE SP0285]. Criteria for determining the adequacy of protection shall be selected by the corrosion engineer as applicable:

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NOTE: The following criteria are applicable only to iron and steel structures. Refer to NACE SP0169 for appropriate criteria for other metal structures. Not all criteria may be readily applicable to the type of CP system(s) being designed, and the designer should select only the applicable criteria.

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a. A negative voltage of at least 0.85 volt (850 millivolts) as measured between the structure surface and a saturated copper- copper sulfate reference electrode contacting the earth [electrolyte]. Determination of this voltage is to be made with the protective current applied to the [structure] [tank] [pipeline] for a minimum of [24] [_____] hours. Voltage drops must be considered for valid interpretation of this voltage measurement. The method of voltage drop consideration shall be identified by the Contractor's corrosion engineer and approved by the Government corrosion engineer.

b. A negative polarized potential of at least 0.85 volt (850 millivolts) as measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the earth [electrolyte]. Determination of this voltage is to be made after the protective current has been applied to the [structure] [tank] [pipeline] for a minimum of [24] [_____] hours.

c. A minimum polarization voltage shift of 100 mV measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the earth [electrolyte]. This voltage shift shall be determined by interrupting the protective current and measuring the polarization decay. At the instant the protective 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 measure the polarization decay. The polarization decay shall be the difference between the base reading and a voltage measurement made [24] [48] [_____] hours after the interruption of protective current.

3.3 DEMONSTRATION

3.3.1 Instructing Government Personnel

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NOTE: There are restrictions on the type and extent of training. Training is usually on-site, 2 days or less. Factory representatives or others provide basic instructions to facility maintenance and operation personnel. If more extensive training is required, i.e., student travel, special consultants, etc., consult the Contract Division Director and the head of the Comptroller Department for assistance.

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During the warranty testing and at a time designated by the Contracting Officer, make available the services of a technician regularly employed or authorized by the manufacturer of the Cathodic Protection System for instructing Government personnel in the proper operation, maintenance, safety, and emergency procedures of the Cathodic Protection System. The period of instruction shall be not less than [one] [_____] but not more than [two] [_____] 8-hour working day[s]. Conduct the training at the jobsite or at another location mutually satisfactory to the Government and the Contractor. The field instructions shall cover all of the items contained in the operation and maintenance manual.

3.4 SCHEDULE

Some metric measurements in this section is based on a mathematical conversion of an English unit measurement, and not on metric measurement commonly agreed upon by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
a. Reference Electrodes		
Diameter	1 1/4 inches	32 mm
Length	10 inches	255 mm
b. Warning Tape Width	3 inches	75 mm

-- End of Section --