****
USACE / NAVFAC / AFCESA **UFGS-13112N (March 2000)**

Preparing Activity: NAVFAC **Replacing without revision NFGS of same number and date**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005
****

SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13112N

CATHODIC PROTECTION SYSTEM (STEEL WATER TANKS)

03/00

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCESA **UFGS-13112N (March 2000)**

Preparing Activity: NAVFAC **Replacing without revision NFGS of same number and date**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005
****

SECTION 13112N

CATHODIC PROTECTION SYSTEM (STEEL WATER TANKS)
03/00

****
NOTE: This guide specification covers the requirements for steel water tank cathodic protection systems using impressed current systems and galvanic anodes.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents**, including their organization designation and telephone number, is on the Internet.**

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR)**.**

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

****
NOTE: One of the major factors influencing selection of the type of cathodic protection system is the resistivity of the water involved. When the water resistivity is higher than 10,000 ohm-cm, impressed current systems are usually used. Other considerations include availability of electric power and the costs of installation, operation and maintenance. Where relatively small amounts of current are required or where energy is not readily available and water resistivity is low, galvanic anodes may be applied. Where relatively large currents are required and reasonable access to power is available, the impressed current system will generally be found to be more economical. 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 Standard; RPO-388, "Impressed

Current Cathodic Protection of Internal Submerged Surfaces of Steel Water Tanks", and RP0-196, "Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Tanks."

****

****

NOTE: The following information should be shown on the drawings:

1. Dimensions of tank, including riser (if tank is elevated), structural supports and overflow.

2. Locations of all anodes, reference electrodes, junction boxes, test boxes, rectifiers, power connections, wire and conduit.

3. Installation details for anodes and rectifiers.

4. Electrical single-line diagrams, elevations, limiting dimensions, and equipment ratings which are not covered in the specification.

5. Remote indicating or control requirements.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C119.1	(2002) Sealed Insulated Underground Connector Systems Rated 600 Volts

ASTM INTERNATIONAL (ASTM)

ASTM A 518	(1992) Corrosion-Resistant High-Silicon Iron Castings
ASTM A 518M	(1992; R 1997) Corrosion-Resistant High-Silicon Iron Castings (Metric)
ASTM B 3	(2001) Soft or Annealed Copper Wire
ASTM B 8	(2004) Concentric-Lay-Stranded Copper

	Conductors, Hard, Medium-Hard, or Soft
ASTM B 843	(1993; R 2003) Magnesium Alloy Anodes for Cathodic Protection
ASTM D 1248	(2004) Polyethylene Plastics Extrusion Materials for Wire and Cable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2002) National Electrical Safety Code

NACE INTERNATIONAL (NACE)

NACE RP0196	(2004) Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks
NACE RP0388	(2001) Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Tanks

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA FU 1	(2002) Low Voltage Cartridge Fuses
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA RN 1	(1998) Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)
NEMA TC 2	(2003) Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

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

UNDERWRITERS LABORATORIES (UL)

UL 44	(1999; Rev thru May 2002) Thermoset-Insulated Wires and Cables
UL 467	(2004) Grounding and Bonding Equipment
UL 486A-486B	(2003; Rev thru Apr 2004) Wire Connectors
UL 489	(2002; Rev thru May 2003) Molded-Case

	Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 506	(2000; Rev thru Feb 2004) Specialty Transformers
UL 510	(2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 514A	(2004) Metallic Outlet Boxes
UL 514B	(2004) Conduit, Tubing and Cable Fittings
UL 6	(2000; Rev thru May 2003) Rigid Metal Conduit
UL 83	(2003; Rev thru Mar 2004) Thermoplastic-Insulated Wires and Cables
UL 854	(2004) Service-Entrance Cables

[1.2 Related Requirements

Sections 16050N BASIC ELECTRICAL MATERIALS AND METHODS, [16302N UDERGROUND TRANSMISSION AND DISTRIBUTION], and, [16402 INTERIOR DISTRIBUTION SYSTEM], apply to this section except as modified herein.

]1.3 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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 projects.

Submittal items not designated with a "G" are

considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.
****

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 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Rectifier installation

Anode installation

Wiring and schematic diagram

Anode junction boxes

SD-03 Product Data

[Rectifiers; G]

[Impressed current anodes; G]

[Galvanic anodes; G]

Permanent reference electrodes; G

Shunt resistors

Include certified test data for the impressed current anodes stating the maximum recommended anode current output density and the rate of gaseous production if any at that current density.

SD-07, Certificates

Qualifications of Corrosion Engineer; G

SD-10 Operation and Maintenance Data

Cathodic Protection System, Data Package 5; G

Submit in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Initial Cathodic Protection System Field Test Report; G

One Year Warranty Period Cathodic Protection System Field Test Report; G

Final Cathodic Protection System Field Test Report; 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 or licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person certified by the National Association or 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 water [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

****

NOTE: Anode materials, as well as all cathodic protection equipment to be installed in the tank, should be chosen such that there is no contamination of potable water. The type of system to be used, either impressed current or galvanic, must be determined. Select the paragraphs entitled "Impressed Current Anodes" or "Galvanic Anodes" below.

****

[2.1 Impressed Current Anodes

****

NOTE: Choose from anodes listed below. The chemical composition listed are examples only. The actual compositions required shall be determined to provide adequate and economical service.

****

2.1.1 High-Silicon Chromium Bearing Cast Iron

****

NOTE: High-silicon cast iron anodes are rugged, long lasting, and commonly used in icing and non-icing climates. They are generally classified as relatively non-sacrificial having a consumption rate between 227 to 454 grams 0.5 to 1.0 pounds per ampere-year in most fresh waters.

****

Provide cast iron anodes of the following composition and size as indicated.

a. [ASTM A 518M] [ASTM A 518] [Chemical composition:

Carbon	0.70 - 1.10 percent
Manganese	1.50 percent maximum
Silicon	14.20 - 14.75 percent
Chromium	3.25 - 5.00 percent
Copper	0.50 percent maximum
Molybdenum	0.20 percent maximum
Iron	Remainder]

b. Electrical resistivity: 72 micro-ohm-centimeter at minus 6.6 degrees C 20 degrees F (maximum).

c. Physical properties (nominal):

Tensile strength	103.4 MPa 15,000 psi
Compressive strength	689.4 MPa 100,000 psi
Brinell hardness	520
Density	7.0 grams per cubic centimeter
Melting point	1260 degrees C 2300 degrees F

Coefficient of expansion from zero to 100 degrees C 32 to 212 degrees F: 0.0000132 centimeter per degree C 0.00000733 centimeter per degree F.

2.1.2 Aluminum Anodes

****
NOTE: Aluminum anodes are used in cases where annual or frequent replacement is required due to ice damage, and routine cleaning of the tank makes it possible to remove any expended or broken pieces of anode stock from the tank before they accumulate.
****

Provide aluminum anodes of the following nominal composition and size as indicated:

Copper	4.0 percent maximum
Magnesium	0.5 percent maximum
Manganese	0.5 percent maximum
Aluminum	Remainder

2.1.3 Precious Metal Anodes

****
NOTE: At installations where icing conditions exist and the scaling index of water is less than 20,000 (i.e., low hardness water), the designer should consider using precious metal anodes, such as platinized niobium, platinized titanium, or mixed metal oxide for cathodic protection systems. The consumption rate of precious metal anodes is less than that of other relatively non-sacrificial anodes. However, precious metal anodes are more vulnerable to damage and loss particularly during cleaning and reconditioning of the tank.

Selection of the configuration should be left to the designer of the system. Long, continuous wire from lengths of precious metal anodes may have an attenuating effect. This can be overcome by using parallel feeder cable connected to segmented lengths of precious metal anodes at intervals. Such assemblies must be assembled with factory sealed with tested electrical connections to the anodes.
****

Provide [precious metal anodes] [_____] [solid] [composite] [wire] [rod] [expanded mesh] [ribbon] in form. Anode core shall be [copper] [niobium] [titanium] with [platinum] [mixed metal oxide] [_____] coating with thickness of [_____] millimeter mils. Size and length as indicated.

][2.2 GALVANIC ANODES

2.2.1 Magnesium Anodes

[ASTM B 843] Chemical composition as follows:

CHEMICAL COMPOSITION

Aluminum	[0.01 maximum] [2.5 - 3.5] percent
Manganese	[0.50 - 1.30] [0.2 minimum] percent
Zinc	[0] [0.7 - 1.3] percent
Silicon	[0] [0.05 maximum] percent
Copper	[0.02] [0.01] percent maximum
Nickel	0.001 percent maximum
Iron	[0.03] [0.002] percent maximum
Other Impurities	0.05 each or 0.30 percent maximum total
Magnesium	Remainder

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

]2.3 ANODE LEAD WIRES

****

NOTE: Any pinhole, cut, scratch or other damage to the anode cable exposing bare copper to the electrolyte will result in early failure of the impressed current cathodic protection system. For this reason, special, extra heavy insulation is used on anode cable.

****

No. [8] [_____] AWG, stranded copper wire conforming to ASTM B 3 and ASTM B 8. Provide wires with [2.8 mm110 mils [_____] thick, ASTM D 1248, high molecular weight polyethylene (HMWPE) insulation] [a primary insulation of ethylene propylene rubber and an outer jacket of chloro sulphonated polyethylene insulation]. Wires shall be [3050] [6100] [_____] mm [10] [20] [_____] feet in length [of sufficient length to extend to the anode header cable [junction box] without splicing].

2.3.1 Attachment of Anode Lead Wire

Anode lead wires shall be factory installed.

2.3.1.1 End Connected Anode

[Drill] [Cast] a recess [150] [_____] mm [6] [_____] inches deep in one end of the anode. Attach the lead wire to the anode with an anchor device. Not more than 10 mm 1/2 inch of bare wire shall protrude from the anchor device. Attachment shall withstand a 1446 Newton 325 pound pull without loosening the wire or anchor device. Fill the recess with an epoxy sealing compound [, leaving sufficient space for a plug]. [Provide non-metallic plug flush with the anode end surface.] [Install a heat shrinkable anode cap over the attachment, cap shall extend not less than 65 mm 2 1/2 inches on the lead wire and 75 mm 3 inches on the anode.] Cable to anode contact resistance shall be 0.02 ohms maximum.

2.3.1.2 Center Connected Anode

Attach the lead wire to the center of the anode with an anchor device suitably fastened to the wire. Not more than 20 mm one inch of bare wire shall protrude from the anchor device. Encapsulate [each side of] the connection point with [a minimum of 152 mm 6 inches [_____] of] high voltage insulating compound mastic and 102 mm 4 inches [_____] of epoxy resin. Attachment shall withstand [4000] [6675] [_____] N [900] [1500] [_____] pounds pull without loosening the wire or anchor device. Provide a non-metallic [plug flush with the anode end] [end cap] to prevent chaffing of the anode lead wire. Cable to anode contact resistance shall be 0.02 ohms maximum.

2.3.1.3 Mixed Metal Oxide Anode Lead Wires

[[Solidly crimp] [and solder] the connection between the anode rod or ribbon and the lead wire. Seal the connection [with two layers of half lapped mastic tape covered with a heat shrinkable sleeve] [in cast epoxy].] [Tin and anneal the copper wire and hydraulically swage the tubular anode onto copper bushings in contact with the wire. Place a 28 mm 1 1/8 inch long copper sleeve, inner diameter slightly larger than the tubular anode outer diameter, over the tube prior to swaging.] Cable to anode contact resistance shall be 0.02 ohms maximum.

2.4 RECTIFIERS

****

NOTE: FOR USE ONLY WITH IMPRESSED CURRENT SYSTEMS. Air-cooled rectifiers will be used for most applications. Where highly corrosive atmosphere exist, the equipment will be oil-immersed in a tank type housing. For hazardous area applications, oil-immersed equipment will be provided with an explosion-proof or dust-ignition-proof housing, as appropriate. Transformer tap adjusters will be provided in cases where an automatic system is not provided. Variacs should not be used where subjected to corrosive or marine air atmospheres.

****

2.4.1 Transformers

UL 506 and NEMA ST 1, as applicable.

2.4.2 Electrical Ratings

Electrical ratings as follows: Input voltage at 60 Hz: [[115] [208] [230] volts single phase] [[208] [230] [460] volts three phase]

a. Output voltage, dc: [9] [12] [18] [24] [_____] volts [as indicated].

b. Output current, dc: [8] [16] [24] [32] [_____] amperes [as indicated].

The rectifier shall be capable of supplying continuous full rated output at an ambient temperature of 44 degrees C 112 degrees F in full sunlight with expected life of 10 years minimum.

2.4.3 Rectifying Elements

Provide silicon diode rectifying elements, connected in such manner as to provide full-wave rectification. [Silicon diodes shall be protected by selenium cells or varistors against overvoltage surges and by current limiting devices against overcurrent surges.]

[2.4.4 Enclosure

****
NOTE: Choose this paragraph for air cooled rectifier enclosures or the paragraph below entitled "Oil Immersed Enclosures." Oil immersed enclosures shall be used where highly corrosive atmospheres exist. When locating oil immersed rectifiers near buildings, consult with paragraph 3.2.3 of MILHDBK 1008C for fire safety requirements.
****

NEMA ICS 6, Type [3] [3X] [4X] [7] [_____], suitable for [wall] [post] [pad] mounting. Enclosure shall include hinged door with [padlock hasp] [key lock, provide [three] [_____] keys.] [Enclosure locks shall be keyed alike.] Fit enclosure with screened openings to provide for cooling by natural convection. Provide holes, conduit knockouts and threaded hubs of sufficient size and location. The cabinet and mounting support shall be [painted] [hot-dipped galvanized] [stainless] steel [according to the manufacturer's standards].

][2.4.5 Oil Immersed Enclosures

Provide enclosures of 11-gage steel or heavier, with an accessible drain plug. Provide a hinged lid with quick release clamps to secure it in a closed position. The oil level shall be clearly marked. Provide a compressive, oil resistance, positive sealing gasket. Based mounting shall have 100 mm 4 inch high channels. Provide an internal terminal board and connections above oil level for monitoring and adjustment. The cabinet and mounting support shall be [painted] [hot-dipped galvanized] [stainless] steel [according to the manufacturer's standards].

]2.4.6 Wiring and Schematic Diagram

Provide a complete wiring and schematic diagram of the power unit showing both the A.C. and the D.C. connections to anodes on the inside of the cabinet door. Show and label components.

2.4.7 Overload and Short Circuit Protection

UL 489, single-pole, flush-mounted molded case circuit breaker, [magnetic] [thermal-magnetic] type, shall be installed in the primary circuit of the rectifier supply transformer.

2.4.8 D.C. Output Control

D.C. output voltage shall be adjustable by [transformer taps] [automatic controls].

[2.4.8.1 Transformer Taps

****
NOTE: A minimum of five coarse and five fine taps is recommended to provide sufficient voltage adjustment. Variacs should not be used where subjected to corrosive or marine air atmospheres.
****

[Transformer taps, [5] [_____] coarse, [5] [_____] fine.] [Variac.] [_____].

][2.4.8.2 Automatic Controls

Provide control system capable of maintaining a preselected tank-to-water potential, within plus or minus 0.025 volt regardless of changes in water chemistry, temperature, or water level in the tank. [Provide separate D.C. output circuits, means of adjustment, reference electrodes, and metering for the tank bowl and riser pipe.] Provisions shall be made for readily changing the range and limits of the operating potential.

]2.4.9 Output Voltage and Current Meters

Provide separate panel voltmeter and ammeter, not less than 63.5 mm 2 1/2 inch [round] [rectangular] 2 percent full scale accuracy at 30 degrees C 80 degrees F, temperature stability above and below 30 degrees C 80 degrees F of at least 1 percent per 5 degrees C 10 degrees F. Provide toggle switch for each meter.

2.4.10 Grounding Provisions

NFPA 70 and UL 467, including a grounding terminal in the cabinet. The grounding conductor from the terminal to the earth grounding system shall be solid or stranded copper not smaller than No. 6 AWG. The earth grounding system shall consist of one or more 15.89 mm 5/8 inch diameter copper-clad steel rods. Provide minimum 2440 mm 8 feet long ground rod.

2.4.11 Fuses

Cartridge-type fuses conforming to NEMA FU 1. Provide suitable fuse holders in each leg of the D.C. circuit.

2.4.12 Surge Protection

Protect silicon diodes by use of AC and DC lightning arresters or metal oxide varistors against overvoltage surges and by current-limiting device against overcurrent surges.

2.4.13 Efficiency

Overall efficiency of [65 percent] [90 percent] [_____] minimum when operated at full output.

2.4.14 Rectifier Replacement/Spare Parts List

Provide identification and coverage for all parts of each component, assembly, and accessory of the items subject to replacement in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

2.5 REFERENCE ELECTRODES

[Zinc] [copper-copper sulfate] type provided with micro-pore diffusion window for water contact and water-tight plug for renewal of copper sulfate crystals and solution. Provide cells with No. [10] [12] [_____] AWG, stranded copper conductor with 2.8 mm 110 mils [_____] thick ASTM D 1248, high molecular weight polyethylene (HMWPE) insulation 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.

2.6 SHUNT RESISTORS

[0.01] [_____] ohm, [6] [_____] amp, with an accuracy of plus or minus one percent. [Shunts shall conform to MIL-I-1361 [rating as shown]].

2.7 CONDUIT

[UL 6, rigid galvanized steel.] [Outlet boxes: UL 514A and Fitting: UL 514B, threaded hubs.] [Metallic conduit and fittings to be polyvinyl-chloride coated in accordance with [NEMA RN 1, Type A40] [NEMA TC 2, Type EPC-40-PVC]]. Nonmetallic conduit shall conform to NEMA TC 2. Provide conduit support in accordance with NFPA 70.

2.8 CABLE OTHER THAN ANODE LEAD WIRES

****

NOTE: Any pinhole, cut, scratch or other damage to the anode cable exposing bare copper to the electrolyte will result in early failure of the impressed current cathodic protection system. For this reason, special, extra heavy insulation is used on anode cable.

****

Copper wire conforming to ASTM B 3 and ASTM B 8. Wires terminating in a rectifier, junction box or test station shall have a cable identification tag. Refer to paragraph 2.1.4 [_____] for anode lead wires.

2.8.1 AC Power Supply Wiring

[UL 83, Type [THW] [THWN] [TW]] [UL 44, Type RHW,] [UL 854, Type USE], stranded [solid] copper conductors, gage (AWG) and color coded as indicated.

2.8.2 Anode Wire

Type CP [ASTM D 1248, High Molecular Weight Polyethylene (HMWPE)] [cross linked polyethylene (XLPE)] insulation, stranded copper conductors, gage (AWG) as indicated.

2.8.3 Rectifier DC Positive (Anode) Header Cable

Type CP [ASTM D 1248, High Molecular Weight Polyethylene (HMWPE)] [cross linked polyethylene (XLPE)] insulation, stranded copper conductors, gage (AWG) as indicated. Refer to paragraph 2.1.4 [_____] for anode lead wires.

2.8.4 Cable Identification Tags

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

2.8.5 Wire Connectors

UL 486A-486B.

2.8.6 Insulating Tape

UL 510.

2.8.7 Splices

[Splices are not permitted in submerged sections of anode lead wire or anode header cable.] Provide splices with a compression connector on the conductor, 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.

   (1) 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.

2.9 ANODE JUNCTION BOXES

2.9.1 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.

2.9.2 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 16050N GENERAL 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].

2.9.3 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
Reference electrode lead wire - red]

2.10 CLEVIS ASSEMBLIES

Provide clevis assemblies, 6.35 mm 1/4 inch flat steel with a spool opening of 53.975 mm 2 1/8 inch, 114.3 mm 4 1/2 inch long to the centerline of the spindle. Provide porcelain spools, with an outside diameter of 57.15 mm 2 1/4 inch and an overall height of 53.975 mm 2 1/8 inch.

2.11 PIN INSULATORS

Provide pin insulator assemblies, 100 mm 4 inches long overall and 6.35 mm 1/4 inch diameter aluminum bolt 19 mm 3/4 inch long attached to the flat end with a aluminum nut and lock washer. Provide porcelain insulator of non-conducting material with hard glazed finish. Provide insulator with a hole through the bottom no smaller than 13 mm 1/2 inch diameter.

2.12 HANDHOLE ASSEMBLIES

Provide aluminum handhole covers, 175 mm 7 inches in diameter and 1.588 mm 1/16 inch thick and connected to insulating rubber gasket, 175 mm 7 inches in diameter and 3.175 mm 1/8 inch thick. Cut handholes 150 mm 6 inches in diameter. Provide handhole assemblies with 12.7 mm 1/2 inch bolts and 6.35 mm 1/4 inch plate clamping bars.

2.13 EXOTHERMIC WELD KITS

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

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Anode Installation

****
NOTE: Proprietary systems of anode installations are available for areas where icing is expected. For such areas paragraph entitled "Icing Climates" below should be included.
****

[IEEE C2] [NFPA 70].

[3.1.1.1 Icing Climates

Suspend anodes in a manner similar to that in non-icing climates, except provisions shall be made to prevent the anodes and suspending cables from being damaged by freezing or falling ice. Contractor shall certify that the method has been used successfully for similar applications.

]3.1.1.2 Anode Placement

Arrange anodes in the tank [and riser pipe] as shown in the drawings [so that protection can be provided to surfaces without exceeding potentials [in the vicinity of the anodes] that will be detrimental to coatings]. Suspend anodes from roof [plate] [structurals] by means of factory-installed connecting wire designed to support the anodes in air [before submergence] without failure of the electrical wire insulation or the electrical conductors. Prevent contact between anode and tank surfaces such as man-access hatches, ladders, heater pipes, and stay rods.

3.1.1.3 Anode Hangers

Anode hangers shall electrically insulate the anode suspending wire from the tank steel.

3.1.1.4 Handholes

Provide a handhole having a diameter of 150 mm 6 inches in the tank roof for each anode string to permit replacement or inspection of anodes.

3.1.2 Anode Connection

****
NOTE: A single split-bolt will work loose when wires it connects are moved. Minimum of two split bolts will prevent this from happening. In water tanks, split bolts are used (above water line only) because working space is limited and hydraulic or mechanical compression tools may be cumbersome and hazardous to use. At ground level or in trenches, compression tools can be used conveniently, and swedged sleeve connection produced by such tools is more reliable than split bolts.
****

3.1.2.1   Anode Lead Wires

Electrically connect anodes to the positive D.C. header cable with compression connectors or split bolts, or the header cable may terminate in a junction box for connection with all anodes cables. Use a minimum of two split bolts for each connection if split bolts are used. Mark each of the wires terminating in the junction box.

3.1.2.2   Anode Header Cable

Provide header cable on the [underside of the roof] [wall] with electrically insulating hangers which shall enter the tank near the roof line from an externally mounted junction box. External wiring shall be in conduit. Mark each of the wires terminating in the junction box.

3.1.2.3   Splices

****
NOTE: Splices are not allowed below water level.
****

Locate under-roof electric wire splices above the high water line and seal water-tight using a minimum of two 1/2-lap layers of butyl rubber tape followed by two 1/2-lap layers of plastic tape.

3.1.3   Rectifiers

****
NOTE: For impressed current systems only.
****

3.1.3.1   Rectifier Installation

Location and mounting as indicated. Assemble and attach equipment enclosures to [wall] [post] [pad] in accordance with the manufacturer's instructions. Handle wires to prevent stretching or kinking the conductors or damaging the insulation. Use lubricants when pulling wires into conduits. Bond the equipment enclosures to a grounding electrode.

3.1.3.2   Wire-To-Tank Connections

Connect the structure wire to the tank [_____] [by use of an exothermic weld kit] [by brazing]. Clean the structure surface by scraping, filing, or wire brushing to produce a clean, bright surface. [Weld connections using the exothermic weld kits in accordance with the manufacturer's instructions. Test the integrity of the weld, prior to coating, by striking with a 908 gram two pound hammer.] [Cover connections and surrounding cleaned surface with an electrically insulating coating compatible with the existing coating.]

3.1.4   Permanent Reference Electrodes

3.1.4.1   Permanaent Reference Electrode Calibration

Calibrate permanent reference electrodes against a portable electrode in the presence of the Contracting Officer or his approved representative before installation. Calibrate in a test tank containing water with the same composition as the tank to be protected. Permanent electrode shall measure a reference potential agreeing with that measured by the portable electrode within plus or minus 0.010 volt when the sensing windows of the two electrodes being compared are not more than 2 mm 1/6 inch apart but not touching. Permanent reference electrodes not within this potential range 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.

3.1.4.2 Installation

Provide permanent reference electrodes at points in the tank [and riser pipe] which shall monitor minimum and maximum tank[/riser]-to-water potentials [and for automatic control system] [_____], and maintain continuous immersion. Sensing windows of reference electrodes shall be equidistant to and located within 25 mm one inch of the steel tank[/rise pipe] surface and shall be fixed in position, preventing contact with tank wall or appurtenances.

3.2 BOLTED AND RIVETED TANKS

Ensure electrical continuity of joining components.

3.3 GASEOUS EVOLUTION

Provide for possible evolution of gases from anode reaction and ventilation requirements.

3.4 CRITERIA FOR CATHODIC PROTECTION

Conduct in accordance with [NACE RP0388] [NACE RP0196]. Criteria for determining the adequacy of protection shall be selected by the orrosion engineer as applicable.

3.4.1 Minimum

The criterion for cathodic protection shall be a negative potential of at least 0.85 volt as measured between the tank[/riser pipe] and a copper-copper sulfate reference electrode across the tank[/riser pipe] to water interface. Determination of this potential shall be made with the protective current applied to the tank [and riser] 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.

3.4.2 Maximum

The potential between a copper-copper sulfate reference electrode and the tank[/riser pipe] at any point shall not be more negative than a negative 1.1 volt potential taken with the [electrode located within 25 mm one inch of the tank[/riser pipe] surface but not touching it] [protective current interrupted instantaneously or modulated] to minimize the voltage drop effect.

3.5 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.

****

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.

****

3.5.1 Destructive Testing

Contractor shall perform the tests in the presence of the Contracting Officer. Contractor shall include the cost of an additional anode 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 lead wire connections of anodes shall have sufficient strength to withstand a minimum tensile load of [1335] [_____] N [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.]

****

NOTE: Paragraph entitled "Wire for Power Service" for impressed current systems only

****

3.5.2 Wire for Power Service

Test wire for power service at 600 volts or less to determine that the wiring system and equipment are free from short circuits and grounds [by a minimum of two megohms]. Perform the test with a megohm meter having a 500-volt rating.

3.5.3 Initial Cathodic Protection System Field Testing

Upon completion of the installation, fill tank to maximum working level, and the Contractor's corrosion engineer shall test and inspect the cathodic protection system in the presence of the Contracting Officer or his designated representative. Record test data, including date, time, and location of testing and submit to the Contracting Officer. Contractor shall correct and retest, at his expense, deficiencies in the materials and installation observed during the tests and inspections. Measurements shall be made with voltmeters having input impedance not less than 10 megohm. Testing shall include the following:

a. Base potential tests: At least [one week] [24 hours] [_____] after the tank has been filled, but before energizing of the cathodic protection system, measure the base (native) structure-to-water potentials of the tank [and riser]. The locations of these measurements shall be identical to the locations specified for measuring energized structure-to-water potentials.

b. Permanent reference electrode tests: Verify proper operation and calibration of the reference electrode (s) including the entire reference electrode wiring circuit. Verify calibration of the reference electrode in accordance with paragraph 3.1.4.1. [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 -1000 to -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.

****
NOTE: Select paragraph "c" as appropriate.
****

****
NOTE: For impressed current systems only.
****

[c. Rectifier testing: Upon completion of the installation, "Base Potential" and "Permanent Reference Electrode" tests, energize and adjust the rectifier to provide current to the anode at a level that will protect the tank[/riser pipe] in accordance with the criteria listed. Measure D.C. output of the rectifier and current output of each anode at different rectifier settings. Measure the current outputs across the installed shunts. Verify these readings using portable, calibrated meters and shunts. This testing shall demonstrate if the rectifier system is capable of functioning properly as required to provide effective cathodic protection.]

****
NOTE: For galvanic systems only.
****

[c. Anode-to-water potential and anode output current tests: Upon completion of the installation, "Base Potential" and "Permanent Reference Electrode" tests, measure anode-to-water potential of each anode or each anode string with the anodes disconnected. After connecting the anodes to the tank [through junction box], measure current output of each anode or anode string across the calibrated shunt.]

****

NOTE: For all types of cathodic protection systems.
****

d. Energized tank[/riser pipe]-to-water potential tests: After operation of the cathodic protection system for at least 24 hours [one week] [_____], perform the tank[/riser pipe]-to-water measurements listed in the following five paragraphs with a portable reference electrode placed within 25 mm one inch of, but not touching, the tank[/riser pipe] wall and bottom surfaces and appurtenances.

(1) On a vertical line midway between two anode strings beginning at a point 305 mm one foot below water level and continuing at point 915 mm 3 feet apart until the bottom of the tank is reached.

(2) On a second vertical line midway between two anode strings on the opposite side of the tank from the first vertical line beginning at a point 305 mm one foot below water level and continuing at points 915 mm 3 feet apart until the bottom of the tank is reached.

(3) Across the bottom of the tank in a line between the two vertical lines at [915] [_____] mm [3] [_____] foot intervals.

(4) In at least [4] [_____] places which are close to anodes.

(5) On a vertical line in the riser pipe beginning at the top of the riser and continuing at [915] [_____] mm [3] [_____] foot intervals until the bottom of the riser is reached.

3.5.4 Initial Cathodic Protection System Field Test Report

The contractor shall submit a field test report of the cathodic protection system. All rectifier measurements, anode output current measurements, and structure-to-electrolyte measurements, including initial potentials, shall be recorded on applicable forms. Identification of rectifiers, anode junction boxes, test locations, and 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.

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

3.5.5 Government Field Testing

The government corrosion [engineer, LANTNAVFACENGCOM Code 404] [program manager, LANTNAVFACENGCOM 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, LANTNAVFACENGCOM Code 404] [program manager, LANTNAVFACENGCOM 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.

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

3.5.6 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, LANTNAVFACENGCOM Code 404] [protection program manager, LANTNAVFACENGCOM Code 1614C].

3.5.7 Final Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures specified under, "Initial Cathodic Protection System Field Testing". 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 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 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, LANTNAVFACENGCOM Code 404] [protection program manager, LANTNAVFACENGCOM Code 1614C] for approval, and as an attachment to the operation and maintenance manual in accordance with Section 01781, "Operation and Maintenance Data".Text

3.6 DEMONSTRATION

3.6.1 Instructing Government Personnel

****
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.
****

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. 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.

3.7 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:

Product	English Units	Metric Units
a. Ground rod		
- Diameter	5/8 inch	15.89 mm
- Length	8 feet	2440 mm
b. Porcelain spool		
- Diameter	2 1/4 inch	57.15 mm
- Height	2 1/8 inch	53.97 mm
c. Pin Insulator Assemblies		
- Bolt diameter	1/4 inch	6.35 mm
- Bolt length	3/4 inch	19 mm
- Length of assembly	4 inches	100 mm
- Insulator hole diameter	1/2 inches	13 mm

-- End of Section --