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USACE / NAVFAC / AFCESA / NASA | **UFGS-26 42 15.00 10 (April 2006)**

Preparing Activity: USACE | **Replacing without change UFGS-13111A (May 2004)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 18 July 2006

Latest change indicated by CHG tags
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DIVISION 26 - ELECTRICAL

SECTION 26 42 15.00 10

CATHODIC PROTECTION SYSTEM (STEEL WATER TANKS)

04/06

-- End of Section Table of Contents --

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SECTION 26 42 15.00 10

CATHODIC PROTECTION SYSTEM (STEEL WATER TANKS)
04/06

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NOTE: This guide specification covers the requirements for a cathodic protection system using impressed current 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.

****

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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

ASTM INTERNATIONAL (ASTM)

ASTM D 1248	(2005) Polyethylene Plastics Extrusion Materials for Wire and Cable

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

NACE INTERNATIONAL (NACE)

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 TC 2	(2003) Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2004) Grounding and Bonding Equipment
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 6	(2000; Rev thru May 2003) Rigid Metal Conduit

1.2 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. Submittals should be kept to the minimum required for adequate quality control.

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, 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.] [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

Detail Drawings[; G][; G, [_____]]

Within 45 days after the date of award of the contract, and before commencement of any work, and in accordance with SPECIAL CLAUSES, [six] [_____] copies of detail drawings consisting of a complete list of equipment and materials including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. The drawings shall provide tank dimensions and show anode arrangement for both elevated and sectional views of the tank, anode size and number, anode material, anode-suspension details, conduit size, wire size, rectifier size and location, handhole details, wiring diagram, and any other pertinent information considered necessary for the

proper installation and performance of the system. Shop drawings shall also contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. The list of materials and equipment shall include catalog cuts diagrams, and other descriptive data required by the Contracting Officer for the following list of material. Partial lists submitted from time to time will not be allowed.

a. Water resistivity and water analysis.

b. Conductors.

c. Anodes.

d. Coating material in areas where welding and other work is accomplished.

e. Insulated resistance wire.

f. Layout of anodes in tanks, test stations and isolation points, and grounding.

g. Special details.

h. Certified experience data of installing firm.

i. Exothermic weld equipment and material.

j. Test station.

k. Welding method for electrical connections and steel ring connections.

l. Calculations for

(1) Total current required for system.
(2) Life of the anodes.
(3) Anode geometry (showing areas of coverage).

All detail drawings shall be submitted at one time, as a single submittal, in order to demonstrate that the items have been properly coordinated and will function properly as a unit. A notation shall be made on each shop drawing submitted as to the item's specific use, either by a particular type number referenced on the drawings or in the specifications, or by a description of its specific location.

Contractor's Modifications[; G][; G, [_____]]

[Six] [_____] copies of detail drawings, showing proposed changes in location and scope or performance, indicating any variations from, additions to, or clarifications of contract drawings. The drawings shall show proposed changes in anode arrangement, anode size and number, anode materials and layout details, conduit size, wire size, mounting details, wiring diagram, method for electrically isolating each pipe, and any other pertinent information to the proper installation and performance of the system.

SD-03 Product Data

Miscellaneous Materials[; G][; G, [_____]]
Equipment[; G][; G, [_____]]

Within [30] [45] [____] days after receipt of notice to proceed, an itemized list of equipment and materials including item number, quantity, and manufacturer of each item. The list shall be accompanied by a description of procedures for each type of testing and adjustment, including testing of coating for thickness and holidays. Installation of materials and equipment shall not commence until this submittal is approved.

Spare Parts

Spare parts data for each different item of material and equipment specified.

SD-06 Test Reports

Testing, Adjusting, and Placing in Service

Test reports in booklet form tabulating all field tests and measurements performed, upon completion and testing of the installed system and including potential survey, final system test verifying protection, and holiday coating test. Each test report shall indicate the final position of controls. A certified test report showing that the connecting method has passed a 120-day laboratory test without failure at the place of connection, wherein the anode is subjected to maximum recommended current output while immersed in a 3 percent sodium chloride solution.

Contractor's Modifications[; G][; G, [_____]]

Final report including measurements throughout the tank area, indicating that the addition of anodes corrected the conditions which made the additional anodes necessary. The following are required: Installation and testing procedures, anode number, life, and parameters to achieve protective potential.

SD-07 Certificates

Cathodic Protection System

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

Services of "Corrosion Expert"[; G][; G, [_____]]

Evidence of qualifications of the "corrosion expert."

(a) The "corrosion expert's" name and qualifications shall be certified in writing to the Contracting Officer prior to the start of construction.

(b) Certification shall be submitted giving the name of the

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

SD-10 Operation and Maintenance Data

Cathodic Protection System

[Six] [_____] copies of operating manual outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. [Six] [_____] copies of maintenance manual listing routine maintenance procedures, recommendation for maintenance testing, possible breakdowns and repairs, and troubleshooting guides. The manuals shall include single line diagrams for the system as installed, instructions in making tank-to-reference cell potential measurements, and describe the frequency of monitoring. The instructions shall include precautions to ensure safe conditions during repair of system.

Training

The proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered.

1.3 GENERAL REQUIREMENTS

The Contractor shall provide and install all equipment wiring, and wiring devices, necessary to produce a continuous flow of direct current from electrodes in the electrolyte to the metal tank surfaces; and placing the cathodic protection system in operable status.

a. The Contractor shall install complete [automatic] [manual] [_____] cathodic protection to prevent corrosion on the interior submerged surface of the water tank. The Contractor's installation shall meet the criteria and protection outlined in paragraph CRITERIA OF PROTECTION for a 20 year life.

b. The purpose of the system is to adequately and efficiently protect the surfaces of the metal against corrosion where the surfaces are in contact with water; this is in addition to the protective coating on the tank. The contract drawings indicate the location and size of the tank. The design of this system is based on an impressed current system.

c. The Contractor may modify the cathodic protection system after site verification and analysis if the proposed modification will provide equal or better overall system performance. This modification must be fully described and submitted by the Contractor and approved by the Contracting Officer. Modifications or additional anodes shall be at no additional cost to the Government. Any modification shall incorporate all requirements of this specification.

d. The intent of this specification is to use this impressed current system as described with anodes as are found necessary in calculation and submitted data to meet this specification. Anodes shall be installed in sufficient number and of the required type, size and spacing to obtain a uniform current distribution of 3.5 milliamperes per 0.09 square meters 1 square foot to all submerged surfaces in the tank when filled with water to the over-flow level. The anodes shall be suspended from the roof steel with hangers or supporting cables that are electrically isolated from both the metal roof and the water electrolyte. The anodes shall be placed with the roof door midway between two adjacent anodes and hung clear of contact with such items as ladders, heater pipes, and stay rods.

1.3.1 Contractor's Modifications

The Contractor may modify the cathodic protection system after review of the project, site verification and analysis if the proposed modifications include impressed current anodes and rectifiers and will provide better overall system performance. The modifications shall be fully described, shall be approved by the Contracting Officer and shall meet the following criteria. The proposed system shall achieve a minimum "Instant Off" potential of minus 850 millivolts with reference to a saturated copper-copper sulfate reference cell on the tank components. The Contractor shall take measurements and the current and voltage of the rectifier shall be adjusted as required to produce a minimum of minus 850 millivolts "Instant Off" potential between the structure being tested and the reference cell. This potential shall be obtained over 95 percent of the metallic area without the "Instant Off" potential exceeding 1100 millivolts.

1.3.2 Services of "Corrosion Expert"

The Contractor shall obtain the services of a "corrosion expert" to supervise and inspect the installation and performance of the cathodic protection system. "Corrosion expert" refers to a person, who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control on steel water tanks. Such a person must be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or a NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification or licensing that includes education and experience in corrosion control on steel water tanks, if such certification or licensing includes 5 years experience in corrosion control on steel water tanks of the type under this contract. The "corrosion expert" shall ensure that the cathodic protection system is installed, tested, and placed into service in accordance with the requirements specified; and shall also design, make calculations, and assure quality control as required.

1.3.3 Verification of Site Conditions

The Contractor shall coordinate and properly relate this work to the work of all trades. The general locations of the structures to receive protection are shown. The Contractor shall visit the premises and become familiar with all details of the work and working conditions, shall verify existing conditions in the field, determine the exact locations of structures to be protected, and advise the Contracting Officer of any discrepancy before performing any work. The Contractor shall take

resistivity measurement of the water and analysis of the water and provide this data with detail drawings of the system for approval.

1.3.4 Spare Parts

The Contractor shall submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts, special tools, and supplies with current unit prices and source of supply. One spare anode of each type shall be furnished

PART 2 PRODUCTS

2.1 IMPRESSED CURRENT ANODES

2.1.1 High Silicon Cast Iron Anodes

****
NOTE: High silicon cast iron anodes are rugged, long lasting, and commonly used in icing and non-icing climates. The anodes are less vulnerable to damage and loss than other anodes where ice is heavy and the tank level fluctuates over a wide range. They are generally classified as relatively non-sacrificial having a consumption rate between 0.2 to 0.5 kg per ampere year (0.5 to 1.0 pounds per ampere year) in most fresh waters.
****

Cast iron anodes shall be of the size indicated and shall conform to the following requirements:

2.1.1.1 Chemical Composition (Nominal)

****
NOTE: The two grades shown represent manufacturing transition in practice. No significant difference in performance is involved. Either grade may be substituted for the other.
****

	Percent by Weight	
Element	Grade 1	Grade 2
Silicon	14.20-14.75	14.20-14.75
Manganese	1.50 max.	1.50 max.
Carbon	0.70-1.10	0.75-1.15
Chromium	-------	3.25-5.00
Iron	Balance	Balance

2.1.1.2 Electrical Resistivity

Electrical Resistivity shall be 72 microhm-centimeter at minus 7 degrees C 20 degrees F (maximum).

2.1.1.3 Physical Properties (Nominal)

Tensile strength	103.4 MPa
Compressive strength	689.5 MPa
Brinell hardness	520
Density	7000 kilograms per cubic meter
Melting point	1260 degrees C
Coefficient of expansion from 0 to 100 degrees C	132 nanometer per degree C

Tensile strength	15,000 psi
Compressive strength	100,000 psi
Brinell hardness	520
Density	7.0 grams per cubic centimeter
Melting point	2300 degrees F
Coefficient of expansion from 32 to 212 degrees F	0.00000733 centimeter per degree F

2.1.2 Mixed Metal Oxide Anodes

Mixed metal oxide anodes shall be of the size indicated and shall conform to the following requirements.

2.1.2.1 Conductive Material

The electrically conductive coating shall contain a mixture consisting primarily of iridium, tantalum, and titanium oxides. The average composition is generally a 50/50 atomic percent mixture of iridium and titanium oxides, with a small amount of tantalum. The resistivity, as tested by the manufacturer, shall be no more than 0.002 ohm-centimeter, and the bond strength shall be greater than 50 MPa 7.25 ksi to guarantee the current capacity life and the quality of the conductive ceramic coating. The adhesion or bond strength shall be determined by epoxy bonding a 2.54 mm 0.1 inch diameter stud to the ceramic coating and measuring the load to failure (about 70 MPa 10.15 ksi) of either the epoxy or the interface between the coating and the substrate. The anode must be inert and the electrically conductive ceramic coating dimensionally stable. The ceramic coated anode shall be capable of sustaining a current density of 100 ampere per square meter 10.764 square feet in an oxygen generating electrolyte at 66 degrees C 150 degrees F for 20 years, to ensure the current capacity life. An accelerated current capacity life test shall be performed by the manufacturer on every lot of anode wire used to construct the anode as described. The mixed metal oxide coating shall be applied to the wire anode by a firm that is regularly engaged in and has a minimum 5 years experience in manufacturing and applying mixed metal oxide coating to titanium anode substrates. The mixed metal oxide shall be sintered to the titanium surface to remain tightly bound to the surface when bent 180 degrees onto itself.

2.1.2.2 Anode Life Test

The anode wire material shall sustain current densities of 100 ampere per square meter 10.764 square feet in an oxygen generating electrolyte for 20 years. The manufacturer shall certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria. The test cell sustains a current density of 10,000 ampere per square meter 10.764 square feet in a 15 weight percent sulfuric

acid electrolyte at 66 degrees C 150 degrees F without an increase in anode to cathode potential of more than 1 volt. The cell containing the anode shall be powered with a constant current power supply for the 30 day test period. The representative sample shall be 125 mm 5 inch in length taken from the lot of wire that is to be used for the anode.

2.1.2.3 Anode Connecting Cables

The connection between the anode rod or ribbon and the lead wire shall be made with a solid crimp couple with solder. The connection shall be sealed in cast epoxy.

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, 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.
****

2.1.3.1 Selection Requirements

Precious metal anodes shall be [solid] [composite] [wire] [rod] [expanded mesh] [ribbon] in form. Selection of the configuration should be left to the designer of the system. Long, continuous wire form 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 shall be factory assembled with factory sealed and tested electrical connections to the anode.

2.1.3.2 Anode Life Test

The anode wire material shall sustain current densities of 100 ampere per square meter 10.764 square feet in an oxygen generating electrolyte for 20 years. The manufacturer shall certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria. The test cell sustains a current density of 10,000 ampere per square meter 10.764 square feet in a 15 weight percent sulfuric acid electrolyte at 66 degrees C 150 degrees F without an increase in anode to cathode potential of more than 1 volt. The cell containing the anode shall be powered with a constant current power supply for the 30 day test period. The representative sample shall be 125 mm 5 inch in length taken from the lot of wire that is to be used for the anode.

2.1.4 Anode Connecting Cables

Anodes, except for mixed metal oxide and precious metal wire anodes, shall have connecting cables installed at the factory. The Contractor shall submit a certified test report showing that the connecting method has passed a 120-day laboratory test without failure at the place of connection wherein the anode was subjected to maximum recommended current output while immersed in a 3 percent sodium chloride solution. Aluminum anodes connected together by a threaded system shall have water-tight seals and be

electrically continuous.

2.2 RECTIFIERS AND ASSOCIATED EQUIPMENT

2.2.1 Rectifier Unit

****
NOTE: Air-cooled rectifiers will be used for most applications. Where highly corrosive atmospheres 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.
****

Rectifier unit shall consist of a transformer, rectifying elements, [transformer tap adjuster,] terminal block, [one dc output voltmeter, one dc output ammeter,] [one combination volt-ammeter,] one toggle switch for each meter, fuse holders with fuses for each dc circuit, variable resistors, an ac power-supply circuit breaker, lightning arresters for both input and output; all wired and assembled in a weatherproof cabinet. The overall efficiency of the rectifier shall be not less than 65 percent when operated at nameplate rating and 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 in excess of 10 years.

2.2.1.1 Transformer

Transformer shall conform to UL 506.

2.2.1.2 Rectifying Elements

****
NOTE: Below about 500 volt-amperes of dc rated output, single phase selenium rectifiers cost less to acquire and operate than silicon rectifiers. Above 1000 volt-amperes silicon rectifiers are more economical for both single phase and three phase. Silicon rectifiers are more economical to repair.
****

Rectifying elements shall be [silicon diodes] [selenium cells] connected to provide full-wave rectification. [Silicon diodes shall be protected by selenium surge cells or varistors against over-voltage surges and by current limiting devices against over-current surges.]

2.2.1.3 Meters

Meters shall be accurate to within plus or minus 2 percent of full scale at 27 degrees C 80 degrees F, and shall possess temperature stability above and below 27 degrees C 80 degrees F of at least 1 percent per 5 degrees C 10 degrees F. Separate meters shall be 63.5 mm 2-1/2 inch nominal size or larger.

2.2.1.4 Circuit Breaker

A [single] [double] [three]-pole, flush-mounted, fully magnetic, properly rated nonterminal type circuit breaker shall be installed in the primary circuit of the rectifier supply transformer.

2.2.1.5 Fuses

Cartridge-type fuses conforming to NEMA FU 1 with suitable fuse holders shall be provided in each leg of the dc circuit.

2.2.1.6 Automatic Cathodic Protection Control

The system shall be capable of maintaining a tank-to-water potential criterion of protection within plus or minus 25 millivolts regardless of changes in water chemistry, temperature, or water level in the tank. Provision shall be made for readily changing the range and limits of the criterion. The controller shall be either housed integrally with the rectifier or in a separate weatherproof cabinet with provisions for locking. The automatic controller shall be a completely solid-state design, and shall be capable of automatically maintaining the tank-to-water potential at minus 900 millivolts with respect to a copper-copper sulfate reference electrode within an accuracy of 25 millivolts. The tank-to-water potential measured and maintained by the controller shall be free of "IR" drop error.

2.2.1.7 Tank To Water Potential Meter

The controller shall be equipped with a calibrated voltmeter having an internal impedance exceeding 1 megohm which shall be so connected to read, from the system reference cell, the tank-to-water potential being maintained by the cathodic protection system. This voltage reading shall be free of "IR" drop error.

2.2.2 Cabinet

Cabinet shall be constructed of [not lighter than 1.56 mm No. 16 gauge [steel] [hot dipped galvanized steel] [stainless steel] [aluminum]] [molded fiberglass reinforced polyester], and shall be provided with a full door. The enclosure shall have oil-resistant gasket. The door shall be hinged and have a hasp that will permit the use of a padlock. The cabinet shall be fitted with screened openings of the proper size to provide for adequate cooling. Holes, conduit knockouts, or threaded hubs of sufficient size and number shall be conveniently located.

2.2.2.1 Wiring Diagram

A complete wiring diagram of the power unit showing both the ac supply and the dc connections to anodes shall be on the inside of the cabinet door. All components shall be shown and labeled.

2.2.2.2 Grounding

Grounding provisions shall [be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.] [comply with NFPA 70 and UL 467 including a ground 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 rods. Ground rods shall be [copper-clad steel conforming to UL 467] [zinc-coated

steel conforming to ANSI C135.30] [solid stainless steel] not less than [16] [19] mm [5/8] [3/4] inch in diameter by [2.4] [3.1] m [8] [10] feet in length. Rods shall be driven full length into the earth. Sectional type rods may be used.

2.2.2.3 Resistance to Ground

****
NOTE: Remove this pagagraph if not required in the project
****

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, [_____] additional rods not less than 1.8 m 6 feet on centers, or if sectional type rods are used, [_____] additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

2.2.2.4 Cabinet Paint System

[The cabinet and mounting support shall be [painted] [hot dipped galvanized] [aluminum] [stainless steel] with the manufacturer's standard paint system.] [The mounting support for the fiberglass cabinet shall be [painted] [hot dipped galvanized] [aluminum] [stainless steel] with the manufacturer's standard painting system.]

2.2.3 Wiring

Wiring shall be installed in accordance with NFPA 70 utilizing type TW or RHW or polyethylene insulation. Fittings for conduit and cable work shall conform to UL 514A. Outlets shall be of the threaded hub type with gasketed covers. Conduit shall be securely fastened at 2.4 m 8 foot intervals or less. Splices shall be made in outlet fittings only. Conductors shall be color coded for identification. Cable for anode header and distribution shall be No. [2] [_____] AWG stranded copper wire with type [cathodic protection high molecular weight polyethylene] [Dular/Halar] insulation.

2.2.4 Oil Immersed Enclosures

****
NOTE: The enclosure should not be used in areas prone to flooding unless required for hazardous locations. Provisions should be made for flooding.
****

Enclosures shall be of 3.1 mm 11 gauge steel or heavier, with an accessible drain plug. The oil level shall be clearly marked. The lid shall be hinged and have quick release clamps to secure it in closed position. A stop shall limit the swing of the lid when opened. A compressible, oil resistant, positive sealing gasket shall be provided. The gasket shall return to its original shape upon release of lid pressure. The gasket shall be attached to the tank or lid and joints shall be free of gaps.

Base mounting using 102 mm 4 inch high channels shall be provided. Conduits entering the enclosure shall be internally sealed and shall enter or exit above the oil fill line.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Reference Electrodes

The electrodes shall be copper-copper sulphate type provided with micro-pore diffusion window for water contact and water-tight plug for renewal of copper sulphate crystals and solution. A minimum of four reference electrodes shall be part of this system. Electrodes shall be designed for 15 year life.

2.3.2 Electrical Wire and Associated Materials

2.3.2.1 Anode Connecting Wire

****

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 cathodic protection system. For this reason, special, extra heavy insulation is used on anode cable. While it is often expedient to use the same type wire for the cathodic (negative) cable in order to avoid a mix-up in the field, the cathode cable is not subject to anodic failure and lesser insulation can be used.

****

Anode connecting wire shall be No. [8] [_____] AWG stranded copper wire with type CP high molecular weight polyethylene insulation, 2.8 mm 7/64 inch thick, 600 volt rating. Cable-to-anode contact resistance shall be 0.003 ohms maximum.

2.3.2.2 Anode Header Cable

Cable for anode header and distribution shall be [_____] AWG stranded copper wire with type CP high molecular weight polyethylene, 2.8 mm 7/64 inch thick insulation, 600-volt rating. Cable-to-anode contact resistance shall be 0.003 ohms maximum.

2.3.2.3 Reference Electrode Wire

Reference electrode wire shall be stranded copper wire with NFPA 70 type RHW-USE or polyethylene insulation.

2.3.3 Conduit

Rigid galvanized steel conduit and accessories shall conform to UL 6. Nonmetallic conduit shall conform to NEMA TC 2.

2.3.4 Test Boxes and Junction Boxes

Boxes shall be outdoor type conforming to UL 514A.

2.3.5 Polyethylene Insulation

Polyethylene insulation shall comply with the requirements of ASTM D 1248 and of the following types, classes, and grades:

2.3.5.1 High Molecular Weight Polyethylene

High molecular weight polyethylene shall be Type I, Class C, Grade E5.

2.3.5.2 High Density Polyethylene

High density polyethylene shall be Type III, Class C, Grade E3.

2.3.6 Pressure-Sensitive Vinyl Tape

Tape shall conform to UL 510.

PART 3 EXECUTION

3.1 ANODES

3.1.1 Anode Installation

****

NOTE: In water tanks, split bolts are used (above the waterline only) because working space is limited and hydraulic or mechanical compression tools may be cumbersome and hazardous to use; since a single split-bolt will work loose when the wires it connects are moved, a minimum of two split bolts should be used. At ground level or in trenches, compression tools can be used conveniently, and the swaged sleeve connection produced by such tools is more reliable than split bolts.

In icy climates, a single split bolt connection should not be used above the water line in water tanks. One of the other methods described above should be utilized.

****

Anodes shall be suspended to prevent icing damage to anodes and suspending cables. Anodes shall be suspended from roof [plate] [structural members] 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 conductor. Anodes shall be suspended preventing contact with tank surfaces and shall be hung clear of man-access roof hatches and such items as ladders, heater pipes, and stay rods. Anode hangers shall electrically insulate the anode suspending wire from the tank steel. A handhole having a minimum diameter of 150 mm 6 inches shall be provided in the tank roof for each anode string to permit replacement or inspection of anodes. The Contractor shall certify that the method chosen has been used successfully for similar applications.

3.1.2 Anode Connections

Anodes shall be electrically connected to the positive dc header cable with compression connectors or split bolts, or the header cable may terminate in a junction box for connection with all anode cables. A minimum of two

split bolts shall be used for each connection if split bolts are used. Header cable shall be installed on the underside of the roof with electrically insulating hangers and shall enter the tank near the roof line from an externally mounted junction box. External wiring shall be in conduit. All under-roof electric wire splices shall be made above the high water line and sealed 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.

3.2 RECTIFIERS

3.2.1 Rectifier and Control Installation

Mounting shall be [of the wall mounted type.] [of the cross-arm mounted type.] [of the floor mounted on stand type.] [as shown.]

3.2.2 Rectifier Grounding

The grounding system for grounding rectifier cabinets shall have a resistance to earth of not more than 25 ohms as determined by an approved method.

3.3 PERMANENT REFERENCE ELECTRODES

3.3.1 Calibration

Permanent reference electrodes shall be calibrated against a standard electrode before installation. Calibration shall be done in a test tank containing water with the same composition as the tank to be protected. The permanent electrodes shall measure reference voltage agreeing with that measured by the standard electrode within plus or minus 0.005 volt when the sensing windows of the two electrodes being compared are not more than 4 mm 1/6 inch apart but not touching.

3.3.2 Installation

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NOTE: The requirements for installation of permanent reference electrods are similar to those for anode installation. See the NOTE in paragraph Anode Installation.
****

Reference electrodes shall be operable under the same icing conditions as the anode system. Installation of permanent reference electrodes shall be made at points in the tank which will monitor minimum and maximum tank-to-water potentials [and as otherwise needed for automatic control system]. Sensing windows of reference electrodes shall be located between 6 mm 1/4 inch and 13 mm 1/2 inch away from the steel surface sensed and shall be fixed in position preventing contact with tank steel.

3.4 CRITERIA OF PROTECTION

Acceptance criteria for determining the adequacy of protection on the internal submerged surfaces of steel water tanks shall be in accordance with NACE RP0388 and as specified below.

3.4.1 Minimum

The criterion of protection shall be a negative voltage of at least minus

850 millivolts as measured between the tank and a saturated copper-copper-sulphate reference electrode. Determination of this voltage shall be made with the cathodic protection system in operation. Voltage drops shall be considered for valid interpretation of this voltage measurement. A minimum of minus 850 millivolts "instant off" potential between the tank surface being tested and the reference cell shall be achieved over 95 percent of the area of the structure. Adequate number of measurements shall be obtained over the entire tank surface to verify and record achievement of minus 850 millivolts "instant off." This potential shall be obtained over 95 percent of the total metallic area without the "instant off" potential exceeding the maximum limit indicated below.

3.4.2 Maximum

In order to mitigate disbonding of the interior coating in the tank, potential between a copper-copper-sulphate reference electrode and the tank at any point shall not be more negative than minus 1.07 volt measured with the electrode located between 6 mm 1/4 inch and 13 mm 1/2 inch and away from the steel surface but not touching it.

3.5 TESTING, ADJUSTING, AND PLACING IN SERVICE

3.5.1 Electrode Potential Measurements

Upon completion of the installation, the tank shall be filled to maximum working level and with the entire cathodic protection system in operation; electrode potential measurements shall be made using a copper-copper sulphate reference electrode and a potentiometer-voltmeter, or a direct current voltmeter having an input impedance of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements shall be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements shall be recorded.

3.5.1.1 Tank-to-Water Potential Measurements

The following series of tank-to-water potential measurements with a portable reference electrode placed not more than 13 mm 1/2 inch away from but not touching the tank wall shall be performed:

a. On a vertical line midway between two anode strings beginning at a point 300 mm 1 foot below water level and continuing at points 900 mm 3 feet apart until the bottom of the tank is reached.

b. 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 300 mm 1 foot below water level and continuing at points 900 mm 3 feet apart until the bottom of the tank is reached.

c. Across the bottom of the tank in a line between the two vertical lines at 900 mm 3 foot intervals.

d. In at least four places which are closest to anodes.

3.5.1.2 Reference Electrode Calibration

The portable reference electrode used for the test shall be calibrated against the standard electrode specified in paragraph PERMANENT REFERENCE ELECTRODES.

3.5.1.3 Test Measurement Recording

All test measurements and their locations, as well as measurements made with the permanent electrodes simultaneously with the test measurements, shall be recorded.

3.5.2 Adjusting

Final adjustment of the rectifier output current shall be made so that repeated voltage readings taken as specified for testing meet the criteria in paragraph CRITERIA OF PROTECTION.

3.5.3 Placing in Service

After final adjustment, the cathodic protection system shall be placed in service and the condition of the system as left by the Contractor shall be recorded and shall indicate transformer tap settings; voltage readings from reference electrode to tank, readings both horizontal and vertical; automatic control differential setting; ac supply voltage; adjusted dc output voltage; and total protective current.

3.6 TRAINING

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of [_____] hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations. The Contracting Officer shall be notified at least 14 days prior to date of proposed starting of the training course.

-- End of Section --