

SECTION 264200 - CATHODIC PROTECTION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

1.2 DESCRIPTION

- A. This section specifies furnishing, installing and testing cathodic protection systems upgrades for the exterior bottom floor of the above ground storage tanks and the exterior coated steel underground aviation fuel supply lines as specified herein and indicated on drawings.
 - 1. Provide the materials as listed for revision upgrades and additions to both the impressed current and galvanic cathodic protection systems that serve the structures at the aviation fuel facility.
 - 2. Install the listed materials for upgrading and additions to both the impressed current and galvanic cathodic protection systems that serve the structures at the aviation fuel facility.
 - 3. Survey the cathodic protection system(s) to evaluate the effectiveness of the additions / upgrades, adjust the output of the rectifier for the impressed current system for optimum operation. Provide a detailed report of the survey findings.
- B. Related Sections:
 - 1. Division 01 and 31 Specification Sections.

1.3 QUALITY ASSURANCE

- A. Installation and Testing
 - 1. Contractor shall employ an individual or firm as his Corrosion Consultant to supervise the installation of cathodic protection systems revisions / additions. The field corrosion inspector shall have at least three (3) years of successful experience in work of comparable type and quality to the work specified in this Section. All work designated as being performed by the field corrosion inspector shall be performed under the supervision of a NACE International (National Association of Corrosion Engineers) accredited Corrosion Specialist or Cathodic Protection Specialist. Testing shall be performed by personnel representing the Corrosion / Cathodic Protection Specialist having at least five (5) years of experience testing cathodic protection systems.
 - 2. Contractor shall employ an individual or firm to perform exothermic welds. Individuals performing the exothermic welds shall have at least five (5) years of successful experience in work of comparable type and quality to the work specified in this Section.

3. Contractor shall employ an individual or firm with demonstrated proficiency and experience in the operation of test equipment, including a Digital Ultrasonic Thickness Gage and 4-Gas Meter.

B. Corrosion Control and Cathodic Protection Products and Equipment

1. Use only specified products and equipment or a project engineer approved equal, that duplicate products and equipment which have been in satisfactory use for a minimum period of five (5) years.
2. Use only new products and equipment.
3. Products and equipment shall be obtained from firms regularly engaged in the manufacture and distribution of the products and equipment specified in this specification.

1.4 REFERENCED STANDARDS

The work shall be performed in accordance with the latest requirements of laws and codes governing this work, including but not limited to:

- A. Federal, State and Local Laws, Regulations and Codes.
- B. Occupational Health and Safety Administration (OSHA) Safety and Health Standards
- C. American Petroleum Institute (API) Standards and Recommended Practices
- D. American Society of Mechanical Engineers (ASME) Codes, Standards and Recommended Practices
- E. NACE SP0169-2007 (formerly RP0169), Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- F. NACE RP0193-2001, External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms.
- G. NEC - National Electrical Code.

1.5 SUBMITTALS

- A. Submit qualifications for Corrosion / Cathodic Protection Specialist, Tester & Inspector. Include a brief description and dates for each project, with names and telephone numbers of contact persons at owners of installations on which testing was performed for each person. Also include a copy of the Corrosion / Cathodic Protection Specialist's NACE certificate.
- B. Submit qualifications for individuals who will perform exothermic welds. Include a brief description (including whether welds were performed on active fuel lines) and dates for each project, with names and telephone numbers of contact persons at owners of installations on which work was performed for each person.

- C. Submit list of test equipment to include items identified at Part 3.2 of this Specification, a Digital Ultrasonic Thickness Gage and 4-Gas Meter. The list shall include the manufacturer's name, model number, and calibration certificate for each instrument. The calibration certificate shall show that each instrument was calibrated by an independent agency within one year of use for this Work. Additionally, submit reports for daily calibrations performed during the course of the work.
- D. Construction Work Plan which shall detail all critical sequencing, procedures, construction methods, temporary protection and control methods, emergency procedures and schedule. Work Plan shall be coordinated with BNIA Fuel Farm operations, emergency and spill response plans. An approved Work Plan shall be in place prior to construction activity. Also see Part 1.8, Additional Project Conditions, of this Specification.
- E. Submit product data including manufacturer's descriptive and technical literature, catalogue cuts and installation instructions for each cathodic protection item.
- F. Submit test reports, including date of installation, photo's of installation, field data sheets for each cathodic protection system revision / upgrade to the project engineer as each is completed.
- G. Submit as-built drawings showing the location of each anode, test station lead wire attachment point and test station housing with respect to at least two permanent reference points.
- H. Upon completion of the installation / revisions, conduct a cathodic protection survey of the affected structures and document the effectiveness of the work performed Submit a final report that combines documentation of all work performed on the cathodic protection systems at the facility.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Package and ship all materials in clearly marked containers.
- B. Accept only materials which are not visibly damaged, which bear the correct manufacturer's identification and certification, and which conform to the proper styles and dimensions specified in this Specification.
- C. Store all materials on pallets, dry and in original packing.
- D. Protect all materials from weather and physical damage.

1.7 SEQUENCING AND SCHEDULING

- A. Schedule the cathodic protection system installation to minimize impact on active airport operations.
- B. Work in the area of the above ground fuel storage tanks is to be scheduled to limit the interruption of present cathodic protection current serving the tanks. One (1) tank anode system is to be allowed for upgrades at a time. Upon completion of the revisions at a tank, the rectifier output is to be adjusted to reflect the changes in the groundbed.

- C. Airport Security and Fire Departments are to be notified of daily operations and are to be notified of proposed work one (1) week in advance of activity.

1.8 ADDITIONAL PROJECT CONDITIONS

- A. Contractor will be required to perform a dry-run walk through of intended construction activities as set forth in its Work Plan, with particular focus on proposed exothermic welding practices, to be observed by the Owner's representatives and conducted prior to the actual construction. The walk-through activity shall include emergency procedures and coordination (e.g. communication, fuel shutdown, spill response, etc.)
- B. Contractor is to employ a 4-Gas Meter to screen work areas and assess the potential for conditions that may prevent work from being performed. The meter shall have the ability to measure flammable/combustible gas conditions, oxygen levels, carbon monoxide levels and hydrogen sulfide levels. Measurements shall be taken prior to the start of work and additional measurements taken, during the course of work, to monitor real-time conditions. Measurements shall be recorded at the time taken and provided to the Owner's representative on a daily basis.
- C. For work requiring exothermic welds, Contractor shall use a Digital Ultrasonic Thickness Gage to measure the thickness of the structure to which the weld will be placed and record this information (along with the structure, location, date and time) on a cathodic protection activity log. Evaluation of measurements will be made in accordance with Part 3.1 of this Specification prior to any actual welds being performed.
- D. Contractor shall allow Owner's representatives to observe and document (including photograph) conditions exposed during the course of the work. Related conditions are expected to include (but not necessarily limited to) subsurface pipe conditions, pipe coating, subsurface soils, exterior oil-water separator surfaces, etc.
- E. In the event that excavation activities encounter deleterious or suspect-contaminated material, Contractor shall immediately notify the Engineer and/or Owner's representative to obtain direction as to how to proceed.
- F. Contractor shall pressure test all direct buried pipe sections exposed by excavation associated with this project. As Part of the Construction Work Plan referenced in Section 1.5.D of this Specification, the contractor shall propose pressure testing methods and a sample report format for review and approval by the Owner. Baseline testing is to be performed prior to construction activities and additional testing performed after completion of the construction activities. Contractor shall furnish separate reports to the Owner indicating the results of baseline and post-construction testing. Contractor will be responsible for repairs to pipes damaged by construction activities.

1.9 WARRANTY

- A. Contractor shall warrant that the cathodic protection systems will be free from defects in materials and workmanship for a period of one year from date of final acceptance. Contractor shall repair or replace at the option of and at no additional cost to the Owner any component of the cathodic protection systems found to be defective or non-conforming during the Contract Period.

PART 2 - PRODUCTS

2.1 EXTERIOR PIPE COATINGS

- A. Any piping exposed which is found to have defects in the coating are to be reported to the Project Engineer for review and repair decisions. Defects in the coating caused by excavation will be repaired at the cost of contractor.

2.2 WIRE AND WIRE ATTACHMENTS

- A. Rectifier Negative Extension to Above Grade Fuel Storage Tank(s): Provide AWG #4 stranded copper wire with HMWPE insulation, suitable for underground service. Wires are permitted to be spliced using a split bolt or crimped connector and then wrapping the connection with two (2) overlapping wraps of rubber tape, followed by two (2) overlapping wraps of electrical tape, (in a similar way for a Y-splice but without the third wire) as depicted in drawing details. The overlapping tape wraps are to extend over the removed wire installation a minimum of 2 inches on either end of splice. Routing of cable and all points of connections or splice points are to be documented on "AS-BUILT" drawings, submitted to the project engineer and included in the final report appendices.
- B. Above Grade Fuel Storage Tank(s) Header Cable: Provide AWG #4 stranded copper wire with HMWPE insulation, suitable for underground service. Wires are permitted to be spliced using a split bolt or crimped connector and then encapsulating the connection with epoxy splice kit, as depicted in drawing details. Routing of cable and all points of connections or splice points are to be documented on "AS-BUILT" drawings, submitted to the project engineer and included in the final report appendices.
- C. Galvanic Anodes Header Cable: Provide AWG #8 stranded copper wire with HMWPE insulation, suitable for underground service. Wires are permitted to be spliced using a split bolt or crimped connector and then wrapping the connection with two (2) overlapping wraps of rubber tape, followed by two (2) overlapping wraps of electrical tape, as depicted in drawing details. The overlapping tape wraps are to extend over the removed wire installation a minimum of 2 inches on either end of splice. Routing of cable and all points of connections or splice points are to be documented on "AS-BUILT" drawings, submitted to the project engineer and included in the final report appendices.
- D. Test Station Wires: Provide AWG #8 stranded copper wire with HMWPE insulation, suitable for underground service. Black insulation for the anode header cables. Provide AWG #12 stranded copper wire with THHN / TW insulation, suitable for underground service, Black insulation for the test wires to the structure connection(s). Splices of replaced test station individual wires to allow extension or the wire to the test station are allowed only as follows: Pipe leads and galvanic anode wires are permitted to be spliced using a split bolt or crimped connector and then wrapping the connection with two (2) overlapping wraps of rubber tape, followed by two (2) overlapping wraps of electrical tape (in a similar way for a Y-splice but without the third wire) as depicted in drawing details. The overlapping tape wraps are to extend over the removed wire installation a minimum of 2 inches on either end of splice. Routing of cable and all points of connections or splice points are to be documented on "AS-BUILT" drawings, submitted to the project engineer and included in the final report appendices.

- E. Thermite Welding Materials: Provide molds and thermite welding cartridges suitable for welding test wires to pipes and oil / water separator ERICO ELECTRICAL PRODUCTS or approved equal. All welds are to be documented on “AS-BUILT” drawings, submitted to the project engineer and included in the final report appendices
- F. Thermite Weld Covers: Provide prefabricated weld coating caps with manufacturer recommended primer. Royston Handy-Cap and Roybond 747 Primer, or approved equal.

2.3 GALVANIC (SACRIFICIAL) ANODES

A. Cast Magnesium Anode

1. Provide high potential cast magnesium anodes. Anodes shall consist of a core with a cast magnesium ingot. Additional requirements are:

- a. The core shall be 1-7/8-inch.
- b. The cast magnesium ingot shall be nominally 5-1/2-inch by 5-3/4-inch by 19-7/8-inch with a nominal bare weight of 32 pounds. Type “D”
- c. The ingot shall have the following composition:

<u>Element</u>	<u>Percent by Weight</u>
Aluminum	0.01, max.
Manganese	0.5 - 1.3
Zinc	0
Silicon	0.05 max
Copper	0.02, max.
Iron	0.01, max.
Nickel	0.001, max.
Other Metallic Elements	0.3 max.
Magnesium	Remainder

- d. Each anode is to have a 20 ft lead wire of #12 AWG solid copper with TW insulation. The lead wire is to be silver soldered to the core and the connection primed and sealed with an insulating asphalt potting compound at the factory.
- e. The manufactured anode final pre-packaged weight will be 70 pounds and the composition of the backfill material will have the following properties:

<u>Element</u>	<u>Percent by Weight</u>
Gypsum	75.0.
Bentonite	20.0
Sodium Sulphate	5.0

- f. Each anode is to be pre-packaged in an inner cloth bag for installation, and an outer paper bag containing the 20 ft lead wire of #12 AWG solid copper. This outer paper bag is removed prior to soaking the anode when preparing the anode for installation.

Stuart Steel High Potential Magnesium Anode or approved equal

2.4 IMPRESSED CURRENT ANODES

1. Provide High Silicon Iron Tubular Anodes. Manufactured to standard ASTM A518 G3 (BS 1519 14.4) Additional requirements are:

- a. Anodes shall consist of a High Silicon Tubular Cast Iron Anode.
- b. The core anode to have diameter 2.6 inch diameter by 48 inch length a exterior surface area of 2.7 sq. ft. and with a nominal bare weight of 41 pounds.
- c. The High Silicon Tubular Cast Iron Anode shall have the following composition:

<u>Element</u>	<u>Percent by Weight</u>
Silicon	14.20-14.75
Chromium	3.25-5.00
Carbon	0.70-1.10
Manganese	1.50 max
Copper	0.05 max.
Molybdenum	0.20 max.

- d. Each anode is to have a 10 ft lead wire of #8 AWG stranded copper with HMWPE insulation. The lead wire is to be zinc connected by hydraulic pressed into taper seat at anode center. The connection is to withstand 1,000 kg cable tension and 1,000 kg dislodgement force and factory sealed using epoxy encapsulation of lead wire connection.
- e. The manufactured anode final pre-packaged size will be 4 inch diameter by 60 inch long and the fill composition of metallurgical coke breeze backfill material with following properties:

<u>Element</u>	<u>Percent by Weight</u>
Fixed Carbon	85.89
Ash	8 - 10
Moisture	6 - 9
Sulfur	0.8
Volatile Matter	0.5

- f. Each anode is to be pre-packaged in a spiral wrapped canister for installation,.

2.5 TEST STATION AND APPURTENANCES

- A. Pole Mount Type Test Station: Provide a test station with a cast aluminum test head, capable of mounting on a 3" diameter pole (rigid galvanized steel conduit) by slip fit connection housings complete with the following requirements:

1. Test Head Dimensions: 9" high, 8 3/8" wide and 2 1/2" deep
2. Test Head Mounting: Slip – fit mount on to a 3" diameter pole (rigid galvanized steel conduit).
3. Terminal Board: Phenolic board, eleven terminals, sized to fit inside the test head. Terminals consisting of corrosion resistant bolts, washers and locking nuts.
4. Bonding Straps: Corrosion resistant metal straps, sized to fit between adjacent terminals may be used instead of the jumper wire.
5. Test Station Pole: 3" Diameter rigid galvanized steel conduit 5' long section.
TESTOX Series 2000 Pipe Mounted Test Station by Gerome Manufacturing Company.

- B. Test Station Calibrated Shunt: 0.100 Ohm – 0.5 Amp capacity

Holloway Type RS 0.1 OHM, 0.5 AMP SHUNT

- C. Provide fast drying (not longer than 2 hours at 70°F) cold applied, high electrical resistivity rubberized mastic coating. Use primer as recommended by manufacturer. The use of asphalt roofing products shall not be permitted. Royston Roskote R28 Mastic or approved equal

2.6 ELECTRICAL TAPE & SPLICE COATING COMPOUND

- A. Plastic Vinyl Tape – Scotch[®] Brand Super 88 by 3M Company.
- B. Rubber Splicing Tape – Scotch[®] Brand 130C by 3M Company.
- C. Electrical Splice Sealing Coating Compound – Scotchkote[®] by 3M Company.

2.7 GENERAL ITEMS

- A. Nonmetallic Permanent Wire Markers (Tags): Nylon Panduit Wire Tie markers (PLF1M-M69).
- B. Test Station Wire Termination Lug: All wires including jumper wires shall be terminated at their designated terminals using appropriately sized, tinned solid copper, ring tongue, solderless crimp-type connectors.

Burndy Electrical "HYLUG[™]" type YAV, or equal.

- C. Nonmetallic strapping or tape.
- D. Stainless Steel Anchoring Bolt.
- E. PVC Pipe and Bushings: Schedule 40, diameter to suit application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Exothermic (Thermite) Welding:

1. Preparation of the structure for which the weld will be connected shall be performed in accordance with Detail “D” of Drawing C-501 along with the conditions stipulated in this subpart of the specifications.
2. The facility manager is to be notified and fire control alerted to a HOT ZONE operation so that all safety procedures, and placement of personnel for the procedures, are satisfied.
3. The area is to be tested with a 4-Gas Meter per Part 1.8 of this Specification, and for the presence of hydrocarbons, and declared satisfactory for welding work to be undertaken prior to continuing.
4. Preparation of the surface on the coated steel structures will require the removal of coating to establish an area to accommodate the weld furnace (typically 2” x 2”). The area of coating removal shall be limited to this condition.

A. The surface to be welded shall be cleaned with a wire brush or other approved method to a bright metal.

B. The technician shall use a Digital Ultrasonic Thickness Gage to measure the thickness of the structure to which the weld will be placed and record this information (along with the structure, location, date and time) on a cathodic protection activity log. The reading thickness will be compared to the original pipe specification wall thickness:

1. If the pipe wall thickness measured is 90% of the manufactured structure wall thickness and greater than 0.25” thick, continue to step 5 below.
 2. If the pipe wall thickness measured is less than 90% of the manufactured structure wall thickness and/or less than 0.25” thick, Contractor shall immediately notify the Engineer and/or Owner’s representative to obtain direction as to how to proceed.
5. Cadwelds (exothermic welds) on a structure shall be a minimum of 6” center-to-center of any other cadweld. In the event of a failed cadweld, the area of the failed cadweld will be wire brushed to clean bare metal and then coated with a minimum of three coatings of primer followed by the placement of a Royston HandyCap. A new cadweld area will be prepared to take the place of the failed connection.
 6. All connections between copper conductors, anodes, and the pipe shall be made with exothermically welded connections as shown. Wires will have added length to allow for movement during back filling operations to minimize stress on the exothermic weld connection to the structure. All connections shall be made conforming to the manufacturer’s recommended procedures, materials and equipment, with the following additional requirements:

- A. Do not allow the hot mold or welding debris to contact coated pipe.
 - B. Remove all slag from the mold after each weld. Clean the mold cover after every 6 to 10 welds.
 - C. Remove the slag from the weld after it has cooled. Test all welds on the piping by striking at a 45 degree angle with a two pound hammer while pulling on the wire.
 - D. Cover the entire area of test station wire welds on the pipe with a weld cover in accordance with the manufacturer's instructions.
- B. Galvanic Anodes: Install magnesium anode(s) for piping, as indicated below the fuel supply piping or below the midpoint of the oil / water separator.
- 1. Horizontally each magnesium anode is to be installed remote of the steel pipe(s) such that the anode is 1 foot below the centerline of the fuel supply pipe and a minimum of 5 feet from the piping and a minimum of 3 feet from foreign structures. Anode spacing can be adjusted for obstructions with approval of the Corrosion Engineer.
 - 2. Pre-soak each magnesium anode a minimum of 30 minutes in a container of water, to aid in the activation of cathodic current, prior to placing the anode in the soil.
 - 3. Splice as indicated and terminate the anode wire at the test station.
 - 4. Backfill the excavation of anodes with native soil, free of stones, bricks or other debris. Wet the backfill to aid compaction around the anode. The use of select fill or sand for backfilling the excavation to an elevation of one (1) foot above the anode shall not be permitted. The use of approved select fill or sand for backfilling the elevation of one (1) ft above the anode to grade shall be permitted at the project engineer's discretion.
- C. Liquid Coating: Thoroughly cover all bare metal surfaces such as tie-rods, clamps and anchor plates with bitumastic. Prior to coating, remove all residual films with suitable solvents and remove all adherent debris and rust with a wire brush. Apply liquid coating in accordance with the manufacturer's instructions using two coats to achieve a final dry film thickness of 20 mils. Allow liquid coating to dry completely before backfilling. The use of roofing tar, or similar, products will not be permitted.
- D. Test stations: Install test stations as indicated at the locations shown. Each test station shall include the required anode and pipe wires, 0.100 OHM shunt, jumper wire (or bonding strap) and test station housing as indicated on the drawings. All test station wires shall be permanently identified inside the test station housing, using nylon permanent markers. The following requirements shall also apply:
- 1. Install pipe wires and anode lead wires as indicated on drawings.
 - 2. A minimum of 6 inches of slack shall be maintained in all wires within the conduit of the test station. Each wire shall be identified as shown. Slack wire shall be neatly coiled and tucked in the conduit. If insulation is stripped at the free ends, it shall be taped to avoid electrical contact. ANODE WIRES MUST BE KEPT ELECTRICALLY ISOLATED FROM THE PIPE UNTIL THE "BASE" OR "NATURAL" STRUCTURE-TO-ELECTROLYTE

POTENTIALS HAVE BEEN MEASURED AND RECORDED BY THE CORROSION ENGINEER.

- E. Impressed Current Anodes: Install high silicon cast-iron anode(s) for above grade fuel storage tanks as indicated within the dike containment area.
1. Prior to disruption of the impressed current cathodic protection system, the affected circuit is to be de-energized by the following steps:
 - a. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 - b. Power off the rectifier using the circuit breaker on the rectifier panel. Contractor is to provide for lock-out and coordinate activity with Fuel Farm personnel.
 - c. Disconnect the circuit of the effected tank in the anode current distribution box.
 - d. Cap and tag the removed wire.
 - e. Power on the rectifier using the circuit breaker on the rectifier panel so that the tanks, that are not affected by the work, continue to receive cathodic current.
 - f. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 2. Excavation within the dike area will require temporary removal of the crushed stone surface and excavation of the clay which comprises the dike integrity. Caution should also be observed to NOT undermine the footing that supports the above ground tanks. After anode placement and splicing, the filling and compaction of the removed soil shall be to established standards to maintain the dike integrity to contain the product of the tank, if a failure occurred.
 3. Install pre-packaged high silicon cast-iron anodes adjacent to tank as depicted on drawings. Install the anode such that the depth of the anode is 4 foot below the grade of the tank and a minimum offset of 5 ft (maximum of 10 ft) of the tank wall that the anode serves. Spacing of anodes to a foreign structure shall be offset by a minimum of 5 feet. Anode spacing / location can be adjusted for obstructions with approval of the Corrosion Engineer.
 - a. Areas around the main tank farm and adjacent, above-ground piping complex, may contain impervious and/or low permeability fill materials or soil layers. Disruption to this material shall be kept to a minimum and every effort shall be made to maintain and/or restore the integrity of the existing conditions. Related efforts shall include stockpiling, reusing and compacting the excavated low permeability material to restore disturbed areas to existing conditions.
 - b. In the event that the excavation reaches bedrock, the bottom of the excavation is to be backfilled with the impervious soil and compacted to a minimum one (1) foot cover over the bedrock. The anode is to be placed on the compacted soil.

- c. After the anode has been placed, backfill with the impervious soil to a minimum of one (1) foot cover of the exposed anode, compacting the soil at six-inch lifts.
 - d. The lead wire from the anode will be spliced at the depth above the compacted soil in step c. above.
4. Splice as indicated to the header cable and terminate the header cable by splicing both ends to the existing anode header from the rectifier for the tank. All splices are to be made with a mechanical crimp or split bolt connection, then sealed from exposure using the epoxy splice kit in accordance with the details and manufacturer's instructions.
5. Backfill with native dike soil, free of stones, bricks or other debris for backfilling. Wet the backfill to aid compaction around the anode. The use of backfill, other than native soil, shall be permitted only at the project engineer's discretion.
6. Upon completion of the effected impressed current cathodic protection system, the affected circuit is to be re-energized by the following steps:
 - a. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 - b. Power off the rectifier using the circuit breaker on the rectifier panel. Contractor is to provide for lock-out and coordinate activity with Fuel Farm personnel.
 - c. Remove the cap from the disconnect wire and re-connect the circuit of the effected tank in the anode current distribution box.
 - d. Decrease the tap settings of the rectifier a minimum of three (3) fine steps.
 - e. Power on the rectifier using the circuit breaker on the rectifier panel, observe the output current and voltage.
 - f. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 - g. Compare the observed output current and compare it to the current obtained in Step 1, substep a., above. Perform the following based on the current obtained:
 1. If the current obtained is BELOW 5% of the current reading obtained in Step 1, substep a., above:
 - a. Power off the rectifier using the circuit breakers on the rectifier panel.
 - b. Increase the tap settings of the rectifier one (1) fine step.
 - c. Continue at Step 6, sub-step e, above.
 2. If the current obtained is ABOVE 5% of the current reading obtained in Step 1, substep a., above:

- a. Power off the rectifier using the circuit breakers on the rectifier panel.
 - b. Decrease the tap settings of the rectifier one (1) fine step.
 - c. Continue at Step 6, sub-step e, above.
 3. If the current obtained is within 5% of the current reading obtained in Step 1, substep a., above continue to the following step “h”.
 - h. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
- F. Rectifier Negative Extension to Above-Grade Fuel Storage Tanks
1. If the negative of the rectifier is to be disconnected at either the rectifier or the termination on the pipe supports, the following steps will be performed. **The duration of the interruption of the circuit is to be minimized. WARNING: THE RECTIFIER IS NOT TO BE ENERGIZED WITH THE NEGATIVE CONNECTION DISCONNECTED!**
 - a. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 - b. Power off the rectifier using the circuit breakers on the rectifier panel.
 - c. Disconnect the negative at the rectifier or termination of the rectifier negative that necessitated this interruption.
 - d. Cap and tag the removed wire, as well as the rectifier circuit breaker, as being “OUT-OF-SERVICE”.
 - e. After performing the work that necessitated the disconnection of the negative connection, re-energize the rectifier as follows.
 - f. Remove the tag and un-cap the removed wire, and remove tag from the rectifier circuit breaker stating “OUT-OF-SERVICE”.
 - g. Power on the rectifier using the circuit breaker on the rectifier panel, observe the output current and voltage.
 - h. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.
 - i. Compare the observed rectifier output current and compare it to the current obtained in Step 1, substep a., above. Perform the following based on the current obtained:
 1. If the current obtained is outside 5% of the current reading obtained in Step 1, substep a. above, contact the Project Engineer and the Corrosion Engineer to advise them of a drastic change in the impressed current system operation. TURN the RECTIFIER OFF and note this action on the rectifier operation sheets.

2. If the current obtained is within 5% of the current reading obtained in Step 1, substep a., above complete this task by finalizing step “j”.
- j. Record the rectifier output current and voltage, coarse and fine tap settings, date, time, system effected, identify work progress and the initials of the person performing the work.

3.2 TESTING

A. Tests:

1. General: The Contractor’s Corrosion Consultant shall conduct the electrical tests and inspections specified for:
 - a. Pipe wires.
 - b. Impressed current anodes.
 - c. Magnesium anodes.
2. Test Procedures: Prior to pipe installation, the Contractor shall submit detailed test procedures for each test specified below. Procedures shall include test schematics and a outline narrative of each test. The Engineer shall observe the approved initial field tests. Should the techniques appear valid after two separate tests, final approval will be forwarded to the Contractor by the Engineer. Following such approval, the testing techniques shall not be varied or changed without approval from the Engineer.
3. Equipment: The Contractor shall submit a list of test instruments to be used for the electrical testing. The list shall include the manufacturer’s name, model number, and calibration certificate for each instrument. The calibration certificate shall show that each instrument was calibrated by an independent agency within one year of use for this Work. Test instrument requirements are as follows:
 - A. High Impedance Digital Voltmeter/Ammeter: Should have a minimum input impedance of 10 megohms and a 2 or 10 volt range, in addition the meter should have millampere current ranges. A Fluke Multimeter Model 87 / 89 or equivalent is an acceptable instrument.
 - B. High Impedance Portable Digital Oscilloscope: Should have a minimum input impedance of 10 megohms and a 2 or 10 volt range. A Tectronix Model 720 or equivalent is an acceptable instrument
 - C. DC Clamp on current probe. Should be suitable of reading individual wire current without disruption of the circuit wiring and which can be utilized with either of the above meters. AEMC AC/DC current probe Model SL261 or equivalent is an acceptable instrument.
 - D. Electronic timed switching device with precise timing accuracy to interrupt cathodic protection current. (MCM Model CI-30)

- E. Test Wires: Single conductor cable, stranded copper, sized AWG #22 /20 /18 with a minimum 300 V water resistant insulation. Sufficient lengths to establish test circuits with appropriate terminal lugs and clamp or clip terminations.
 - F. Reference Electrodes: Portable saturated copper-copper sulfate reference half-cell with a length of 5 inches, a diameter of 1-3/8 inches or 3 inches, and a porous wood / ceramic plug. Electrochemical Devices (EDI) / M.C. Miller,/ Tinker and Rasor or equivalent.
 - G. Electrical Contact Locator: Nilsson Model 715 Detector, or approved equal.
 - H. Soil Resistivity Tester: Wenner 4-Pin Method in conjunction with a Nilsson Model 400 Soil Resistance Meter, or equal.
 - I. Digital Ultrasonic Thickness Gage: DeFelsko Model PostTector UTG Std or equal
- 4. Documentation: The Contractor shall submit data sheets and calculations to the Engineer for each test for review and approval. Individual inspection and test reports shall be submitted to the Engineer within 10 business days of testing. A final test and inspection report shall be submitted within 30 days of the completion of all individual component tests. A cathodic protection system verification report shall be submitted within 60 days of completion of the individual component tests.
 - 5. Physical Inspection: During installation and prior to backfilling the following items shall be tested or inspected by the Contractor as indicated:
 - a. Each thermite weld to piping shall be tested by striking the weld at a 45° angle with a 2-pound hammer while pulling firmly on the wire. Defective welds shall be replaced at the Contractor's expense.
 - b. The areas of pipe, weldment, and bare wire exposed around exothermic welds shall be inspected to assure that all metal is fully covered weld covers (Handy-Cap).
 - c. Pipe coatings inspection: Refer to Part 2.1 of this specification.
 - 6. Test Station Wire Effectiveness: After backfilling electrical measurements will be made on each test lead in each completed test station. Measurements shall include:
 - a. Structure to Soil Potential: Measure the "base" or "native" structure-to-electrolyte potentials of the structure, and anodes (without the shunt in place) with respect to a portable saturated copper-copper sulfate reference electrode placed in soil next to the test station and over the structure of each test.
 - b. Anode / Anode bank current using the test station connections and a external DC current meter.
 - c. Structure to Soil Potential: Measure the structure-to-electrolyte potentials of the structure, and anodes (with the shunt in place) with respect to a portable saturated copper-copper sulfate reference electrode placed in soil next to the test station and over the structure of each test.

- d. Anode / Anode bank current using the installed shunt installed in the test station
7. Cathodic Protection System Effectiveness: Subsequent to the completion of individual component tests, the Contractor shall activate the cathodic protection systems and verify that the structures are satisfactorily protected in accordance with the most current version of NACE SP0169 & RP0193. System effectiveness testing shall be conducted at all test locations. The testing shall include but not be limited to the following:
- a. Anode current across the shunt.
 - b. Structure-to-electrolyte potential with respect to portable saturated copper-copper sulfate reference electrode placed in soil over / adjacent to the structure of each test.
 - c. Within the area on the fuel farm side of the access tunnel (under runway) Structure-to-electrolyte potential with respect to portable saturated copper-copper sulfate reference electrode placed in soil over / adjacent to the structure of each test. Cycling the output of the rectifier in a 12 second with current / 3 seconds without current interrupted cycle of the DC (+) Output.

END OF SECTION 264200