SECTION 13 4713

#### CATHODIC PROTECTION

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LANL MASTER SPECIFICATION SECTION

Available online at <http://engstandards.lanl.gov>

This template must be edited for each project.  In doing so, specifier must add job-specific requirements.  Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.  Once the choice is made or text supplied, remove the brackets.  The specifications must also be edited to delete specification requirements for processes, items, or designs that are not included in the project - and specifiers’ notes such as these.  Additional tailoring requirements are contained in ESM [Chapter 1](http://engstandards.lanl.gov/ESM_Chapters.shtml#esm1) Section Z10 Att. F, Specifications.

To seek a variance from requirements in the specifications that are applicable, contact the Engineering Standards Manual Electrical[POC](http://engstandards.lanl.gov/POCs.shtml). Please contact POC with suggestions for improvement as well.

When assembling a specification package, include applicable specifications from all Divisions, especially Division 1, General requirements.

Specification developed for ML-4 projects.  For ML-1, 2, and 3 applications, additional requirements and independent reviews should be added if increased confidence in procurement or execution is desired; see ESM Chapter 1 Section Z10 Specifications and Quality requirements.

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PART 1 GENERAL

# EXTENT

1. Furnish and install:
	1. Cathodic protection system with active or passive subsystems including the following:
2. Rectifiers
3. Anodes
4. Cables
5. Bonding
6. Connections
7. Test Station
8. Grounding

# RELATED WORK

1. Coordinate the work specified in this Section with work specified in the following related sections:
	* 1. Section 01 2500 - Substitution Procedures
		2. Section 01 3300 - Submittal Procedures
		3. Section 01 4000 - Quality Requirements
		4. [Section 33 0130 –Linings and Coatings for Utilities.]

# REFERENCE DOCUMENTS

1. Related standards, specifications, manuals, codes and other publications of nationally recognized organizations are referenced herein. Methods, equipment and materials shall comply with applicable or specified portions of the referenced documents, in addition to Federal, state, or local codes having jurisdiction.
2. The materials and equipment supplied shall be designed, manufactured, tested, shipped, installed, and site tested in accordance with industry standards and publications. The applicable standards and publications include but are not limited to those stated herein from the following organizations. All references to publications are to the latest issue of each together with all latest addenda, amendments, or addictions thereto as of the date of Subcontract.
3. List of Organizations
	* 1. ANSI - American National Standards Institute
		2. ASTM - American Society for Testing and Materials
		3. IEEE - Institute of Electrical and Electronics Engineers
		4. NECA - National Electrical Contractor Association
		5. NEC - National Electrical Code
		6. NEMA - National Electrical Manufacturers Association
		7. NFPA - National Fire Protection Association
		8. UL - Underwriters Laboratories
4. Related publications for the materials and equipment specified herein include the following:
	* 1. American National Standards Institute:
5. ANSI/NFPA 70 - National Electrical Code
6. ANSI/ IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements
7. ANSI/IEEE 142 - Foundation for Grounding
8. ANSI/AWWA D104-04 - Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks
	1. ISO
		* + 1. ISO 9001 - Quality Management Systems – Requirements
				2. ISO 9002 - Quality Systems Model for Quality Assurance in Production, Installation and Servicing.
	2. Occupational Safety and Health Act of 1970 (OSHA)
	3. National Association of Corrosion Engineers (NACE)
9. NACE SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
10. NACE SP0177 – Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
11. NACE SP0193 – External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms
12. NACE SP0285 – Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
13. NACE SP0286 – Electrical Isolation of Cathodically Protected Pipelines
14. NACE SP0388 – Impressed Current Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks.
	1. Code of Federal Regulations (CFR)
15. 40 CFR, Part 280 – Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)
16. 49 CFR, Part 192 – Transportation of Natural Gas and other Gas by Pipeline
17. 49 CFR, Part 195 – Transportation of Hazardous Liquids by Pipeline

# SUBMITTALS

* 1. Submit the following in accordance with Section 01 3300, *Submittal Procedures*.
1. Design Drawings:
	1. Schematic, logic, programming, and other functional drawings
	2. Internal and external wiring drawings.
	3. Mounting and support drawings.
	4. Outline drawings with center of gravity dimensioned and weight indicated.
	5. Electrical identification schedule (nameplate lists) including list of wording, symbols, letter size, color coding, tag number, location, and function.
2. Lists and Data
3. Catalog Data: Submit catalog data describing the supplied equipment and parts supplied. (Include equipment ratings and other data substantiating that materials comply with specified requirements.)
4. Part lists shall be complete in every respect with parts identified by the original manufacturer's part number as well as by Subcontractor's identification (e.g., number).
5. Spare parts lists and list of recommended spare parts to be stocked by LANL for a minimum period of 18 months after acceptance of the work.
6. Programming software, configuration, and data files.
7. Component set point lists and calculations.
8. Procedures
9. Procedures for Storage, Handling, and Surface Preparation.
10. Equipment Production Test Procedures.
11. Equipment Performance Test Procedures.
12. Surveillance/Inspection Procedures.
13. Field Test Procedure.
14. Operating and Maintenance Manuals
15. Operating and maintenance instruction manuals with detailed minor and major maintenance instructions, including description, troubleshooting guide, use of special tools furnished, lubrication, painting, and preventive maintenance schedule.
16. Installation instructions, including mounting requirements. Indicate application conditions and limitations of use stipulated by product testing. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
17. Complete and detailed operating instructions, including safety precautions, philosophy of operation, start-up and shutdown actions, and, where applicable, process optimization techniques.
18. Operation and maintenance manuals shall include:
	* + - 1. Name, address and telephone number of nearest authorized service facilities and parts distributor.
				2. Manufacturer's installation instructions.
				3. Parts lists.
				4. Recommended spare parts.
				5. Lubrication requirements and list of lubricants including acceptable substitutes.
				6. Maintenance requirements and schedules for all equipment.
				7. Safety Procedures.
				8. Proper operation of all equipment.
				9. Routine maintenance procedures.
				10. Assembly drawings and descriptive literature.
				11. Wiring, schematics, and logic drawings with software and programming.
19. Schedules
20. Engineering Schedule
21. Fabrication and Production Test Schedule
22. Delivery Schedule
23. Certifications
24. Certification that products meet or exceed the specified requirements including that the products are listed and labeled by a nationally recognized testing laboratory (NRTL) such as Underwriters Laboratories, Inc. as suitable for the application and environment in which installed
25. Manufacturer’s certificate of compliance for each component with applicable standard (e.g., ANSI, ASTM, NEMA) or any other NRTL acceptable to OSHA.
26. Certifications demonstrating that firms meet qualifications specified in "Quality Assurance" Article to demonstrate capabilities and experience. Include list of completed projects with project names, addresses, names of architects and owners, and other information specified.
27. Letter indicating that manufacturer will issue a one-year commercial warranty against defects in material or workmanship when LANL has received, inspected and accepted the equipment.
28. Certificate of Conformance from installer stating compliance with all Section and NACE Standard requirements including calculations, drawings, and material.

# QUALITY ASSURANCE AND QUALITY CONTROL

* 1. Perform work identified in this section under a quality assurance program in accordance with Section 01 4000, *Quality Requirements*.
	2. Comply with the requirements of NFPA 70, *National Electrical Code (NEC)* for components and installation.
	3. Provide products that are listed and labeled by a NRTL such as Underwriters Laboratories, Inc. as suitable for the application and environment in which installed.

# INSPECTIONS AND TESTS

* 1. Notify the LANL Construction STR at least 14 days prior to beginning any testing. LANL will be present during all tests including production and factory performance tests.
	2. Test Control: Establish a test program with the following features:
		1. Measures to assure that any testing required to demonstrate that the systems and or components perform satisfactorily in service is performed in accordance with written test procedures that incorporate the requirements and acceptance limits contained in the Specification. Test procedures shall include provisions for assuring that all prerequisites for the given tests have been met and that adequate testing is performed under appropriate environmental conditions. Test results shall be documented and evaluated to assure those test requirements and acceptance limits have been satisfied.
		2. The test procedures shall provide a complete description of proposed testing sequence and criteria used for determining the acceptance or rejection of the specific equipment, as well as the description of the various levels of responsibility and authority regarding decisions on acceptance or rejection of test results.
		3. The test procedures shall provide reference to specific articles and or sections of applicable industry (ANSI, IEEE, etc.) standards incorporated into the test program.
	3. Control of Measuring and Testing Equipment: Establish measures to establish that tools, gages, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated and adjusted at specified periods to maintain accuracy within limits described.
	4. Factory Tests: Test and document, prior to shipment from the factory, that the equipment performs to the stated ratings, functions, and meets the requirements of industry codes and standards.
	5. Field Test: Conduct testing under the supervision of a service engineer representing the manufacturer to verify the installation and operational features.
	6. Base cathodic protection designs on historical knowledge and specific field tests made at the proposed construction site. Tests should include, but not be limited to:
		1. Soil or water corrosivity (resistivity)
		2. Current requirements
		3. Potential surveys
		4. Stray current interference potential
		5. Water chemistry/corrosivity (pH).
	7. Promptly correct all deficiencies as required by the LANL Construction STR.

# DELIVERY, HANDLING, AND STORAGE

* 1. Receive, store, protect, and handle products according to NECA 1, *Standard Practices for Good Workmanship in Electrical Construction.*
	2. Store equipment in a clean, dry space and protected from the weather.

# [PROJECT/SITE CONDITIONS

1. Attachment 1 to this Section provides environmental, seismic, and other project site conditions in accordance with the facility design documents.]

# SCHEDULING

1. Coordinate and schedule Facility Manager through the Project Leader.

# MAINTENANCE

* 1. Maintenance Materials: Furnish any special tools or test equipment required to operate and maintain the equipment.

## PART 2 PRODUCTS

## MANUFACTURERS AND PRODUCTS

* 1. Alternate products may be accepted: follow Section 01 2500, *Substitution Procedures*.

## RATINGS

## Not Used.

## COMPONENTS

* 1. General
1. Application – Design cathodic protection to protect all underground ferrous piping, tanks, and structures. Construction Subcontractor's vendor shall be a company specializing in cathodic equipment.
2. Function - The cathodic protection system controls the electrochemical corrosion of the exterior surfaces of ferrous piping buried in soil, the internal, submerged surfaces of water tanks, and the external tank bottoms of oil tanks.
3. NACE Standard Practices - Cathodic protection systems shall conform to latest edition of NACE SP0169 - *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*; and this Specification.
4. Reference Half-cells – Provide one copper/copper sulfate reference half-cell at each anode bed location and other locations shown on drawings. Route and terminate reference half-cell extension cabling at the test station located adjacent to the pipe run.
5. Test Stations - A test station is required at each anode bed for measurement of anode current and pipe-to-soil potential. A test station is also required at each casing pipe location.
6. Piping Isolation - Dielectric type flanges or unions shall be installed where the pipe exits the ground (see the mechanical drawings) to provide electrical isolation from above ground equipment.
7. Casing - All road crossings shall be cased with ASTM A53 Gr. B carbon steel pipe. Casing shall be coated with same material as the protected pipe. Protected pipe shall be electrically isolated from the casing by insulated pipe shoes and rubber boots installed at each end of casing. Take resistance measurements to verify electrical isolation from casing prior to backfilling trench.
8. Rectifiers
9. Size rectifier unit input based on system requirements. Rectifier output shall be determined by cathodic protection vendor and Construction Subcontractor, suitable for the system installed and quantity of protection required.
10. Each rectifier shall have a minimum of three coarse and four fine adjustment taps for voltage settings.
11. Rectifier enclosure shall be rated for outdoor installation, NEMA 3R (air- cooled).
12. Rectifiers shall be Universal Rectifiers Inc., or LANL-approved equal, with output voltage and current meters.
13. Anodes
14. Impressed Current Anodes for installation in soil: High silicon iron or graphite anodes with a factory-sealed cable connector for each anode.
15. Impressed Current Anodes for installation on water tanks: Mixed Metal Oxide wire anode
16. Sacrificial Anodes: Individual magnesium or zinc package anodes electrically connected with a cathodic protection cable to the protected surface.
	* 1. Magnesium anodes to be used in soil shall have the following composition per ASTM B843:

### Material Composition (% by weight)

Aluminum 0.01 max.

Copper 0.02 max.

Iron 0.03 max.

Manganese 0.5 to 1.3

Nickel 0.001 max.

Other 0.05 per component, 0.3 max. total

Magnesium Remainder

* + 1. Factory prepared backfill mixture for each magnesium anode shall be 75% gypsum, 20% bentonite, and 5% sodium sulfate.
		2. Magnesium anodes to be used in water applications shall have the following composition:

### Material Composition (% by weight)

Aluminum 6.7 max.

Copper 0.05 max.

Iron 0.003 max.

Manganese 0.15 max.

Nickel 0.003 max.

Silicon 0.3 max.

Other 0.03 max.

Magnesium Remainder

* + 1. Zinc anodes shall conform to ASTM B418-88 Type II alloy:

### Material Composition (% by weight)

Aluminum 0.005 max.

Cadmium 0.003 max.

Copper 0.002 max.

Iron 0.0014 max.

Lead 0.003 max.

Zinc Remainder

* + 1. Factory prepared backfill mixture for each magnesium anode shall be 75% gypsum, 20% bentonite, and 5% sodium sulfate.
		2. Coat Breeze
			1. Lorensco type SC-3 or approved alternative.
1. Cable
2. Cable used to interconnect anodes, rectifiers, and protected surfaces shall be Type CP with high molecular weight polyethylene (HMWPE) or high density polyethylene insulation rated at 600 volts.
3. Minimum size for anode leads shall be #8 AWG and have corrosion resistant and waterproof connections. Minimum size for cathodic protection header cable around each tank perimeter shall be #2 AWG.
4. Underground marking tape (2” wide) shall be installed 12” above and run parallel to buried cathodic protection cable. Marking tape shall read: “CAUTION: BURIED CATHODIC PROTECTION CABLE.
5. Bonding/Connections for Cathodic Protection Systems in Soil
6. Anode leads shall have corrosion resistant and water proof connections.
7. Splices used to connect anode leads to a cathodic protection header cable shall be made with a compression C-tap connector (Burndy type YC or equal). All underground compression connections shall be soldered and insulated as specified before burial.
8. All joints shall be insulated with materials and methods that will equal the dielectric strength of the original cable insulation. Joint insulation shall be completed by using a catalyzed resin poured into a cast joint mold or by taping with four half-layers of high-voltage rubber splicing tape followed by two half-layers of plastic splicing tape. Tape shall overlap undamaged end of joint no less than 1 inch. Sharp edges or projections shall be removed or sufficiently rounded prior insulating joints.
9. Soldered connections shall be completed with 50-50 lead-tin solid solder and non-acid flux. Any flux residue shall be removed prior to taping or pouring joint mold.
10. Materials used to repair pipe coating at the pipe lead or joint bond shall be the same as originally used to coat the pipe.
11. Flange insulating kits shall be installed on all above ground metallic flanges to electrically isolate the piping from equipment.
12. Bonding/Connections for Cathodic Protection Systems in Potable Water Tanks
	* + 1. All connections and coatings shall comply with ANSI/NSF-61.
13. Test Stations
14. Test stations suitable for outdoor installation and weatherproof—Big Fink, Testox 715, or approved equal.
15. Test stations shall have a minimum of five terminals and be accessible from both sides when the cover is removed. Terminals shall be nickel-plated copper or brass.
16. Locate test stations (anode junction boxes) at each anode bed for buried pipe for measurement of anode current and pipe-to-soil potential. Install additional test stations along the pipeline to measure pipe-to-soil potentials.
17. Locate a test station at each tank for measurement of anode current and tank bottom-to-soil potential at the center of the tank and the tank periphery.
18. Reference Half-Cells
	* + 1. Permanent underground reference half-cells shall be the saturated, gelled, copper-copper sulfate-type package in manufacturer prepared backfill. Each electrode cable shall be no less than 100 feet in length, #12 AWG Type CP cable with high molecular weight polyethylene (HMWPE) insulation. Manufacturer: AGRA Equipment Company or approved equal.
			2. Permanent reference half-cells for use in water tanks shall be ANSI/NSF‑61 approved. Each electrode cable shall be no less than 50 feet in length, #14 AWG Type CP cable with RHH-RHW insulation. Manufacturer: EDI or approved equal.

## FINISH REQUIREMENTS

1. Finish: ANSI C37.20.1, manufacturer's standard gray (ANSI 61) finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

## PART 3 EXECUTION

1. EXAMINATION
2. Examine surfaces and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of the system. Do not proceed with installation until unsatisfactory conditions have been corrected.
3. INSTALLATION
4. Anode Beds
	1. Install magnesium anode beds vertically at a minimum depth centered on the piping to be cathodically protected and a minimum of 5 feet horizontally away from the pipe to be protected.
	2. Install impressed current shallow vertical anodes at a minimum depth of 10 feet to the bottom of the anode in a one-foot diameter coke breeze column with at least one foot of coke breeze below the bottom of the anode and one foot of coke breeze above the top of the anode.
	3. Where it is undesirable, detrimental, or uneconomical to install anode beds adjacent to underground pipe or to adequately protect numerous underground metallic pipes over a large area, a deep-well anode bed shall be located and drilled to meet the protection requirements for underground pipe. Route a vent pipe to safely discharge chlorine gas produced by the anode bed. Install a guardrail or bollards to prevent vehicle damage to the wellhead, vent pipe, and electrical connections.
	4. Impressed-current deep anode beds shall be drilled to a depth of 167 feet and the top of the coke breeze in the anode column shall be a minimum depth of 115 feet or as required. Install a current measurement shunt in each impressed current anode test or bond box for the measurement of individual anode current output. Three galvanic anodes (max.) may be combined under a single shunt.
	5. Additional backfill material, if required, shall be uniformly distributed, compacted and moistened.
5. Cable and Splices
	* 1. Install cathodic protection cables a minimum of 2’ below grade with a minimum of 1-foot slack to allow for pipe movement.
		2. Splice connections shall be sealed and made watertight.
		3. Restore pipe protective coating after installation of exothermic connections.
6. Exothermic Connections
	* 1. Exothermic connections that pull apart or break loose from pipe when the cable(s) are pulled, struck with a moderate hammer blow, or look porous or deformed shall be rejected.
		2. Do not bury connections until they have been inspected and covered with 3M FBE melt sticks, manufacturer-supplied weld cap, or two-part epoxy—or wrapped with an approved pipeline tape with primer.
7. Pipe Coating
	* + 1. Ensure that all specified pipe coatings are applied properly and remain undamaged (or are repaired as specified) to provide a complete and effective corrosion protection system. Use a holiday detector to verify that repaired coating will perform as originally designed prior to backfilling piping. [See Specification 33 0130 – *Linings and Coatings for Utilities.]*
8. Test Stations
	* + 1. Install post-type test stations as close as possible to directly above the protected pipeline. If is unsuitable due to vehicular traffic, then an alternative location nearby which provides protection such as behind a pole, tree, or other structure is recommended. A ground-level traffic box with a cast iron lid marked “CP” may also be used in high traffic areas.
9. Reference Half-Cells
	1. Store underground reference half-cells in a clean, dry environment (above 40 ºF) until activation and installation. Install in moist soil as close as possible to the cathodically protected pipe, below the frost line, and covered with no less than 6 inches of clean fill free from rocks or other solid objects that may damage the half-cell. Test the half-cells according to manufacturer's instructions for proper operation before burial.
10. Over Voltage Fault Protection Devices
	* 1. Mount over-voltage protection (OVP) devices on the pipe flanges by mounting steel brackets on both of the flange faces on a flange bolt and attaching the OVP device to the bracket on the positive or grounded side of the flange. The single wire lead is negative; attach to the electrically isolated or cathodically protected side of the flange. Electrically short brackets to flange faces by removal of coating as required and sanding the flange surface to bare metal.
		2. Install polarization cell replacement (PCR) devices at a location near the insulating flange because maximum length of cables is 6.5 feet. The 2/0-stranded cables are factory installed in the sealed unit and connected to the internal bushing stud; attach the negative cable to the electrically isolated or cathodically protected pipe.
		3. Flange Guard Over Voltage Protection
11. Flange guard to be installed over insulating flange on piping systems.
12. ADJUSTING AND CLEANING
13. The cathodic protection system shall check to determine if adequate protection is available to isolated systems.
14. Insulated flanges shall be measured to determine if electrical isolation exists as required. Insulated connections shall not be disassembled or reworked if test results are acceptable.
15. Measure pipe-to-soil potentials after the cathodic protection system is placed in-service to verify that 850mV potential (referenced to copper/copper sulfate half-cell) exists at all protected surfaces.
16. Design and install the cathodic protection system to prevent or minimize the effects of stray current corrosion to surrounding buried pipe or other metallic structures.
17. Adjust voltage taps on rectifiers to achieve specified potentials at all protected surfaces.
18. Measure the current-off polarization potential for all protected underground pipes to determine if hydrogen over-voltage potential may exist that may damage pipe protective coatings.
19. Measure the structure-to-soil potential of the surrounding structures before and after the cathodic protection system is placed in to service to verify that these structures have not been made anodic by an impressed current system.
20. RECORD DOCUMENTATION
	1. Send submittals to LANL for review and approval prior to their use. LANL will return same to the Construction Subcontractor who shall forward a copy of the documents indicating approval of LANL to the Testing Agency. At the completion of the Project, turn over the documents in the project file to LANL’s Project Manager.
	2. At the conclusion of the project, provide a Certificate of Conformance stating compliance with all Section and NACE Standard requirements including calculations, drawings, and materials.
	3. Prepare and submit as-built drawings of what was actually constructed.

END OF SECTION

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Do not delete the following reference information:

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THE FOLLOWING STATEMENT is FOR LANL USE ONLY

This project Specification section is based on LANL Master Specification Section 13 4713, Rev. 0, dated July 1, 2019.