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April 26, 2016

Chris Hoidal
Director, Western Region
U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration
12300 W. Dakota Avenue, Suite 110
Lakewood, Colorado 80228

Re: CPF 5-2016-7002M

Attached please find Hilcorp Alaska LLC's amended procedure *P-195.561 External Corrosion* in response to NOA CPF 5-2016-7002M regarding the North Star Sales Oil Pipeline in Prudhoe Bay, Alaska.

Please feel free to contact me at (907) 777-8430 or emckay@hilcorp.com if further information is needed.

Sincerely,

HILCORP ALASKA, LLC

Erin M McKay

Digitally signed by Erin M McKay
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Erin McKay
Regulatory Compliance Manager
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Enclosures
cc (e-mail): Donald T. Johnson (PHMSA)
Mr. Richard Novcaski, Vice President and
Alaska Operations Manager Harvest Alaska, LLC

P-195.561: External Corrosion

Description	This procedure prescribes requirements for protecting buried or submerged metallic pipelines from external corrosion in conformance with applicable codes, accepted industry practices and company specifications. External corrosion control procedures, including those for designing, installing, operating and maintaining cathodic protection systems must be carried out by or under the direction of a person qualified in pipeline corrosion control methods.
Regulatory Applicability	All pipeline required to be cathodically protected. ☒ Regulated Transmission Pipelines ☒ Regulated Gathering Pipelines – Non-rural ☒ Regulated Gathering Pipelines – Rural ☒ Regulated Low Stress Pipelines in Rural Areas

Frequency

Installation	Within one year of construction, relocation, replacement or other change
External examination of exposed pipe	Whenever buried pipe is exposed
Monitoring external corrosion control on protected pipe	Once each calendar year at intervals not to exceed 15 months; however, if tests at those intervals are impractical for separately protected short sections of bare or ineffectively coated pipelines, testing may be done at least once every three calendar years, but with intervals not exceeding 39 months
Monitoring external corrosion control on unprotected pipe	Once every three calendar years, but with intervals not exceeding 39 months
Inspecting rectifiers & other devices	• Rectifiers, reverse current switches, diodes and interference bonds whose failure would jeopardize structural protection: At least six times each calendar year, but with intervals not to exceed 2 ½ months • Other interference bonds: At least once each calendar year, but with intervals not to exceed 15 months

Reference

49 CFR 195.557	Which pipelines must have coating for external corrosion control?
49 CFR 195.559	What coating material may I use for external corrosion control?
49 CFR 195.561	When must I inspect pipe coating used for external

		corrosion control?
	49 CFR 195.563	Which pipelines must have cathodic protection?
	49 CFR 195.567	Which pipelines must have test leads and how do I install and maintain the leads?
	49 CFR 195.571	What criteria must I use to determine the adequacy of cathodic protection?
	49 CFR 195.573	What must I do to monitor external corrosion control?
	49 CFR 195.575	Which facilities must I electronically isolate and what inspections, tests and safeguards are required?
	49 CFR 195.577	What must I do to alleviate interference currents?
	49 CFR 195.585	What must I do to correct corroded pipe?
	49 CFR 195.588	What standards apply to direct assessment?
Forms	F-195.422	Leak Investigation / Repair and Exposed Pipe and Foreign Crossing Report
	F-195.561	Cathodic Protection Installation
	F-195.573	External Corrosion Control Monitoring
Related Specifications	API 1162	Public Awareness Programs for Pipeline Operators
	API Spec. 12F	Specification for Shop-Welded Tanks For Storage Of Production Liquids
	API 650	Welded Steel Tanks for Oil Storage, Including Addenda 1-3
	API RP 651	Cathodic Protection of Aboveground Petroleum Storage Tanks
	ASME/ANSE B31G	Manual for Determining the Remaining Strength of Corroded Pipelines
	NACE RP-0169-96	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
OQ Covered Task List	CT1--Conducting Cathodic Protection Surveys	
	CT1.1--Measuring structure-to-soil Potentials	
	CT1.2--Conduct Close Interval Surveys	
	CT1.3--Test to Detect Interference	
	CT1.4-- Inspect and perform electrical test of bonds	
	CT1.5-- Inspect and test isolation device	
	CT2--Maintain Test Leads	
	CT2.1--Inspect and verify test lead continuity	
	CT2.2--Repair damaged test leads	
	CT2.3--Install test lead by non-exothermic welding methods	
	CT2.4Install test leads by exothermic welding methods	
	CT3-- Inspect Rectifier (Obtain Voltage and Current output reading from rectifier to verify proper performance)	
	CT4-- Maintain and Repair Rectifier	
	CT4.1--Troubleshoot rectifier	

CT4.2--Repair or replace defective rectifier components

CT4.3--Adjustment of rectifier

CT8--Cathodic Protection Remediation

CT8.1--Install Bonds

CT8.2--Install Galvanic Anodes

CT8.3--Install Rectifiers

CT8.4-- Install impressed current ground beds

CT8.5--Repair shorted casing

CT8.6--Install electrical insulating device

CT14--Apply and Repair External Coating on Buried or Submerged Pipe

CT14.1--Prepare surface for coating using hand tool and power tools

CT14.2--Perform water pressure cleaning

CT14.3--Perform surface for coating by abrasive blasting

CT14.4--Apply coating using hand application methods

CT14.5--Apply coating using spray applications

CT14.6--Perform coating inspection

(In order to perform the tasks listed above, personnel must be qualified in accordance with the company's Operator Qualification program or directly supervised by a qualified individual.)

REVIEW AND REVISION LOG

This O&M Procedure shall be reviewed at intervals not exceeding 15 months, but at least once each calendar year, and appropriate changes shall be made as necessary to ensure that the manual is current, complete, and effective.

Review and/or Revision Date	Reviewer	Revision Description
December 2013	Erin McKay	Annual Review of manual and reformat plan into new format.
October 2014	Erin McKay	Annual Review of Manual & Procedures.
May 2015	Ben Wasson	Annual Review.
July 2015	Ben Wasson	Annual Review. Rev'd *Criteria for Close Interval Survey*: CIS inspection procedure. Separated procedures from Manual.
July 2015	Keith Sanfacon	Updated Cad welding procedure.
July 2015	Phil Ceder-Reinke	Updated and reviewed CP procedures
October 20, 2015	Ben Wasson	Minor corrections, clarification of CIS requirements and investigation of corrosion damage (P. Ceder-Reinke). Revised to address training requirements, supervisor qualifications, and procedure effectiveness review. Minor additional editorial revisions.
April 5, 2016	Phil Ceder-Reinke	Revised Applying External Coating sections to include holiday testing for newly coated areas > 5ft.

PROCEDURE STEPS

Cathodic Protection

Per DOT 49 CFR 195.563, each buried or submerged pipeline that is constructed, replaced or otherwise changed must have cathodic protection that is in operation no later than one (1) year after the construction, replacement or change.

Each buried or submerged pipeline converted under 49 CFR 195.5 for use in transporting hazardous liquids must have cathodic protection if the pipeline:

- Has cathodic protection that substantially complies with one or more applicable criteria contained in paragraphs 6.2 and 6.3 of NACE SP0169; and/or
- Is a segment that is relocated, replaced or substantially altered.

All other buried or submerged pipelines that have an effective external coating[1] must also have cathodic protection. This requirement does not apply to breakout tanks, and does not apply to buried piping in breakout tank areas and pumping stations until December 29, 2003.

Bare pipelines, breakout tank areas, and buried pumping station piping must have cathodic protection in places where regulations in effect before January 28, 2002 (i.e. previous editions of this part in 49 CFR parts 186 through 199) required cathodic protection as a result of electrical inspections.

Unprotected pipeline must have cathodic protection if a three or five-year re-evaluation (required under 49 CFR 195.573(b)) indicates cathodic protection is warranted.

Note: The procedure steps listed below are the minimum required to meet regulatory compliance. Project specific instructions or Facility specific manuals may require more detailed data collection or reporting requirements. These reporting requirements should be verified with the Facility Engineers, Project Managers and Regulatory Compliance Specialists to insure all necessary information will be collected.

Supervisor Qualifications (§195.555)

Personnel who perform and/or supervise corrosion control activities shall be qualified by training, industry certifications and/or previous experience prior to engaging in the practice of corrosion control for external corrosion. Hilcorp management is responsible for ensuring that the qualifications of those who oversee and direct corrosion control activities are adequate and appropriate for the type of work being performed for hazardous liquids in transportation established under Title 49: Part 195 -Subpart H-Corrosion Control. If Hilcorp does not have qualified personnel, they may utilize the services of a competent, qualified contractor or consultant. Qualified supervisors shall take prompt remedial action to correct any deficiencies observed during cathodic protection monitoring and determine the appropriate repairs required.

[1] *A pipeline does not have an effective external coating if the current required to cathodically protect the line is the same as if the line was bare.*

External Corrosion Design Considerations

Structure design should include but not be limited to corrosion control considerations and cathodic protection current requirements in the following sections. Refer to local engineering and construction standards manuals and typical drawings for additional details.

Electrically isolate the pipeline from all the following points, except where the pipeline is electrically interconnected with a structure and both are cathodically protected as a single unit or where the pipeline is intentionally bonded to mitigate interference currents:

- Shipper/customer and other mechanically interconnected pipelines at changes in ownership;
- Metallic casings and wall sleeves;
- Metal buildings and foundation steel;
- River weights;
- Valve enclosures (metallic buried valve boxes);
- Pipeline bridges;
- Other foreign metallic structures; and
- Anywhere electrical isolation is required to facilitate applying cathodic protection.

Note: Avoid installing insulating devices in areas containing a combustible or explosive atmosphere without taking precautions to prevent arcing.

Consider the following when designing for external corrosion:

- Induced A/C current while operating in power line rights-of-way;
- Shielding;
- Other foreign cathodic protection systems near the facility; and
- Protect pipelines and insulating devices from fault currents and lightning with grounding anodes and fault current mitigation devices such as solid state surge suppressors.

Electrical Isolation

Electrical isolation may be attained by:

1. **Flange insulation**: Mating standard raised face flanges may be made into an insulating device by installing an insulating kit in the flange. An insulating kit consists of an electrically non-conductive gasket, non-conductive sleeves to encase the studs, and non-conductive washers for both nuts of a stud. Steel washers should also be placed immediately under nuts to protect the insulating washer from being crushed during torquing. When welding the insulating flange unit or the weld type insulated coupling into the line, care shall be exercised to be sure that the insulation is not damaged by the current “arc” which could occur from welding. This can be achieved by moving the ground cable to the same side of the flange set as the electrode cable thus eliminating current “arc” across the insulating flange during welding.
2. **Monoblock insulating joints**: Monoblock insulating joints are factory-assembled insulating assemblies that are welded into a pipeline; they have no serviceable parts.

3. **Insulated unions**: Insulating unions are usually used for small diameter (3” or less) piping attachments that required electrical insulation.
4. **Casing centralizers and end seals**: Non-conductive centralizing devices are attached to pipelines where the carrier pipe passes through a cased crossing. These centralizers prevent electrical contact between the casing and the carrier pipe. Casing end seals prevent water or soil from entering the annular space between the carrier pipe and casing and causing an “electrolytic” short between the casing and pipe.
5. **Other devices**: Frequently, high-pressure laminated (e.g., micarta) dielectric blocks or neoprene rubber pads are used to electrically isolate a pipeline from supports or other structural appurtenances which are not a part of the cathodically protected pipeline.

Test Stations and Other Contact Points

Provide sufficient test stations or other contact points for electrical measurements to determine if cathodic protection is adequate.

Test points include test leads, valves, taps, meters, risers and other aboveground piping and should generally be no more than one mile apart. Install corrosion control test leads at:

- Pipe casings;
- Foreign metallic structure crossings, if practical; and
- Buried insulating joints (install insulating joints above ground when practical).

These factors are important when selecting test point locations:

- Land use;
- Accessibility;
- Distance from other test points;
- Population density;
- Pipe coating condition and pipeline current demand;
- Problem areas indicated by close interval survey data; and
- Span length test stations.

The following may also be used in conjunction with test stations:

- Cathodic protection determining coupons; and
- Permanent reference electrodes.

Attaching Test Leads

1. Exothermic welding shall be carried out by personnel proficient in using the equipment and requirements of this specification to produce satisfactory results. Personnel conducting thermite welding shall perform a satisfactory cable-to-pipe demonstration weld (on a sample pipe), witnessed by a Hilcorp representative, prior to welding to product piping.

2. Connect structure leads to piping

3. Do not make connections within 6 inches of pipe girth welds or in areas of visible corrosion metal loss. Maintain at least 1 inch of spacing from longitudinal pipe welds. Leads shall be separated by at least 24 inches on piping.

4. Prepare the connection area by removing any existing coatings using a knife or scraper. Clean the area to bare metal. Remove an approximately 3” x 3” square area of coating and feather the edges (do not exceed 4” x 4” in exposed metal). File with a coarse file or rasp, or grind with a disc grinder and flexible disc to bright metal. Brushing the surface is not sufficient. Do not use resin-based sanding disks. Remove only the amount of metal necessary to achieve a clear, clean area.

5. Cut cable ends using a cable cutter to minimize deformation. Remove jacketing from the end to allow for insertion into the mold. Do not remove more that will be covered by the encapsulation. The conductor must be clean and dry to ensure a good weld. If the conductor end is wet and muddy, heat the conductor using a torch to remove all moisture. Wiping while heating helps to remove mud. Next, rap the conductor to remove as much dirt as possible. Finally, wire brush the conductor ends to remove any remaining dirt and oxidation.

6. Verify that the correct mold type is being used. Ensure the mold used is clean, dry and in good condition. Confirm the following items:

   a. The conductor fits snugly in the cable opening (preventing leakage), and the opening is not chipped or worn out of round.
   b. The weld cavity is well-defined, with no chips or gouges.
   c. The tap hole is well-defined.
   d. The disk seat is not worn or chipped, and allows the disk to seat properly.
   e. The mold parting face is not chipped, and has been cleaned properly using a towel or cloth since the last use. Do not use a wire brush to clean this face.

7. Heat the mold before using for the first time each day. The mold may be dried by heating to around 250° F with a torch.

8. Preheat the open mold with a torch to a maximum of 150° F. Place cable end into the mold. Close and lock the mold. Insert the metal disk (concave side up) in the weld metal cavity, covering the tap hole. Prepare the mold with the appropriate charge size (provided in section 2.04). Substitutions are not permissible.

9. To ensure the base metal is dry, preheat the base material to 70-150° F using a torch. Next, gently set the mold on the base metal. When ready, hold the mold steady and ignite the starting material using a flint igniter. Never use a match or lighter for igniting the charge. Lightly tap the mold with the igniter while it is burning to help produce a more uniform weld.

10. Wait approximately 40 seconds for the reaction to complete, the weld to solidify, and the weld to cool. Open and remove the mold.

11. Examine the weld visually and by impact testing to ensure that it is acceptable.
    a. Visual Examination: Visually confirm that the weld is free of excessive slag, and is reasonably smooth and porosity free. Excessive porosity is usually due to contaminants such as dirt, water and oil. Reject and replace the weld if slag deposits cover more than 20% of the connection surface; if cable strands are exposed after slag removal; if a 1/32-inch diameter wire (paper clip) can penetrate a surface pinhole beyond the center of the

conductor; or if the any portion of the conductor within the normal confines of the weld is exposed.

b. Impact Test: Impact test the connection to determine mechanical integrity using a metal or plastic hammer (1-2 lbs). Tap the base of the weld to confirm proper bonding. If the connection moves or breaks free, reject the weld and repeat the weld process.

12. Remove rejected welds by grinding, minimizing removal of the base metal. Do not reweld within 6 inches of a prior weld location. Consult Engineering for coating instructions for areas of exposed metal due to rejected welds.

13. Encapsulate the completed cable connection using a Royston Handy Cap IP encapsulation (4" x 4"), or a Handy Cap XL IP (5" x 5"). These encapsulations employ an integrated primer and do not require further priming. Install the encapsulation per the manufacturer's instructions. Consult the on-site Field Engineer if the "XL" encapsulation is not large enough to cover the exposed area.

14. Prior to backfilling, perform a pipe-to-soil survey.

15. Backfill without disturbing the test station or wires.

16. Install post or pole with station attached directly above the pipeline. Do not connect the post or pole directly to the pipeline.

17. If more than one pipeline is monitored at this test station, attach permanent labels designating each pipeline to the appropriate station terminals and wires.

18. Add test station number and location to the most recent annual survey and map.

19. Distribute revised maps as required.

Applying External Coatings

1. Identify section to be coated. Coat all external surfaces. When evaluating existing coating, repair any locations where the coating is not well bonded to the substrate or has visible gaps.
2. Identify existing coating type, if previously coated.
3. Determine type of coating to be applied. Coating must:
   a. Be designed to mitigate corrosion of the buried or submerged pipe;
   b. Have sufficient adhesion to the metal surface to prevent under film migration of moisture;
   c. Be sufficiently ductile to resist cracking;
   d. Have enough strength to resist damage due handling and soil stress;
   e. Support any supplemental cathodic protection; and
   f. If the coating is an insulating type, have low moisture absorption and provide high electrical resistance.
4. Obtain the necessary tools, materials, and safety equipment.
5. If pipeline was previously coated, remove damaged coating on existing pipe.

6. Prepare surface for coating application according to coating manufacturer's specification. Make all practical efforts to dry the pipe before applying coatings or primers. Never apply coatings when the steel surface is wet unless the coating is designed to be applied to wet surfaces as specified in the coating manufacturer's application instructions. Review the recommended cleaning and surface preparation requirements for each coating before applying. All coatings have improved performance based on the quality of surface preparation. Abrasive grit blasting is the preferred surface preparation method. If abrasive grit blasting is not feasible, use methods such as hand tools or power equipment with 80-grit abrasive disk pads, air driven needle scalers or non-woven abrasive pads to remove corrosion rust products, old coating products and to prepare the surface for coating.
7. Examine the pipe for evidence of corrosion, pitting, gouges, dents or other surface damage.
8. Does the pipe surface have any of these damages that require further investigation?
    a. If no, continue with Step 9.
    b. If yes, seek assistance from the Pipeline Maintenance Technician for additional investigation and corrective actions before applying coating.
9. Apply coating according to vendor specifications. Allow time for the coating to sufficiently cure.
10. Just prior to lowering the pipe into the ditch, submerging the pipeline, or covering repair, inspect the pipe coating for damage. Repair any damage found with a protective coating compatible with the original coating.
    a. The coating on new or replacement pipeline installations shall be inspected over the entire surface area for coating holidays using an electronic holiday detector prior to lowering in the ditch and backfilling. Large-scale coating repairs (> 5 feet in length) utilizing a paint or epoxy-coating system (non-tape wrap systems), shall also be inspected for coating holidays using an electronic holiday detector prior to backfilling the pipeline. Wrapped systems such as wax tapes and A-Plus wraps will be visually inspected. Repair all coating holidays detected with a compatible approved coating prior to backfill.
    b. All small-scale coating repairs (≤ 5 feet in length) or patch coating repairs shall be visually inspected for coating holidays and repaired prior to backfill.
    c. The necessary holiday detector voltage will vary with the type of coating and thickness. The application tables include guidance voltage for holiday detector settings. As a rule, detector voltage setting should be 125 times the coating mil thickness. Example for 30 mil coating: 125 x 30 = 3,750 volts. Consult the coating manufacturer's literature for additional guidance.
    d. Holiday detectors for higher voltage ranges are available with metal coils, metal brushes or conductive rubber wands for contact. Low voltage types using a wet sponge wand are available for small, irregular painted surfaces up to 10 mils thick (or on painted surfaces up to 20 mils thick with suitable wetting agent).

> Note: Provide additional protection to the coating where needed during backfilling by using clean earth padding, rock shield or pipeline felt.

    e. Buried pipe that extends above grade should be coated with an approved underground coating at least one foot above grade. Coating application may be less than one foot if applying coating limits proper operation of control valves or other appurtenances. Paint over the aboveground coating to match the paint color applied for atmospheric corrosion and to protect the below grade coating from ultraviolet rays from the sun.

11. Have Manual Coordinator (or designated individual) document the type of coating applied.

Coating Performance Considerations

Tape Coatings

Hot applied tapes can be used on pipelines ≤ 16” in diameter with an operating temperature ≤ 120° F.

Apply per manufacturer’s instructions.

Liquid Epoxy Product Coatings

Liquid epoxy product coatings provide excellent coating performance but require surface preparation to a near white cleanliness and 2 mils or more anchor pattern for best results. Correct mixing ratios are necessary for proper reaction. Liquid epoxies specified in the tables have a wide range of operating temperature limitations and various cure times for cold or warm weather application.

1. Prepare the surface by blasting with appropriate abrasive grit media to a white metal surface; use 80-grit abrasive sandpaper or hand power equipment with an 80-grit disk to roughen the surface to a white metal finish.
2. Apply to a thickness specified by the manufacturer.
3. Apply by pouring, brushing, rolling, spraying or daubing as specified by the manufacturer.

New and Existing Casings

Avoid installing casings whenever allowable or practical. Remove all casings that are no longer required if practical, such as at abandoned railroad crossings, road crossings and canals. In some cases, however, railroad or public highway regulations require the installation of a casing for right-of-way crossings. When casings are required, the carrier pipe will be electrically isolated from the casing.

Cathodic Protection Design

Pipelines and Stations

Follow these considerations when designing cathodic protection systems:

1. Materials and installation practices shall conform to existing codes and National Electrical Manufacturers Association (NEMA) standards.
2. Select and design the cathodic protection system for optimum economies of installation, maintenance and operation.
3. Deliver sufficient cathodic protection current to the structure to meet an applicable criterion for cathodic protection efficiency.
4. Minimize interference currents on neighboring structures.

Breakout Tanks

This procedure shall apply to the design, construction, and monitoring of all Hilcorp Alaska tank facilities.

Responsibility

Corrosion personnel shall be responsible for determining the level of protection on protected facilities and implementing appropriate remedial action when so required. Refer to API 651, Sections 5-7 for information on the need for protection, type of system and system design.

Design and Construction of Tanks Installed after 10/2/2000

All tanks designed and installed after the above date shall include a cathodic protection system in accordance with API Recommended Practice 651. The cathodic protection must be in operation no later than one year after construction is complete. The following equipment may be considered during the design.

1. Determine need for protection using API 651, Section 5.
2. Determine type of system to install using API 651, Section 6.
3. Design the system according to API 651, Section 7.
4. Install galvanic anode system according to API 651, Section 9.2
5. Install impressed current systems according to API 651, Section 9.3.1 and the applicable sections:
6. Shallow ground beds (API 651, Section 9.3.2);
7. Deep ground bed (API 651, Section 9.3.3);
8. Rectifiers (API 651, Section 9.3.4); and
9. Cables (API 651, Section 9.3.5).
10. Install corrosion control test station, connections and bonds according to API 651, Section 9.4.
11. Determine interference currents and isolate according to API 651, Section 10.

Design and Construction of Tanks Installed before October 2, 2000

During retrofitting or upgrading of tanks installed prior to the above date, utilization of equipment as listed above should be considered.

Current Requirements

Current requirement estimates may be obtained from:

- Using a "generator" test to arrive at the actual current required to meet one or more of the applicable cathodic protection criteria; and/or
- Prior experience or test data obtained from pipelines with a similar coating material in similar electrolytes.

Note: Additional current capacity should be provided in the design based on a best engineering estimate of coating deterioration rates, pipeline expansion, bond currents, etc.

Field Survey Work

For all impressed current cathodic ground bed designs:

1. Determine the foreign facility crossings within the projected influence of the designed cathodic protection facility.
2. Obtain accurate measurements of the proposed cathodic protection system hardware locations.
3. Conduct current requirement and interference testing when practical.
4. Verify accessibility to the proposed work site.
5. Verify A/C power availability, voltage and phase.
6. Verify and document any existing/historical ground bed locations.
7. Review site for environmental considerations.

For deep anode ground bed designs, determine the geology of the strata at the deep anode location.

For distributed and conventional impressed current ground bed designs and galvanic anode designs, determine the electrolyte resistivity for the proposed anode locations.

Reviewing Design and Construction Work

Personnel knowledgeable in corrosion and/or Hilcorp Alaska Integrity Group practices shall review impressed current and galvanic anode ground bed designs. The review should include calculation accuracy an agreement with assumptions and empirical design parameters, conformance to Hilcorp Alaska material and design standards, drawings, specifications and applicable codes.

All construction work designed for corrosion control systems shall be in conformance with the latest revisions of construction drawings, specifications and applicable codes.

Criteria for Cathodic Protection

This procedure specifies criteria (applied individually or collectively) to provide adequate cathodic protection for all regulated facilities. No single criterion has proven satisfactory or practical to evaluate cathodic protection effectiveness for all conditions. Special cases may require using criteria different from those provided in this procedure.

Consult with the Area Corrosion representative (or designated individual) for assistance with applications that may require other monitoring criteria.

Buried or Submerged Steel Structures Cathodic Protection Criteria

A Negative 850 mV with Protective Current Applied

A negative (cathodic) voltage of at least 850 mV as measured between the structure and a saturated copper-copper sulfate electrode (CSE) contacting the electrolyte.

Determine this voltage with the protective current applied. Place the half-cell directly over the pipeline to measure the pipe-to-soil (P/S) potential. Consider IR drops other than those across the structure's electrolyte boundary for valid voltage measurement interpretation, such as:

- Historical performance of the cathodic protection system;

- Measuring or calculating the voltage drop;
- Evaluating the physical and electrical characteristics of the pipe and its environment;
- Visual inspection of pipeline assets; and
- Determining whether or not there is physical evidence of corrosion.

Negative 850 mV – Instant Off

Place the CSE directly over the pipeline to measure the P/S potential. Determine voltage by interrupting the protective current. When the current is initially interrupted, an immediate voltage shift will occur. Use the voltage reading after the immediate shift. If this reading is more negative than 850 mV, compliance is achieved.

100 mV Polarization Shift

A minimum negative (cathodic) polarization voltage shift of 100 mV measured between the structure surfaces and a saturated CSE contacting the electrolyte.

Following are two methods for determining the 100 mV polarization shift.

- First method: Place the CSE directly over the pipeline to measure the P/S potential. Determine polarization voltage shift by interrupting the protective current and measuring the polarization decay. When the current is initially interrupted, an immediate voltage shift will occur. Use the voltage reading after the immediate shift as the base reading from which to measure polarization decay. When polarization decays 100 mV or more, compliance is achieved.
- Second method: Place the CSE directly over the pipeline to measure the P/S potential. Determine the instant-off (polarized potential) by interrupting all current sources affecting the test point and recording the instant-off P/S potential. Compare the instant-off polarized potential to the static potential and confirm 100 mV or greater difference.

The 100 mV shift can be measured against data from a Depolarization Survey. A Depolarization Survey is conducted by isolating the structure (pipeline) from all sources of CP current. The structure is allowed to depolarize. Each test station is surveyed by measuring the P/S potential between the structure and a CSE placed directly over the pipeline. The data gathered in either of the two methods described above can be compared to the Depolarization Data to determine if compliance has been achieved using the 100 mV polarization shift criteria.

If a structure is able to meet either of the negative 850 mV criteria described above it is not necessary to use Depolarization Survey data in order to determine compliance. If a structure is using the 100 mV shift to meet compliance, then it is necessary to consider the accuracy of the data from the Depolarization Survey. Typically Depolarization Surveys are conducted (when needed to determine compliance) every 5 to 7 years. If a structure is relying on the 100 mV shift to meet criteria, use sound engineering judgment to determine if a new Depolarization Survey should be conducted.

Breakout Tanks

Use API 651, Section 8 to determine the criteria for cathodic protection on breakout tanks.

Cathodic Protection Installation

Note: Installation of new or additional cathodic protection is documented on F-195.561: External Corrosion Control Installation and Monitoring.

Ground Beds

1. Excavate line and install sacrificial or impressed current anodes per project specific instructions and manufacturer guidelines.
2. Surface beds:
   a. Remote: Install vertically or horizontally between 5-15' deep on 10-15' centers at distances up to 400' away from pipeline.
   b. Distributed: Locate in close proximity to structure. In stations and terminals, anodes should be located 5-10' away from the structure.
3. Deep beds:
   a. Shallow well anodes.
      i. Installed in vertically drilled holes.
      ii. Drill hole depths according to company and manufacturer standards.
      iii. Install anode singular or multiple stacked according to company needs.
      iv. Backfill with carbonaceous backfill materials.
   b. Deep well anodes:
      i. Installed in vertically drilled holes up to 500 feet deep
      ii. Drill hole depths according to company and manufacturer standards.
      iii. Install anodes per project instructions and manufacturer recommendations.
      iv. Backfill with carbonaceous backfill materials.

Bonds

1. Test for the presence of AC/DC current interference. Potential sources include, but are not limited to, other pipeline cathodic protection facilities, DC traction systems (subways, light rail systems, trolleys, etc.), high-voltage AC transmission lines, welding facilities, stray currents, etc. Install bonds according to the following section as applicable. Follow these steps to install bonds for cathodic protection:
2. Conduct joint cooperative interference tests with the effecting structure to determine location of current discharge and magnitude of interference current.
3. Install test wires on both structures at location of current discharge.
4. Test wires are to be attached by thermite weld (Cadweld, Thermoweld, etc.), brazing or other method which will yield a permanent, low resistance connection. Welding must be done by a qualified welder.
5. Terminate test wires inside of appropriate test, box that is accessible to both structures.

6. Inside of the test box, install shunts for measurement of current flow. Also, install resistors as required, to limit current interchange between the structures.
7. Install blocking diodes as required.
8. Conduct tests to determine effectiveness of the installed interference bond.
9. Install rectifiers or reverse current switches in unusual situations where a conventional metallic bond is not effective. This installation must be done by a qualified person.

Galvanic Anodes

1. Determine the most suitable location for anode installation.
2. Excavate anode hole.
3. Install anode by placing in augured hole or horizontal excavation.
4. Wet down anode prior to backfilling or prior to installation in ground.
5. Uncoil anode pigtail and extend fully being careful not to damage or kink wire.
6. Backfill carefully with native soil backfill. Use rock-free backfill to pad anode and the anode lead wire.

Impressed Current Anodes

1. Determine location of anode installation.
2. Excavate vertical hole or horizontal ditch for anode installation.
3. Carefully install anodes in excavated hole. Do not lift or lower the anode by its lead wire.
4. Surround anode with coke breeze or bentonite. For vertically augured holes bring coke breeze level up to just under ground surface and if a vent pipe is not installed to make a porous path for off-gassing to occur.
5. Backfill with native soil. Use rock free soil to pad the anode and the lead wire, being careful not to damage either.

Cathodic Protection Surveys, Monitoring and Adjustments

Conduct periodic measurements and inspections to detect changes in the cathodic protection system to ensure that each part of the cathodic protection system is operating properly. As conditions that affect cathodic protection change with time, changes may be required to maintain protection.

Pipe-to-Soil Surveys

Measure pipe-to-soil readings at least once each calendar year, not to exceed 15 months at all established test points on all pipelines and appurtenances needed to meet the applicable criteria.

New metallic pipelines shall be cathodically protected and must have a post-installation close interval cathodic survey performed within one year of the installation date. Normally a close interval survey collects voltage readings approximately every three feet as a person walks the pipeline right-of-way. In cases where access is restricted—such as off-shore, tidal zones and beneath rivers, and underneath built structures—reasonable steps will be taken to assess cathodic protection levels.

Measure Pipeline-to-Soil Potentials, DC

1. Bring proper equipment:
   a. Hi-impedance voltmeter;
   b. Copper-copper sulfate reference electrode (half-cell); and
   c. Test leads.
2. Properly locate the half-cell relative to the structure.
3. Measure pipeline-to-soil potential by connecting the voltmeter's positive lead to the pipeline and the negative (common) lead to the half-cell. Use the DC voltage scale.
4. Document readings in appropriate format. Use Form F-195.573(a): Casing Inspection.
5. Field-analyze readings to ensure that are within the desired range, more negative than -850 mV.
6. Promptly notify appropriate personnel if readings do not fall within desired range.
7. Forward all results to appropriate personnel for interpretation.
8. Determine proper correction of any deficiencies found.

Measure Casing-to-Soil Potentials, DC

Repeat Steps 1-4 from Measuring Pipeline-to-Soil Potentials, DC (above) for all casings, except connect voltmeter's positive lead to the test station lead connected to the casings. Keep the voltmeter negative lead (common) connected to the half-cell. If test station lead to the casing does not exist or produces a questionable reading, crosscheck by connecting positive lead of voltmeter directly to a clean metallic spot on the casing vent pipe, and retake reading. Note missing or inactive test station lead wire in Comment section of Form F-195.573(a): Cathodic Protection Survey.

Measure Pipeline-to-Soil Potentials, AC

1. All steps are the same as for measuring pipeline-to-soil DC potentials, Steps 1-4, except for Step 3 where the scale setting of the voltmeter must be changed to AC voltage.
2. Notify appropriate personnel immediately if any reading is above 15 volts AC.
3. Determine proper correction of any deficiencies found.

Measure Amperage at Test Stations Where Anode Lead-Wire(s) Come Above Ground

1. Use voltmeter on DC millivolt scale to read voltage drop across shunt, if installed. Record directions of current flow, positive or negative, using the following convention for use of the voltmeter: attach pipeline side of the shunt to the positive lead of the voltmeter, and the anode side to the negative, or "common" lead.
2. Record the DC millivolt reading, and whether the voltage is positive or negative.
3. Forward all results to appropriate personnel for interpretation.

Cathodic Protection Units (CPU) Surveys

Electrically check all impressed current rectifiers or other impressed current sources for proper operation. Read and record output at least six times each calendar year, not to exceed 2.5 months. Aerial indicators may be an acceptable means of verifying proper operation of impressed current rectifiers.

Inspect Rectifier

1. Read volts across rectifier terminals, with rectifier on-line.
2. Read amps on panel meter. Also check and record amperage across pre-installed shunt by using millivolt scale of a portable voltmeter. If amps on panel meter do not agree with amps determined by shunt, have the panel meter adjusted.
3. Open rectifier top cover and record tap positions, coarse and fine. Also, check oil level and condition if the unit is oil cooled.
4. Take and record pipe-to-soil potential on the pipeline in an area protected by the rectifier. If reading is more positive than –850 mV, adjust the rectifier. Go to procedure section Adjust Rectifier.
5. Turn rectifier off briefly or interrupt on a known cycle. Go over to pipeline and take another pipe-to-soil potential reading. Reading should be more positive than reading taken in Step 4.
6. Turn rectifier back on. Amps and voltage should return nearly to pre-"off" conditions, although amperage may be slightly higher.
7. Take one more pipe-to-soil reading, at the same location as in Steps 4 and 5. Voltage should be within 0.04 volts of the voltage read in Step 4.
8. Write a work order (Form F-195.422: Leak Investigation Repair and Exposed Pipe and Foreign Pipeline Crossing Report), if any step above shows rectifier is not working properly.

Obtain Rectifier Voltage/Current Output Reading

1. Determine voltage by connecting a suitable voltmeter across the output terminals of the rectifier.
   a. Connect the positive lead to the rectifier positive terminal.
   b. Connect the negative lead to the rectifier negative terminal.
2. Determine current on a pre-installed shunt by reading the millivolt drop across the shunt and multiplying by the shunt ratio.
3. Obtain the shunt ratio by reading the value labeled on the shunt and dividing the amp value by the mV value.
4. Examine rectifier for any abnormal defects.
5. Does the rectifier need adjusting?
   a. No – Continue with Step 6.
   b. Yes – Notify appropriate personnel of the rectifier output adjustment.
6. Record all required readings.

Check Rectifier for Proper Operations

1. Perform basic unit inspection.
2. Read and record the rectifier output voltage.
3. Determine voltage:
   a. Connect a suitable voltmeter across the output terminals of the rectifier.
   b. Connect the positive lead to the rectifier positive terminal.

   c. Connect the negative lead to the rectifier negative terminal. The reading should be positive.
4. Determine current on a pre-installed shunt by reading the millivolt drop across the shunt and multiplying by the shunt ratio.
5. Obtain the shunt ratio by reading the value labeled on the shunt and dividing the amp value by the mV value.
6. Examine rectifier for any abnormal defects.
7. Does rectifier need adjusting?
   a. No – Continue with Step 8.
   b. Yes – Notify appropriate personnel of the rectifier output adjustment.
8. Compare observation with historical data.

Perform On/Off Test

1. Perform basic unit inspection.
2. Read and record the rectifier output voltage.
3. Determine voltage:
   a. Connect a suitable voltmeter across the output terminals of the rectifier.
   b. Connect the positive lead to the rectifier positive terminal.
   c. Connect the negative lead to the rectifier negative terminal.
   d. The reading should be positive.
4. Determine current on a pre-installed shunt by reading the millivolt drop across the shunt and multiplying by the shunt ratio.
5. Obtain the shunt ratio by reading the value labeled on the shunt and dividing the amp value by the mV value.
6. Examine rectifier for any abnormal defects.
7. Collect on potential readings at structures to be protected.
8. Install current interrupter per manufacturer's instructions or briefly turn rectifier off.
9. Recollect potential readings on structures to be protected.
10. Determine if readings meet compliance requirements.
11. Does rectifier need adjusting?
    a. No – Continue with Step 12.
    b. Yes – Notify appropriate personnel of the rectifier output adjustment (See Adjust Rectifier).
12. Compare observation with historical data.

Adjust Rectifier

1. Turn rectifier "off" with external switch using internal breaker on the unit.

2. Increase the fine tap setting in progressive steps. Turn rectifier back on after each step, and take structure pipe-to-soil potential reading again. Continue fine adjustment step-wise until desired structure pipe-to-soil has been achieved.
3. If the fine tap setting reaches its highest setting and desired structure pipe-to-soil potential has not yet been achieved, turn rectifier off again. Set fine tap to the lowest setting and increase the coarse tap in increments of one. Turn rectifier back on and recheck structure pipe-to-soil pipeline voltage. Repeat step-wise fine tap adjustments per Step 2 until desired structure pipeline voltage is obtained.
4. Record final new tap settings, and voltage and amperage outputs. Read amperage both on panel meter and by mV drop across permanent shunt. Leave rectifier switched on.

Troubleshoot/Repair Rectifier

Note: Rectifier servicing should be performed by a licensed electrician or a technician familiar with the maintenance and operation of the rectifier unit.

1. Complete the following on primary AC breaker:
   a. With power on, check that voltage is being supplied to the rectifier by confirming AC voltage on the line side of the rectifier's circuit breaker.
   b. With the rectifier's circuit breaker closed, check that voltage is being supplied to the rectifier by confirming AC voltage on the secondary side of the rectifier's circuit breaker.

Note: AC voltage should be the same on the supplied and secondary sides of the circuit breaker.

2. Complete the following on primary AC fuses:
   a. Remove fuse or fuses.
   b. Check fuse or fuses for continuity with ohmmeter.
3. Complete the following on transformer:
   a. With the unit on, check the transformer secondary by reading AC voltage between the center studs of the tap setting terminals.
   b. Voltage may be checked between any of the secondary taps.
   c. The entire secondary winding can be measured between the highest coarse tap and the highest fine tap.
   d. If the circuit breaker trips, indicating a short circuit, the transformer may be isolated from the DC circuit by removing the secondary tap changing link bars.
   e. If the circuit breaker continues to trip, look for visible shorts between the transformer leads.
   f. If the circuit breaker does not trip, the short is not in the transformer, but in the DC circuit.
4. Complete the following on secondary AC fuses:
   a. Remove secondary AC fuses located in the circuit between the center studs of the tap setting terminals and the bridge connections on the stack.
   b. Check fuse or fuses for continuity with ohmmeter.
5. Complete the following on stack:

Caution: To check diodes in a stack, turn off the unit at disconnect breaker and the unit breaker.

   a. Remove either the fine or coarse tap link bar.
   b. Remove either the positive or negative DC output lead.
   c. Connect one ohmmeter lead to either the coarse or fine tap center stud and the other lead to the positive terminal. Reverse the leads and check again.
   d. Move the lead from the positive terminal to the negative terminal. Reverse the leads and check again.
   e. Move the other lead from whichever tap center stud it is connected to the other tap center stud and repeat the checks at the negative and positive output terminals.

f. Each diode should have a low resistance value in the forward direction and a very high or infinite resistance measured in the reverse direction. If a diode has a low or high resistance in both directions, replace and retest the stack.

Note: Diodes are tested to check the rectifier efficiency

6. Complete the following on DC fuses:
   a. Remove fuse or fuses.
   b. Replace defective fuse or fuses with proper size fuse.
7. Examine rectifier for any abnormal defects.
8. Does rectifier need adjusting?
   a. No – Continue with Step 10.
   b. Yes – Seek assistance from appropriate personnel for additional investigation and corrective actions before making any adjustments.
9. Record all required information per the Corrosion Control Data Management System and the Cathodic Protection Unit Logbook

Replacing Defective Rectifier Components

Note: Rectifier servicing should be performed by a licensed electrician or a technician familiar with the maintenance and operation of the rectifier unit.

1. Complete the following on primary AC breaker:
   a. Disconnect wires from supply to breaker.
   b. Disconnect wires from breaker to rectifier.
   c. Replace defective breaker with new breaker.
   d. Connect wires from breaker to rectifier.
   e. Connect wires from AC supply to breaker.
2. Complete the following on primary AC fuses:
   a. Remove fuse or fuses.
   b. Replace defective fuse or fuses with proper size fuse.
3. Complete the following on transformer:
   a. Disconnect wires from rectifier AC breaker to transformer.
   b. Disconnect wires from transformer to coarse and fine tap panels.
   c. Replace defective transformer with new transformer.
   d. Connect wires from transformer to coarse and fine tap panel.
   e. Connect wires from transformer to AC rectifier breaker.
4. Complete the following on stack:
   a. Disconnect wires from fine and coarse tap panel to stack.
   b. Disconnect wires from stack to positive and negative DC output terminals.
      i. If stack is selenium: Remove stack and replace with new stack.

    ii. If stack is silicon: Remove defective diodes and replace with new diodes.

   c. Connect wires from stack to positive and negative DC output terminals.
   d. Connect wires from fine and coarse tap panel to stack.

5. Complete the following on DC fuses:
   a. Remove fuse or fuses.
   b. Replace defective fuse or fuses with proper size fuse.
6. Examine rectifier for any abnormal defects.
7. Does rectifier need adjusting?
   a. No – Continue with Step 8.
   b. Yes – Seek assistance from appropriate personnel for additional investigation and corrective actions before making any adjustments.
8. Record all required information per the Corrosion Control Data Management System and the Cathodic Protection Unit Logbook.

Interference Bond Surveys (Positive and Negative)

Test positive interference bonds, diodes, and reverse current switches whose failure would be detrimental to structure protection for proper operation at least six times each calendar year, not to exceed 2.5 months. Positive interference is where current discharges from a regulated structure into an electrolyte and the bond, diode or reverse current switch is intended to prevent this current discharge into the electrolyte and the associated corrosion.

Test negative interference bonds, system bonds, diodes, or reverse current switches whose failure would not be detrimental to structure protection for proper operation at least once each calendar year, not to exceed 15 months. Negative interference is where current discharges from a non-regulated structure into an electrolyte and the bond, diode or reverse current switch is intended to prevent this current discharge into the electrolyte and the associated corrosion.

Interference Bonds

1. Select the proper instrumentation, test leads and half-cell.
2. Make proper connections between instrument, test station and half-cell.
3. Take correct reading of instrument.
4. Review readings to ensure they are within the desired range.
5. Determine if existing bonds provide desired result.
6. Recommend appropriate modifications to the bond in order to provide adequate bonding.
7. Document reading and recommended modifications in appropriate format.

Isolation Device Surveys

Test the insulating effectiveness of each insulating set necessary to facilitate applying corrosion control to ensure that electrical isolation is adequate at least once each calendar year, not to exceed 15 months.

Check for Interference between Pipeline and Foreign Structures

The voltage shifts caused by foreign interference can be sharp, and confined to small areas. It is likely that foreign interference will not be detected by review of test-station data alone.

The locations of current in flow and out flow on the affected line may be very close to each other, or they can be widely separated, perhaps several miles apart.

1. Review close interval survey or structure-to-soil potentials for possible interference. Look for unexplained rises or falls in voltage not explained by positioning/condition of anodes, or changes in soil condition.
2. Determine possible sources of the cathodic interference.

Note: This can sometimes be difficult to accomplish. The following steps are often helpful.

   a. Determine whether any impressed current ground-beds for foreign structures are near the affected pipeline.
   b. Consider routes of foreign pipelines and locations of any associated rectifiers in deciding which foreign pipelines to investigate. Foreign pipelines that run parallel to the affected pipeline are more likely to contribute to interference than pipelines that approach and cross the affected pipeline’s route only a single time. Also, consider the proximity of any branches of a foreign pipeline to the affected pipeline.

3. Determine if there are high voltage transmission lines above the pipeline.
4. Discuss with personnel representing a suspected foreign structure the usefulness of impressing clearly distinguishable on/off cycles of applied known potential on the foreign structure(s), and look for a corresponding response pattern of changing pipe-to-soil potentials on the affected (interfered with) pipeline.
5. Recommend the most effective method of interference mitigation between the structures. If it is possible to do, repair of the coating break(s) on the affected pipeline that allows foreign current to enter that pipeline should be considered.
6. Document readings and recommended mitigation in appropriate format.
7. If a foreign interference is determined to exist, and the pipeline’s pipe-to-soil voltage is more positive than –850 mV, time will be of the essence. It will be imperative that corrective action be taken quickly in order to avoid a possible leak. Management (or designated individual) must be immediately notified that such a condition exists.
8. If a bond is used to mitigate interference effects, use Form F-195.573(a): Cathodic Protection Survey to record initial information about connection. Use Form F-195.573(a) to record performance information at least 6 times annually, at intervals not to exceed 2 ½ months.

Test Leads

Inspect and Verify Test Lead Continuity

1. Select the proper instrumentation for taking a structure-to-soil reading.
2. Show how to correctly use the instrumentation.
3. Have a qualified individual measure structure-to-soil potential.

4. Verify that the reading is within the desired range.
5. Confirm that test leads are installed and terminated properly and that test leads are not damaged.
6. If test lead continuity is not found, identify damage if possible and recommend mitigation actions based on readings and visible condition of the test lead.
7. Document findings in proper format.

Repair Test Lead

1. Identify the test lead damage.
2. Where necessary, make proper notifications to Operations prior to working around structure. If excavation is required, also notify the One-Call system.
3. Repair test lead damage.
4. Verify that test leads function properly and are no longer damaged.
5. Where necessary, make proper notifications to Operations that work has been completed.
6. Document actions and readings.

Replace Test Lead

1. Make proper notifications to Operations prior to working around structure.
2. Identify the test lead damage.
3. Remove coating and clean surface where test leads will be installed.
4. Attach test leads properly.
5. Verify that test leads function properly.
6. Notify Operations that work has been completed.
7. Document actions and readings.

Breakout Tanks

Ensure measurements are taken with an adequate level in the tank to maximize contact of the tank bottom with the cushion material.

If the system is shut-off during maintenance, re-energize as soon as possible to avoid corrosion damage during extensive maintenance periods.

Cathodic protection surveys for new systems:

1. Before energizing a new system, take measurements of the native structure-to-soil potential.
2. Immediately after energizing or repairing the system, conduct a survey to verify that it operates properly.
3. After adequate polarization has occurred (several months), take complete an initial survey that includes one or more of the following:
    a. Structure-to-soil potential;
    b. Anode current;

   c. Native structure-to-soil potentials;
   d. Structure-to-structure potential;
   e. Piping-to-tank isolation if protected separately;
   f. Stricture-to-soil potential on adjacent structures;
   g. Continuity of structures id protected as a single structure; and
   h. Rectifier DC volts, DC amps, efficiency, and tap settings.
4. Take annual surveys to ensure the effectiveness of the system. The electrical measurements may include any of those listed above.
5. Inspect all sources of impressed current.
6. Check impressed current facilities for electrical shorts, ground connections, meter accuracy, efficiency and circuit resistance.
7. Inspect isolating devices, continuity bonds, and insulators (on–site or by evaluating test data).
8. Whenever it is possible to access the tank bottom, inspect for corrosion damage. This may be done by coupon cutouts or by nondestructive methods.
9. Take appropriate remedial measures when testing indicates protection is no longer adequate:
   a. Repair, replace or adjust system components.
   b. Provide supplementary facilities when additional protection is needed.
   c. Repair, replace or adjust continuity and interference bonds.
   d. Eliminate accidental metallic contacts.
   e. Repair defective insulating devices.
   f. Resolve interference currents.
10. Keep the following records for 5 years:
   a. Record of surveys, inspections and tests;
   b. Repair of rectifiers and other DC power sources;
   c. Repair or replacement of anodes, connections and cable; and
   d. Maintenance, repair, and replacement of coating, isolating devices, test leads and other test facilities.

Monitoring of Tank Cathodic Protection Systems

Annual structure-to-soil potential surveys should be performed and rectifiers should be checked for proper operation every two months.

Cathodic Protection Structure-to-Soil Readings

Structure-to-soil potential measurements taken with the reference electrode in contact with soil at the perimeter of the tank is the most common method of determining the effectiveness of the cathodic protection system. Consideration must be given to the IR drop in the soil.

Criteria for Close Interval Survey

This procedure shall apply when pipe-to-soil Close Interval Survey (CIS) readings are being considered and/or taken on mainline pipelines. This procedure does not apply to piping within terminals, stations, pumping plants, or other non-mainline areas.

Responsibility

The Area Corrosion Engineer/Specialist/Engineering Assistant (or designated individual) shall be responsible for determining the need for CIS, for the selection of qualified personnel to gather close interval field data, and for analysis of (CIS) data.

Determination of Need

The Corrosion Engineer shall perform, not more than 2 years after cathodic protection is installed, a close interval survey, or comparable technology, to accomplish the objectives of paragraph 10.1.3 of NACE SP 0169, when practicable. In addition, the Corrosion Engineer shall perform a close interval survey, or comparable technology, at least every 10 years, when practicable.

Sound Engineering judgment shall be applied when determining the need for a close interval survey. A close interval survey detects localized changes in the corrosivity of the environment that may go undetected by test point, rectifier and bond inspections. A close interval potential survey should be conducted within two years of any of the following occurrences.

- When two consecutive test point readings at the same location indicate inadequate cathodic protection, perform a close interval survey from the upstream test point to the downstream test point.
- After the amperage output of cathodic protection devices unexpectedly increases, perform a close interval potential survey to locate structures shorted to the pipeline.
- After significant adjustments to cathodic protection systems that are bonded to the pipeline or significant adjustments to the bonds themselves, perform a close interval survey to locate interference and ensure that cathodic protection devices adequately balance cathodic protection levels.
- After excavation work in the pipeline right of way, perform a close interval survey through the disturbed area.
- After significant ground movement in the pipeline right of way following an earthquake, avalanche, or similar event, perform a close interval survey through the disturbed area.
- After a significant spill in the pipeline right of way, perform a close interval survey through the affected area.

- After the installation of new high voltage powerlines that are within 500 feet and parallel to the pipeline right of way or cross the pipeline right of way, perform a close interval survey to detect induced currents and the necessity for grounding grids.
- When in-line inspection (ILI) indicates active external corrosion and cathodic protection shielding is not indicated, perform a close interval survey to determine the area that would benefit from additional cathodic protection.

Determination of the best course for future action should include review of ILI inspection schedules and other integrity management, inspection, and testing programs.

CPU Adjustments

Adjust all cathodic protection unit (CPU) voltage and current settings considering soil moisture conditions along the affected pipeline that can affect soil resistivity. This will help ensure maintaining an acceptable level of output for the unit under varying soil conditions that will prevent damage to the pipe and pipe coating.

Review the rectifier manufacturer owner's manual to determine the unit operating characteristics. Confirm that the installation is correct and that the rectifier ground bed is ready to energize. Items to verify for new rectifier installations include:

- The rectifier positive and negative terminals are labeled correctly.
- The rectifier AC input voltage is as indicated for the rectifier unit installed.
- The rectifier is grounded correctly.
- Pipeline cables are connected to the negative rectifier terminal.
- Anode cables are connected to the positive rectifier terminal.
- Rectifier output does not exceed the rated capacity.

Post-Installation Survey

Conduct a survey after installing any cathodic protection bond, isolation device or CPU system to determine if the installation and cathodic protection adjustments satisfy applicable criteria and operate efficiently.

- Post-installation tests shall include the following survey information:
- Pipe-to-soil potentials at all affected test points;
- Casing-to-soil potentials at all affected casings;
- Foreign line-to-soil potentials at affected crossings;
- Foreign line-to-soil potentials at all affected insulating fittings;
- Copies of all interference test data (if performed), completed company forms and correspondence;
- Current and voltage of impressed current rectifiers affecting the pipeline segment (if applicable); and
- Current of galvanic anodes affecting the pipeline segment (if applicable).

Other types of measurements that may be required to document the post-installation survey include:

- Static pipe-to-soil potentials; and
- Close interval, DCVG, PCM or other appropriate cathodic protection surveys.

Interference Test Surveys

Each impressed current-type cathodic protection system or galvanic anode system must be designed and installed to minimize any adverse effects on existing adjacent underground metallic structures. Conduct interference tests on metallic structures in the immediate area after energizing new cathodic protection units or after installing metallic structures in the area of influence of a cathodic protection unit if either party desires. Resolve any interference problem to the mutual satisfaction of the parties involved.

Shorted Casing Tests

Pipelines at many road and railroad crossings pass through casings. Casings can be either electrolytically or mechanically shorted.

- An electrolytic short is a pipe that is shorted to the casing through a non-metallic path, such as mud or water. It is generally not harmful since the electrolyte will distribute the current throughout the casing.
- A mechanical short is pipe that is shorted to the casing through a mechanical or direct path. Generally, a mechanical short will reduce the effectiveness of cathodic protection.

Test electrical isolation by comparing the casing-to-soil potentials to the matching pipe-to-soil potentials at least once each calendar year, not to exceed 15 months.

Difference	Electrical Isolation	Action
> 50 millivolts	Yes	Inspect at required rate
≤ 50 millivolts	No	Test for type of short

Testing Casings for Type of Short

The test will find the average resistance between the carrier pipe and the casing. The amount of resistance determines the type of short.

Average Resistance	Type of Short
> 0.08 ohms	Electrolytic
≤ 0.08 ohms	Mechanical

Casing Inspections

Perform leakage survey inspections on an electrolytically shorted casing as a non-shorted casing but retest it for a mechanical short every five years. Electrolytically shorted casings may also be treated as mechanically shorted for determining leak inspection frequency.

When treating casings as mechanically shorted, perform leakage survey inspections at the same frequency as mechanically shorted casings, thus eliminating the need for the five-year test to determine if the casing is electrolytically shorted.

Clearing Mechanically Shorted Casings

Clear mechanical shorts if practical prior to the next inspection. Approved methods to attempt to clear shorted casings include:

- Cutting bond straps;
- Trimming back the casing end;
- Installing new end seals; and
- Installing additional insulators at casing ends.

Support the carrier pipe to prevent any movement during or after working on the casing. **Do not jack, pull or move the carrier pipe or casing in any way as a method to clear mechanical shorts.** If exposing one end clears the short, it is not necessary to expose both ends of the casing.

Install approved end seals on any exposed casing end. Replace dresser-type end seals when practical. If possible, use smart pigging to monitor for corrosion inside the casing. Smart pigging and increased inspection cannot replace practical attempts to clear the short.

A/C Voltage and Fault Current Mitigation

Pipelines operating in the same corridor or near electric high voltage transmission lines often experience high voltage levels due to a combination of conditions. These conditions can occur both during steady AC transmission system operation as well as during fault conditions. Take remedial measures to prevent the voltage level from exceeding 15 VAC-RMS.

AC Voltage and Fault Current Remedial Action

When voltage levels exceed 15 VAC-RMS, take mitigation measure, including but not limited to:

- Installing magnesium anodes;
- Installing zinc anodes;
- Installing zinc ribbon in the affected area; and
- Installing AC grounding devices.

Contact Alaska Integrity Group for assistance before developing or installing mitigation plans

Monitor External Corrosion – Unprotected Pipe

NOTE: If an electrical survey is impractical, areas of “Active corrosion” may be determined by other means that include review and analysis of leak repair and inspection records, corrosion monitoring records, exposed pipe inspection records, and the pipeline environment. (“Active Corrosion” is defined as continuing corrosion which, unless controlled, could result in a condition that is detrimental to public safety.)

1. Visually inspect below ground unprotected pipe that is naturally accessible for active corrosion.

2. Determine areas of active corrosion by electrical survey or where impacted by other means that include review and analysis of leak repair and inspection record, corrosion monitoring records, exposed pipe inspection records, and the pipeline environment.
3. Cathodically protect areas that contain “active corrosion”.
4. Evaluate the MOP of the pipeline and revise if necessary.
5. Make necessary repairs.

Remedial Action

When cathodic protection levels are discovered to be below established criteria levels, take remedial action to restore cathodic protection to acceptable levels. Consider the particular problem affecting pipeline integrity in completing the remedial action. Any remedial action necessary to facilitate the effective application of corrosion control must not extend 15 months beyond discovery.

If the remaining pipe wall thickness is less than that required to substantiate the MOP of the pipeline, one of the following will be done:

1. Pipe segment replaced.
2. MOP reduced based on actual remaining wall thickness.
3. Pipe repaired according to Procedure P-195.422: Pipeline Repair Procedures.

The remaining strength of the corroded pipe will be determined using ASME B-31G or RSTRENG, as long as the corroded sections do not exceed 80% of the actual pipe wall thickness.

Testing Electrodes & Voltmeters for Accuracy

After prolonged use, the copper sulfate can become contaminated by outside elements (reverse osmosis). This will cause faulty readings to occur and generate errors. To check your electrode for this type of error, the following is recommended.

1. A new electrode should be prepared as a standard. This standard electrode should be a new reference electrode.
2. One electrode should always be maintained as a standard and not used in the field.
3. Using an LC-4 voltmeter, set the DC voltage scale to 200mv and the input impedance to 200 as well.
4. Attach the standard reference electrode to the negative (or common) side of the meter and the electrode to be tested to the positive DC side.
5. Place the two electrodes end-to-end, making contact with each plug assembly. Once contact is made, you will be checking the potential of the two electrodes. The difference between the standard and the electrode being tested should have a reading of no more than 5mv positive or 5mv negative. Since $CuSO_4$ electrodes are affected by temperature, it is necessary to allow the electrodes needing testing, as well as the standard electrode, to settle to the same room temperature. 72° F is ideal.
6. If you are unable to get a reading, apply a couple drops of $CuSO_4$ and H_2O solution to the plus assemblies to increase the conductivity.

7. If/when an electrode has more than +/- 5mv reading, the electrode should be rejuvenated following the steps mentioned at the beginning of this procedure.
8. The end-to-end method of testing on the RE-5C plug assemblies can be inaccurate. To test an electrode where the RE-5C-type plug assemblies are used, use a $CuSO_4$ solution in a cup or beaker. Instead of placing the electrodes end-to-end, dip both into the $CuSO_4$ solution. The solution will act as a bridge and produce relatively the same results.

Direct Assessment Standards

If direct assessment is performed on onshore pipelines to evaluate the effects of external corrosion, follow the requirements of this section. This section does not apply to the methods associated with direct assessment (close interval surveys, voltage gradient surveys, or examination of exposed pipelines) when used separately from the direct assessment process.

Develop and implement an External Corrosion Direct Assessment (ECDA) plan that follows the requirements of NACE SP0502 and includes procedures addressing pre-assessment, indirect examination, direct examination, and post-assessment.

1. In addition to the requirements in Section 3 of NACE SP0502, the ECDA plan procedures for pre-assessment will include
   a. Provisions for applying more restrictive criteria when conducting ECDA for the first time on a pipeline segment;
   b. The basis on which at least two different, but complementary, indirect assessment tools to assess each ECDA region were selected; and
   c. If an indirect inspection method that is not described in Appendix A of NACE SP0502 is utilized (demonstrate the applicability, validation basis, equipment used, application procedure, and utilization of data for the inspection method.
2. In addition to the requirements in Section 4 of NACE SP0502, the procedures for indirect examination of the ECDA regions must include:
   a. Provisions for applying more restrictive criteria when conducting ECDA for the first time on a pipeline segment;
   b. Criteria for identifying and documenting those indications that must be considered for excavation and direct examination, including at least the following:
      i. The known sensitivities of assessment tools;
      ii. The procedures for using each tool; and
      iii. The approach to be used for decreasing the physical spacing of indirect assessment tool readings when the presence of a defect is suspected;
   c. For each indication identified during the indirect examination, criteria for-
      i. Defining the urgency of excavation and direct examination of the indication; and
      ii. Defining the excavation urgency as immediate, scheduled, or monitored; and
      iii. Criteria for scheduling excavations of indications in each urgency level.
3. In addition to the requirements in Section 5 of NACE SP0502, the procedures for direct examination of indications from the indirect examination must include:

a. Provisions for applying more restrictive criteria when conducting ECDA for the first time on a pipeline segment;

b. Criteria for deciding what action should be taken if either:

   i. Corrosion defects are discovered that exceed allowable limits (Section 5.5.2.2 of NACE SP0502 provides guidance for criteria); or

   ii. Root cause analysis reveals conditions for which ECDA is not suitable (Section 5.6.2 of NACE SP0502) provides guidance for criteria);

c. Criteria and notification procedures for any changes in the ECDA plan, including changes that affect the severity classification, the priority of direct examination, and the time frame for direct examination of indications; and

d. Criteria that describe how and on what basis you will reclassify and re-prioritize any of the provisions specified in Section 5.9 of NACE SP0502

4. In addition to the requirements in Section 6 of NACE SP0502, the procedures for post assessment of the effectiveness of the ECDA process must include:

   a. Measures for evaluating the long-term effectiveness of ECDA in addressing external corrosion in pipeline segments; and

   b. Criteria for evaluating whether conditions discovered by direct examination of indications in each ECDA region indicate a need for reassessment of the pipeline segment at an interval less than that specified in Sections 6.2 and 6.3 of NACE SP0502 (see appendix D of NACE SP0502).

APPENDIX A: GROUNDING PIPE FOR INDUCED VOLTAGE

Purpose

Where the pipeline follows a power line right-of-way (ROW), a hazard may exist if the pipeline lies within the electrical field generated by overhead transmission lines. The pipe can carry a hazardous AC voltage, known as induced voltage, which occurs as a result of stray current from the power lines. This hazard also applies to pipe set up on skids for welding.

The voltage level depends on the current in the transmission lines, the geometric configuration of the pipeline with respect to the transmission lines, and the length of pipeline paralleling the transmission line.

Induced voltage caused by proximity to overhead transmission lines may continue to affect pipelines, even when the pipeline no longer parallels the transmission cables. Induced voltage can be a hazard for up to 16 km (10 mi) beyond the point of departure.

The inducted voltage limit on pipelines and appurtenances that is accepted as safe within industry is 15 volts. Therefore, bonding and grounding is required to bleed off any charge in excess of 15 volts.

Requirements

NOTE: Contact qualified personnel if there are any concerns about induced high voltage and work equipment.

Special Clothing and Equipment

Wear insulating gloves (11-inch, low-voltage lineman's rubber gloves inside lineman's leather gauntlets) at all times when handling pipe, valves, casing or measuring equipment. Before work begins, ground pipelines on the surface and subsurface using ground cables and/or ground mats.

Safety Precautions

If any problems with induced voltage are encountered, stop work and immediately notify the Alaska Integrity Group (or designated individual). Stop work if an electrical storm is passing through the area. Avoid simultaneously contacting the earth and the ground mat when entering or leaving a matted area. This will prevent an electrical shock from voltage difference between the edge of the ground mat(s) and the earth. Electrically driven tools and equipment must be grounded unless specifically designed for ungrounded use, i.e., double insulated. Use ground fault circuit interruption (GFCI) protection when using portable tools outdoors.

Installing Grounding Rods

1. Check the status of the overhead transmission line with the power company, and inform them of the of the pipeline activity on their ROW.
2. Put on insulating gloves.
3. Before starting work (or restarting after an interruption), measure the induced voltage on the pipeline using a high-input, impedance AC voltmeter connected between the pipe and a screwdriver pushed into the ground.
   a. If the voltage exceeds 15 volts, go to step 5.

   b. If the voltage is less than 15 volts, grounding is unnecessary and work may proceed without the use of insulating gloves.

4. Install grounding clamps and bonding cables.
5. Connect the bonding cable to ground (Figure 1):
   a. Braze the cable to three 1 ½ in diameter galvanized steel conduit ground rods 1.2 m (4ft) long at 2 m (6ft) intervals along with the length of the cable.
   b. Drive the ground rods 1 m (3ft) into the ground.

NOTE: The integrity of every grounding/bonding connection should be tested using an AV voltmeter.

6. Measure voltage on the pipeline using a voltmeter (should be zero).
   a. If the voltage measured from pipe to ground exceeds 15 volts, go to step 8.
   b. If the voltage is less than 15 volts, work may proceed without the use of insulating gloves.
7. Ensure the excavation is large enough to install ground mats.
8. Place adequate ground mats in the excavation so that a worker in contact with the pipe can only make contact with the bottom or sides of the excavation through the ground mat.
9. Connect the ground mats together (Figure 2).
10. Connect the mats to the ground (Figure 3).
    a. Connect the spade connector on one end of a #4 AWG wire to a spade connector location on a ground mat.
    b. Connect the other end of the wire to the second nut connection of a grounding clamp.

Warning: If arcing occurs between the wire and grounding clamps when the connection is made between pipe and ground mats, and if an explosive atmosphere could exist in the area where repairs are about to be made, then the connection must be moved to an area where there is no danger of explosion.

11. Proceed with pipeline maintenance.

NOTE: Leave ground mats connected if the line is left exposed over night.

12. When the work is complete, put on insulating gloves.
13. Disconnect the ground connection and bond connection from the pipeline.
14. Carefully remove the ground mats and cables, avoiding any contact with the pipeline.
15. Record the removal of all grounds on the Electrical Equipment Isolation/Clearance Form.

Figure 1: Installing Ground Beds

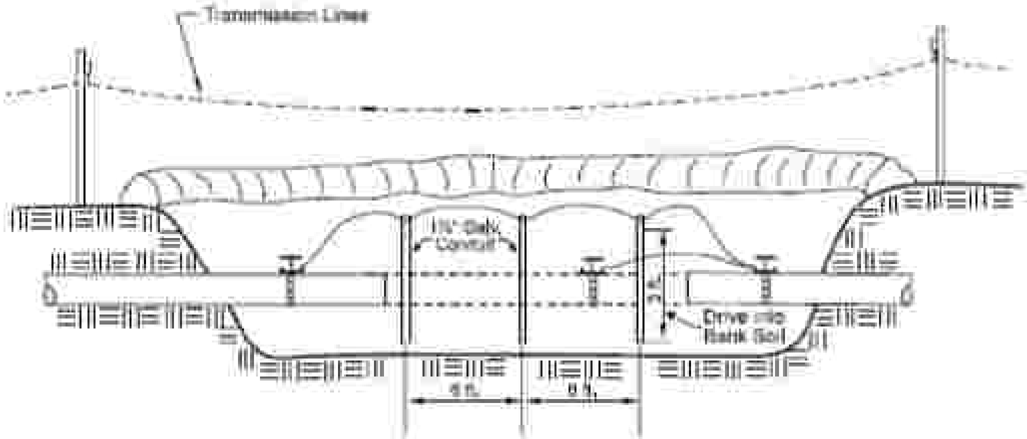
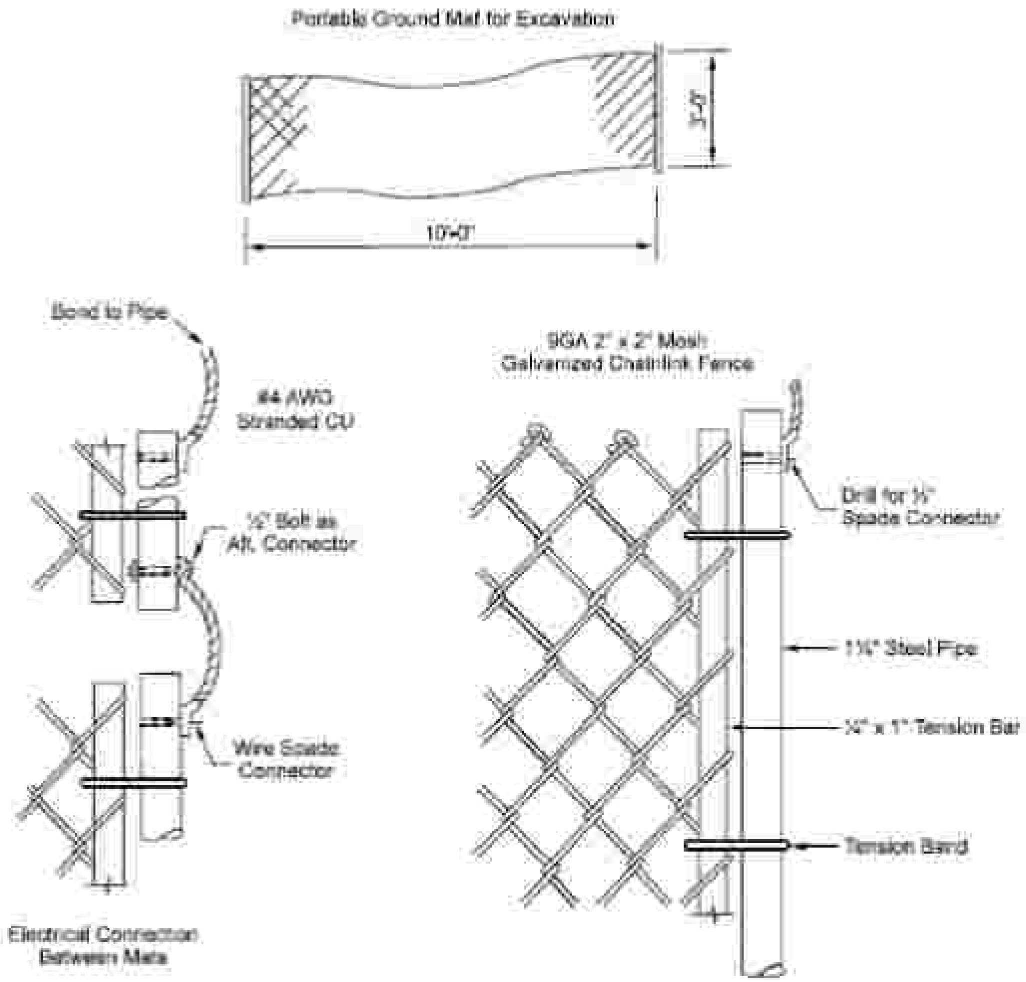


Figure 2: Ground Mats



NOTES

- All bolts, tension bars, bands and pipe are steel hot dip galvanized.
- Smaller ground mats may be used if desired but correspondingly larger quantities will be required.

Figure 3: Installing Ground Mats