Corrosion Control Issues and Regulations for Natural Gas Systems

PHMSA

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

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Pipeline and Hazardous Materials Safety Administration

Safety Regulations Applicable to Small Natural Gas Systems

- The <u>Minimum</u> Federal Safety Standards Applicable to the Transportation of Natural Gas and for Pipeline Facilities Used for this Transportation, Are Found in Part 192, Title 49, of the Code of Federal Regulations.
- The Regulations Applicable to Corrosion Control are Found in Subpart "I" of Part 192.

Subpart "I" Requirements

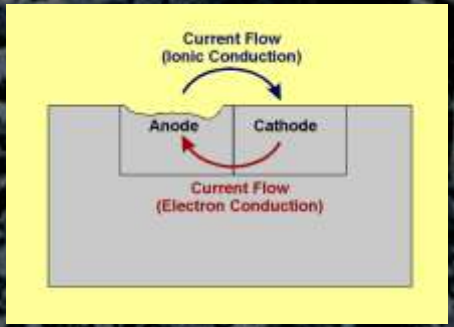
- §192.451 Scope.
- Authority: Natural Gas Pipeline Act of 1968 (49 U.S.C. sec. 1671 et seq.)
- Re-Authorized by the Pipeline Inspection, Protection, Enforcement, and Safety Act of 2006 (PIPES)

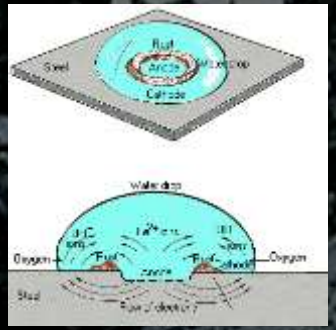
What Is Corrosion?

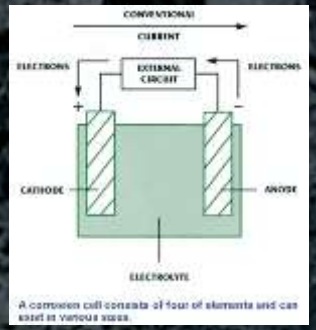
- The Deterioration of a Material, Usually a Metal, that Results from a Reaction With its Environment.
- Galvanic Corrosion of a Metal Occurs Due to an Electrical Contact with a More Noble (Positive) Metal or Non-metallic Conductor in a Corrosive Electrolyte..

Four Parts of a Corrosion Cell

1. Anode (Where current leaves the pipe)
2. Cathode (Where current flows to the pipe)
3. Electrolyte (Soil or Liquid in contact with the pipe which conducts current)
4. Metallic Path (A metal connection between an anode and a cathode)







§192.455 External corrosion control: Buried or submerged pipelines installed after July 31, 1971.

- Must have an External Coating.
- Must design a Cathodic Protection System and have it in operation within 1 year of installation.
- Does not apply to Temporary Lines with a service life of less than 5 years.
- Does not apply to electrically isolated metal alloy fittings on poly, if the operator can show by test, investigation, or experience, that they won't corrode.
- Does not apply to fittings designed to prevent leakage due to localized corrosion pitting.

192.457 External corrosion control: Buried or submerged pipelines installed before August 1, 1971.

- Except for buried piping at compressor, regulator, and measuring stations, installed before August 1, 1971, and Cast & Ductile Iron.
- Each buried or submerged transmission line installed before August 1, 1971, that has an effective external coating must be cathodically protected along the entire area that is effectively coated.
- If Active Corrosion is found on bare or ineffectively coated transmission lines, bare or coated pipes at compressor, regulator, and measuring stations, or on bare or coated distribution lines, they must be cathodically protected.

§ 192.3 Definitions

- **Active Corrosion** means continuing corrosion that, unless controlled, could result in a condition that is detrimental to public safety.

§ 192.3 Definitions

- **Electrical Survey** means a series of closely spaced pipe-to-soil readings over pipelines which are subsequently analyzed to identify locations where a corrosive current is leaving the pipeline.
- **Pipeline Environment** includes soil resistivity (high or low), soil moisture (wet or dry), soil contaminants that may promote corrosive activity, and other known conditions that could affect the probability of active corrosion.

§192.459 External corrosion control: Examination of buried pipeline when exposed.

- Must examine for evidence of external corrosion whenever the operator knows that any portion of the pipeline is exposed, if the pipe is bare, or if the coating is deteriorated.
- Must investigate longitudinally and circumferentially beyond the exposed portion if external corrosion that requires repair is found.

§192.461 External corrosion control: Protective coating.

- Covers coatings applied for external corrosion control, whether conductive or insulating.
- Must be applied on a properly prepared surface.
- Must have sufficient adhesion to the metal surface.
- Must be sufficiently ductile to resist cracking.
- Must have sufficient strength to resist damage due to handling and soil stress.
- Must have properties compatible with any supplemental cathodic protection.

§192.461 External corrosion control: Protective coating.

- Must have low moisture absorption and high electrical resistance.
- Must be inspected prior to lowering in the ditch, and any damage repaired.
- Must be protected from damage due to adverse ditch conditions or supporting blocks.
- Must take precautions to minimize damage if pipe is installed by boring, driving, or similar method.

§192.463 External corrosion control: Cathodic protection.

- Must provide a level of cathodic protection that complies with one of the criteria in Appendix "D".
- Amphoteric Metals: A metal that is susceptible to corrosion in both acid and alkaline environments.
- Are included in a buried pipeline, that contain a metal of different anodic potential.
- Must be electrically isolated from the remainder of the pipeline or the entire pipeline must be cathodically protected to meet Appendix "D" criteria.
- The cathodic protection current must be controlled so that the protective coating or pipe is not damaged.

Isolated Fittings and Short Sections

Appendix D - Criteria for Cathodic Protection and Determination of Measurements.

– I. Criteria for cathodic protection

- (1) A negative (cathodic) voltage of at least 0.85 volt, with reference to a saturated copper-copper sulfate reference electrode. (Current Applied)
- (2) A negative (cathodic) voltage shift of at least 300 millivolts. (Current Applied)
- (3) A minimum negative (cathodic) polarization voltage shift of 100 millivolts.

Appendix D - Criteria for Cathodic Protection and Determination of Measurements.

– I. Criteria for cathodic protection Cont.

- (4) A voltage at least as negative (cathodic) as that originally established at the beginning of the Tafel segment of the E-log-I curve.
- (5) A net protective current from the electrolyte into the structure surface as measured by an earth current technique applied at predetermined current discharge (anodic) points of the structure.

Survey Methods

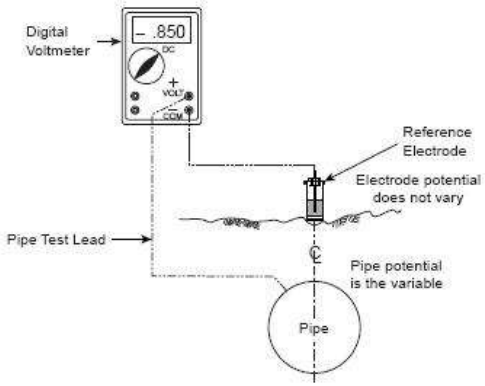


Figure 5.1 Pipe-to-earth potential measurement.

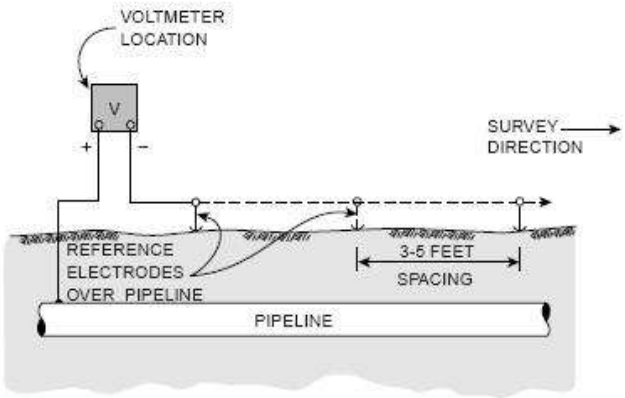


Figure 5.6 Over-the-line potential surveys (Method 1).

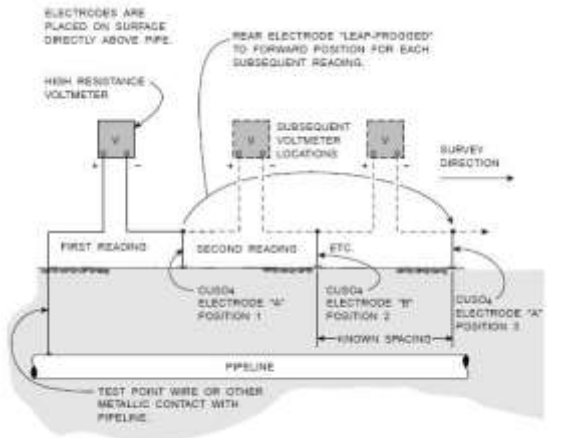


Figure 5.7 Over-the-line potential surveys using two copper sulfate electrodes (Method 2).

§192.465 External corrosion control: Monitoring.

- Cathodically protected pipelines must be tested at least once each calendar year, not to exceed 15 months.
- The operator may test short sections of mains or transmission lines (Not in excess of 100 ft) or seperately protected service lines on a sampling basis.
- At least 10% of the protected structures distributed over the entire system, with a different 10% checked each year so that the entire system is checked within a ten year period.

§192.465 External corrosion control: Monitoring.

- Must inspect rectifiers and impressed current power sources six times each calendar year, with intervals not to exceed 2 ½ months.
- Must inspect and electrically check each reverse current switch, diode, and interference bond six times each calendar year, with intervals not to exceed 2 ½ months.
- Must take prompt remedial action to correct any deficiencies indicated by the monitoring.

§192.465 External corrosion control: Monitoring.

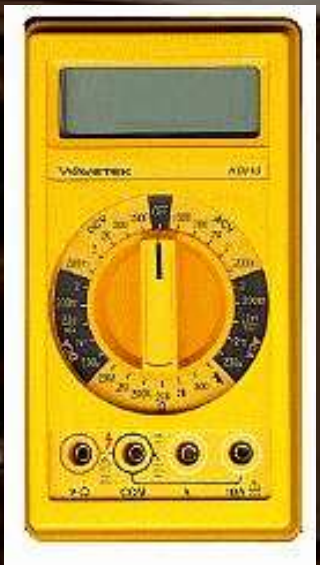
- Must re-evaluate any unprotected pipelines every 3 years at intervals not to exceed 39 months, and cathodically protect them in areas where active corrosion is found.
- Must determine areas of active corrosion by electrical survey if practical, or by review of leak repair and inspection, corrosion monitoring, exposed line inspection, or pipeline environment records.

(Active corrosion: Continuing corrosion which unless controlled could result in a condition detrimental to public safety.)

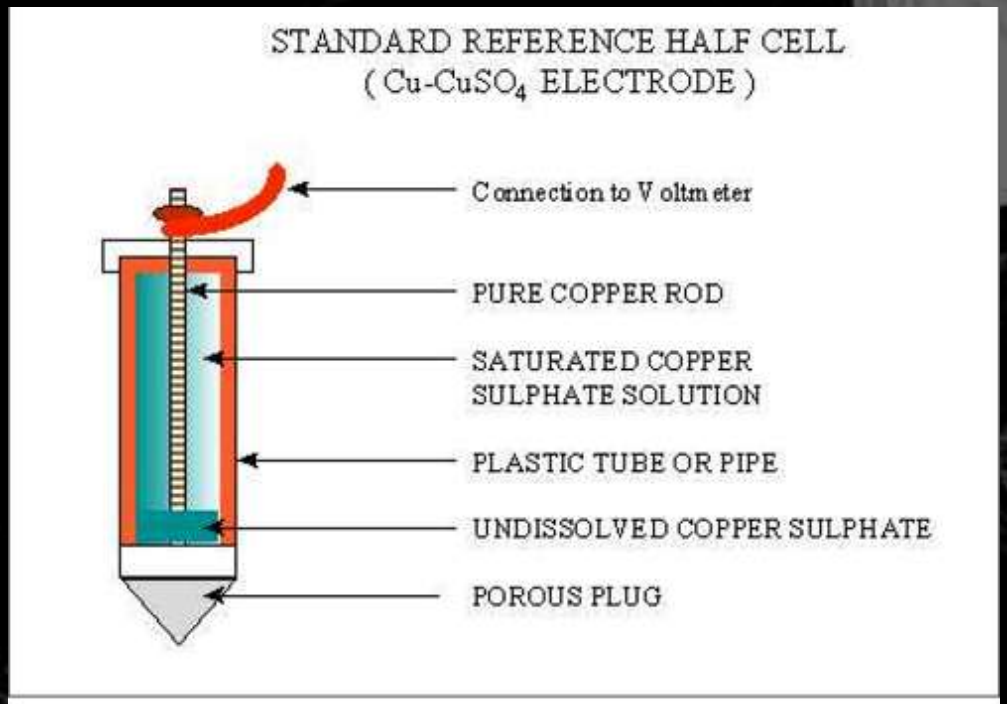
Multimeters For Corrosion Work

- They must have a High Impedance (Input Resistance) to allow for variations in soil to reference electrode resistance (Circuit Resistance).
- They should be chosen with the proper reading range, resolution, and accuracy, to ensure pipe-to-soil readings are accurate.
- They should be chosen for their applicability to the work at hand, with the proper balance of cost, durability, and accuracy.

Multimeters For Corrosion Work



Reference Electrodes (Half Cells)



Reference Electrodes (Half Cells)

Steel Risers

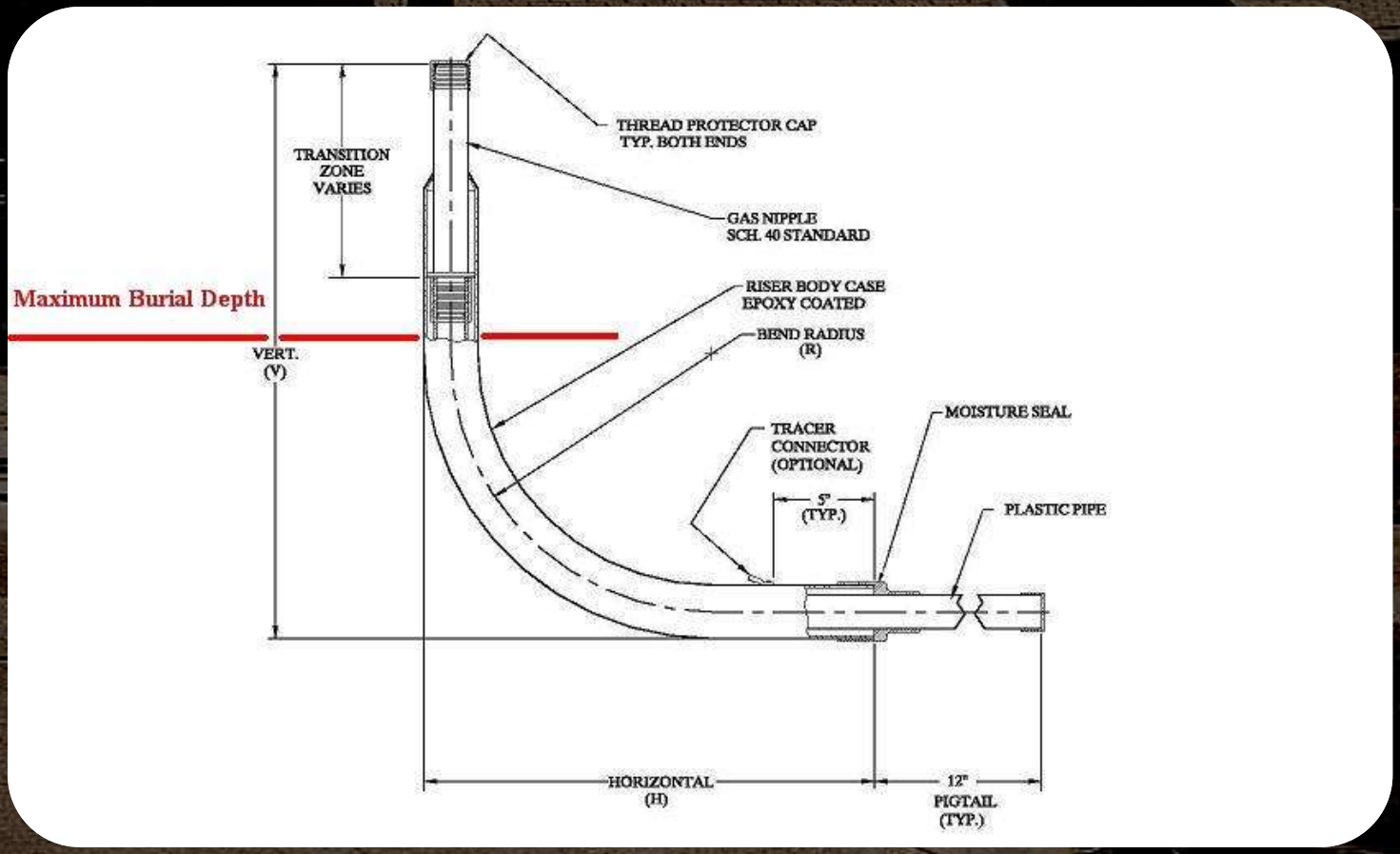
Steel Riser with Anode Attached Above Ground

Steel Riser With Anode Attached Above Ground (Shorted)

Steel Risers

Anodeless Risers

Anodeless Risers



Too Deep if Buried Below the Red Line!

§192.467 External corrosion control: Electrical isolation.

- Must electrically isolate the pipeline from other underground metallic structures, unless they are electrically connected and cathodically protected as a single unit.
- Must install insulating devices where needed to apply corrosion control.
- Must isolate the pipeline from metallic casings, or if impractical take actions to minimize corrosion in the casing.

§192.467 External corrosion control: Electrical isolation.

- Must not install insulating devices in areas of combustible gases unless precautions are taken to prevent arcing.
- Must be protected from fault currents and lightning in areas around electric transmission towers or grounding systems.
- Must take protective measures at insulating devices where damage from fault currents or lightning might result.

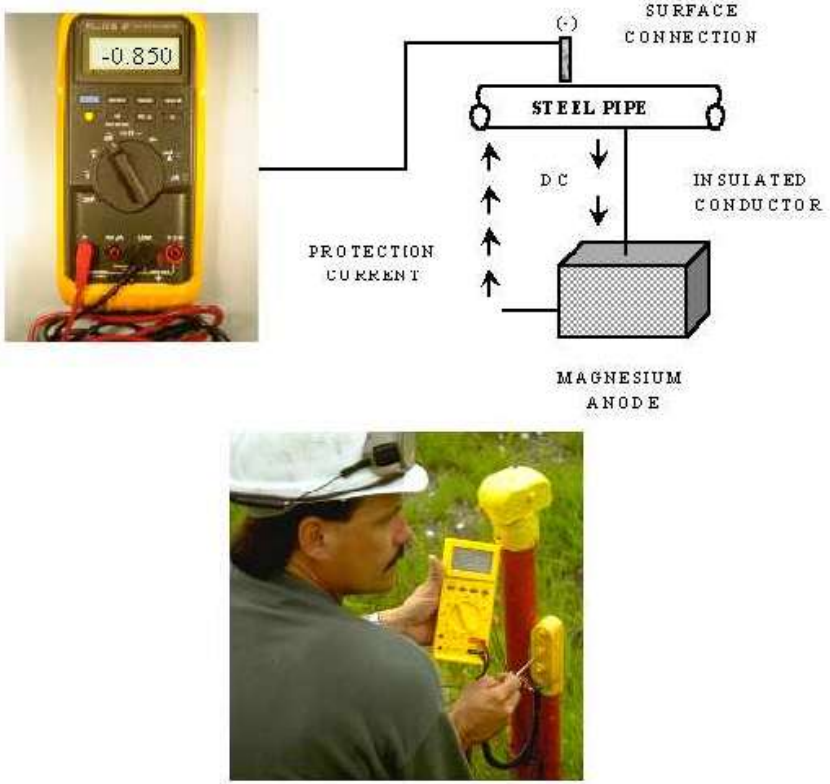
§192.469 External corrosion control: Test stations.

- Must have sufficient test stations or contact points to measure to the adequacy of cathodic protection.

§192.471 External corrosion control: Test leads.

- Must connect each test lead wire to remain mechanically secure, electrically conductive, and to minimize stress concentration on the pipe.
- Must coat bared test lead wire at the point of connection to the pipe, with an insulating material compatible with the pipe and wire coating.

Reading Test Points



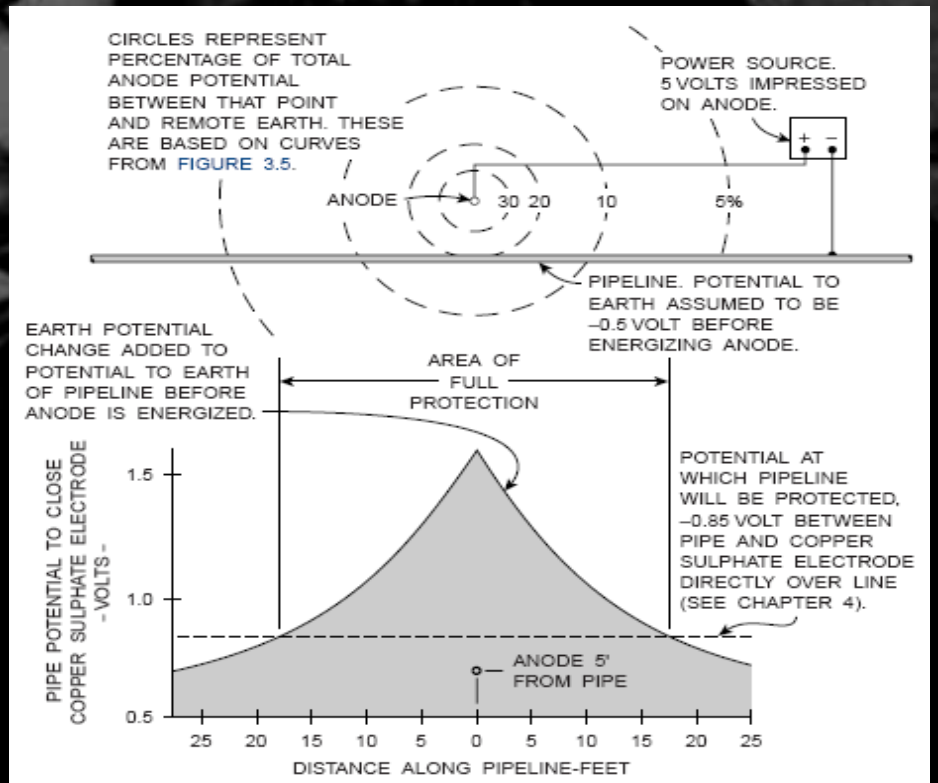


Figure 3.6 Protective potentials impressed on a pipeline by a close ground bed anode.

§192.473 External corrosion control: Interference currents.

- Must have a continuing program in effect to minimize the detrimental effects of stray currents if the system is subjected to stray currents.
- Must design each impressed current cathodic protection system or galvanic anode system to minimize any adverse effects on existing adjacent underground metallic structures.

(Not necessarily just other pipelines!)

§192.479 Atmospheric corrosion control; General.

- Must clean and coat each pipeline or portion of the pipeline that is exposed to the atmosphere.
- Coating material must be suitable for the prevention of atmospheric corrosion.
- <u>Except</u> for portions of pipelines in offshore splash zones and soil-to-air interfaces, the operator need not protect from atmospheric corrosion if they can document that the corrosion will only be a light surface oxide, or will not affect the safe operation of the pipeline until the next scheduled inspection.

§192.481 Atmospheric corrosion control: Monitoring.

- Must inspect each pipeline or portion of the pipeline that is exposed to the atmosphere for evidence of corrosion.
- Must inspect onshore pipelines at least once every 3 calendar years, but with intervals not exceeding 39 months.
- Must inspect offshore pipelines at least once each calendar year, but with intervals not exceeding 15 months.

§192.481 Atmospheric corrosion control: Monitoring.

- Must give particular attention to pipe at soil-to-air interfaces, under thermal insulation, under disbonded coatings, at pipe supports, in splash zones, at deck penetrations, and in spans over water.
- If atmospheric corrosion is found during an inspection, the operator must provide protection against the corrosion as required by Sec. 192.479

Soil to Air Interfaces

Other Steel Equipment

§192.483 Remedial measures: General.

- Metallic Replacement Pipe must have a properly prepared surface and have an external protective coating.
- Metallic Replacement Pipe must be cathodically protected if it replaces pipe removed due to external corrosion.
- Must cathodically protect a segment of buried pipe that was replaced because of external corrosion.

(Except for Cast or Ductile Iron)

§192.485 Remedial measures: Transmission lines.

- Must replace the pipe or reduce the operating pressure, if General Corrosion has reduced the remaining actual wall thickness to less than that required for the MAOP of the pipeline. Corroded pipe may be repaired by a method engineered to permanently restore the serviceability of the pipe.
- Must replace or repair each segment of pipe with corrosion pitting to a degree where leakage might result, or reduce operating pressure based on the actual remaining wall thickness in the pits.

§192.487 Remedial measures: Distribution lines other than cast iron or ductile iron lines.

- Must replace each segment of generally corroded distribution pipe if the remaining wall thickness is less than required to meet the MAOP, or the remaining wall thickness is less than 30% of the nominal wall thickness. Corroded pipe may be repaired by a method engineered to permanently restore the serviceability of the pipe.
- Must replace or repair each segment of distribution pipe with localized corrosion pitting to a degree where leakage might result.

(Except Cast or Ductile Iron lines)

§192.491 Corrosion control records.

- Must maintain records or maps to show the location of cathodically protected piping, facilities, galvanic anodes, and structures bonded to the cathodic protection system.
- Must retain each record or map required by the previous paragraph (a), for as long as the pipeline remains in service.
- Must maintain a sufficiently detailed record of each test, survey, or inspection required by this subpart to demonstrate the adequacy of the corrosion control measures or that no corrosive condition exists.

§192.491 Corrosion control records.

- Must retain these records for 5 years, except that records related to 192.465 (a) and (e) and 192.475 (b) must be retained for as long as the pipeline remains in service.

Subpart P
§192.1011 What records must an operator keep?

- An operator must maintain records demonstrating compliance with the requirements of this subpart for at least 10 years.
- The records must include copies of superseded integrity management plans developed under this subpart.

(Additional Records Requirements Under DIMP)

Common Corrosion Issues Found on Natural Gas Systems

- Unprotected Steel Risers or Anodeless Risers Buried Below Poly to Steel Transition.
- Shorted or Non-insulated Meters and Steel Piping.
- Isolated Inadequately Protected Short Sections of Pipe (Less than 100 ft) and Isolated Buried Fittings. (Valves, Transitions, Couplings, Taps)
- Atmospheric Corrosion on Above Ground Piping, at Soil-to-Air Interfaces, and Under Coatings.

Common Corrosion Issues Found on Natural Gas Systems

- Inadequately Designed Cathodic Protection Systems. (Galvanic and Impressed Current)
- Inadequate Cathodic Protection Level, Does Not Meet Appendix “D” Criteria.
- Inadequately Trained or Qualified Personnel Performing Corrosion Tasks. (Operator Qualification)
- Inadequate Records. (Design, Installation, Operation, Maintenance, Maps)

Information Websites

PHMSA Training and Qualification

http://www.phmsa.dot.gov/pipeline/tq

PHMSA Pipeline Safety Regulations

http://www.phmsa.dot.gov/pipeline/tq/regs