CHAPTER III: CORROSION CONTROL

FEDERAL REQUIREMENTS

This chapter contains a simplified description of the corrosion control requirements contained in the pipeline safety regulations. The complete text of the corrosion control requirements can be found in 49 CFR Part 192.

NOTE: This chapter begins with a review of federal requirements. Readers with little or no experience in corrosion or cathodic protection may find it helpful to read the "Fundamentals of Corrosion" and "Principles and Practices of Cathodic Protection" sections of this Chapter before reading this section on federal requirements. In addition, an internet search for keyword "corrosion" will find several websites that discuss the basics of corrosion and corrosion control.

PROCEDURES AND QUALIFICATIONS

Operators must establish procedures to implement and maintain a corrosion control program for their piping system. These procedures should include design, installation, operation and maintenance of a cathodic protection system. A person qualified in pipeline corrosion control methods must carry out these procedures.

TECHNIQUES FOR COMPLIANCE

If the operator chooses to use a corrosion consultant, it is important to utilize one who is experienced with natural gas piping and the requirements of 49 CFR Part 192. The following is a list of sources where operators of small natural gas systems can find qualified personnel to develop and carry out a corrosion control program:

- There are many consultants and experts who specialize in cathodic protection. Many advertise in gas trade journals. A keyword search using an internet search engine may also provide references.
- Another source, especially for master meter operators, is an experienced corrosion engineer or technician working for a local gas utility company. Such experts may be able to implement cathodic protection for small operators, or refer them to local qualified corrosion control personnel.
- Operators of small municipal systems can contact the transmission company that supplies their gas. A municipal corrosion engineer or technician may be able to supply information as to where to find local qualified corrosion control personnel.
- Operators of small natural gas systems may encourage their respective trade associations (such as state and local mobile home associations or municipal associations) to gather and maintain records of available corrosion consultants or contractors who are qualified in their specific region.

- The local chapter of "NACE International" (National Association of Corrosion Engineers) may be able to provide useful information.
- Operators who are unsure of a consultant's qualification in corrosion control should request references from the consultant and contact gas pipeline operators who have hired the consultant in the past. Ask if the consultant is NACE-certified or equivalent.

CORROSION CONTROL REQUIREMENTS FOR PIPELINES INSTALLED AFTER JULY 31, 1971

All buried metallic pipe installed after July 31, 1971, must be properly coated and have a cathodic protection system designed to protect the pipe in its entirety.

Newly constructed metallic pipelines must be coated before installation and must have a cathodic protection system. While the regulations require that cathodic protection system be installed and placed in operation in its entirety within one year after construction of the pipeline, it is recommended that it be installed and operating as soon as possible. However, if the operator can demonstrate by tests, investigation, or experience in the area of application, including, as a minimum, soil resistivity measurements and tests for corrosion accelerating bacteria, that a corrosive environment does not exist, a very rare situation, no cathodic protection is required.
<u>OPS recommends</u> that all operators of small natural gas systems coat and cathodically protect all new metallic pipe. It is extremely difficult and costly to prove that a noncorrosive environment exists.

Cathodic protection requirements do not apply to electrically isolated, metal alloy fittings in plastic pipelines if the metal alloy used for the fitting provides corrosion control and if corrosion pitting will not cause leakage.

CORROSION CONTROL REQUIREMENTS FOR PIPELINES INSTALLED BEFORE AUGUST 1, 1971

Metallic pipelines installed before August 1, 1971, (bare pipe or coated pipe), must be cathodically protected in areas that are determined to be experiencing active corrosion. All underground natural gas distribution systems, including underground piping related to regulating and measuring stations, must be cathodically protected in areas of active corrosion.

The operator must determine areas of active corrosion by (a) electrical survey, (b) where electrical survey is impractical, by the study of corrosion and leak history records, or (c) by leak detection surveys. Active corrosion means continuing corrosion, which, unless controlled, could result in a condition that is detrimental to public safety.

As a guideline for operators when determining corrosion to be detrimental to public safety (active corrosion), OPS recommends the following:

- For master meter operators and small municipal gas systems, all continuing corrosion occurring on metallic pipes (other than cast iron or ductile iron pipes) should be considered active and pipes should be cathodically protected, repaired, or replaced.

- OPS recommends that operators of small gas systems and their consultants use the following guidelines in determining where it is impractical to do electrical surveys to find areas of active corrosion where:
    1. The pipeline is covered by concrete or paving and is more than 2 feet from the edge of a paved street or within wall to wall pavement areas.
    2. The pipelines in a common trench with other metallic structures.
    3. Stray earth gradient currents exist (due to telluric currents, iron ore deposits, a.c. induction, and other sources).
    4. There is lack of electrical continuity of the gas facility.
    5. Pavement and congestion prevents ready access to the soil around the pipe.
    6. Facilities are not electrically isolated, are often in direct contact with other metallic structures or in indirect contact.
    7. Current may be shielded by nearby objects close to the pipeline.
    8. Current can be picked up by nearby conducting elements such as casings, parallel or crossing lines, scrap metal, or other foreign objects.
    9. Insufficient history and details of facilities exist.
    10. There is extremely dry soil.
    11. There are adjacent underground facilities.

In areas where electrical surveys cannot be used to determine corrosion, the operator should perform leakage surveys on a more frequent basis. Although the regulations require the survey at least every 3 years, <u>OPS recommends</u> that these surveys be run at least once a year.

Electrical surveys to find active corrosion must be performed by a person qualified in pipeline corrosion control methods.

COATING REQUIREMENTS

All metallic pipe installed below ground, as a new or replacement pipeline system, should be coated in its entirety (APPENDIX B, FORM 1). Types of coatings and handling practices are discussed later in this chapter. For aboveground metallic pipe, see “Atmospheric Corrosion” below.

EXAMINATION OF EXPOSED PIPE

Whenever buried pipe is exposed or dug up, the operator is required to examine the exposed portion of the pipe for evidence of corrosion on bare pipe or for deterioration of the coating on coated pipe. A record of this examination must be maintained. If the coating has deteriorated or the bare pipe has evidence of corrosion, remedial action must be taken. The excavation must be widened to expose more pipe to determine if that pipe also requires remedial action. The operator must continue to expose pipe until pipe not requiring remedial action is uncovered. (APPENDIX B, FORM 1).

CRITERIA FOR CATHODIC PROTECTION

Operators must meet one of five criteria listed in Appendix D of 49 CFR Part 192, to comply with the pipeline safety regulations for cathodic protection. This is discussed later in this chapter.

MONITORING

A piping system that is under cathodic protection must be monitored. Tests for effectiveness of cathodic protection must be performed at least once every year, not to exceed 15 months between tests. Records of this monitoring must be maintained (APPENDIX B, FORM 14).

Short, separately protected service lines or short, protected mains (not over 100 feet in length) may be surveyed on a sampling basis. At least 10 percent of these short sections and services must be checked each year so that all short sections in the system are tested in a 10-year period. Examples of short, separately protected pipe in a small natural gas system would be:

- Steel service lines connected to, but electrically isolated from, cast iron mains.
- Steel service risers that have cathodic protection provided by an anode attached to a riser that is installed on plastic service lines.

OPS recommends, if a small number of isolated protection sections of pipeline exist in the system, that the operator include all sections in the annual survey. If there are a considerable number, they can be sampled at a rate of 10% per year, but this 10% sample must be distributed all over the system.

When using rectifiers to provide cathodic protection, each rectifier must be inspected six times every year to ensure that the rectifier(s) is properly operating. The interval between inspections must not exceed 2½ months. Records of these inspections must be maintained (APPENDIX B, FORM 15).

Operators must take prompt action to correct any deficiencies indicated by the monitoring.

ELECTRICAL ISOLATION

Pipelines must be electrically isolated from other underground metallic structures (unless electrically interconnected and cathodically protected as a single unit). For illustrations of where meter sets are commonly electrically insulated, see FIGURES 8, 13 and 14 in this chapter.

TEST POINTS

Each pipeline under cathodic protection must have sufficient test points for electrical measurement to determine the adequacy of cathodic protection. Test points should be shown on a cathodic protection system map. Some typical test point locations include the following.

(a) Meter risers,
(b) Pipe casing installations,
(c) Foreign metallic structure crossings,

(d) Insulating joints,
(e) Road crossings.

INTERNAL CORROSION INSPECTION

Whenever a section of pipe is removed from the system, the internal surface must be inspected for evidence of corrosion. Remedial steps must be taken if internal corrosion is found. Adjacent pipe must be inspected to determine the extent of internal corrosion. Records of these inspections must be maintained (APPENDIX B, FORM 1).

ATMOSPHERIC CORROSION

Newly installed aboveground pipelines must be cleaned and coated or jacketed with a material suitable to prevent atmospheric corrosion. Aboveground pipe, including meters, regulators and measuring stations, must be inspected for atmospheric corrosion at least once every three years, not to exceed 39 months between inspections. Remedial action must be taken if atmospheric corrosion is found. Records of these inspections must be maintained (APPENDIX B, FORM 13).

REMEDIAL MEASURES

All steel pipe used to replace an existing pipe must be coated and cathodically protected. Each segment of pipe that is repaired because of corrosion leaks must be cathodically protected. The new segment should be insulated from any of the existing pipe that will not also be cathodically-protected.

GRAPHITIZATION OF CAST IRON

Cast iron is an alloy of iron and carbon (graphite). Graphitization is the process by which the iron in cast iron pipe corrodes, leaving a brittle sponge-like structure of graphite flakes. There may be no appearance of damage, but the affected area of the pipe becomes brittle. For example, a completely graphitized buried cast iron pipe may hold gas under pressure but will fracture under a minor impact, such as being hit by a workman's shovel.

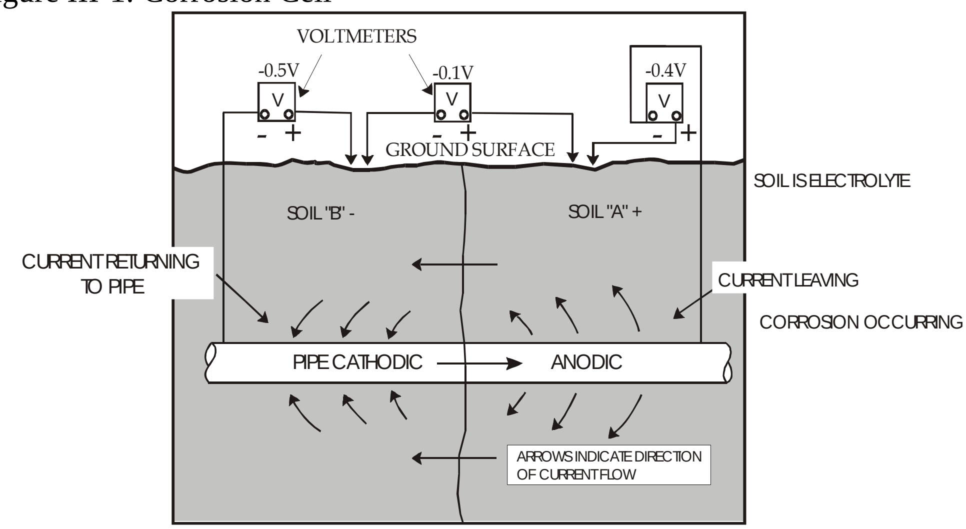
Each segment of cast iron or ductile iron pipe with graphitization (to a degree where a fracture or any leakage might result) must be replaced with steel or plastic and may not be replaced with cast, wrought, or ductile iron. Among other factors, pipeline age and material are significant risk indicators. Pipelines constructed of cast and wrought iron, as well as bare steel, are among those pipelines that pose the highest-risk to safety and should be considered for replacement.

RECORDS

Operators must maintain records or maps of their cathodic protection system. Records of all tests, surveys, or inspections required by the pipeline safety code must be maintained. See APPENDIX B for samples of records/forms.

Corrosion is the deterioration of metal pipe caused by a reaction between the metallic pipe and its surroundings. As a result, the pipe deteriorates and may eventually leak. In order for corrosion to occur there must be four parts: An electrolyte, anode, cathode, and a metallic return path. A metal will corrode at the point where current leaves the anode (see FIGURE III-1). NOTE: Some soils may create an environment that enhances corrosion.

Figure III-1: Corrosion Cell



A corrosion cell may be described as follows:

- Electrical current flows through the soil (electrolyte) from the anode to the cathode. It returns to the anode through the return circuit (the pipe).
- Corrosion occurs wherever current leaves the metal (pipe, fitting, etc.) and enters the soil. The area where current leaves the pipe is said to be anodic. Corrosion, therefore, occurs in the anodic area.
- Current returns to the pipe at the cathode. No corrosion occurs here. The cathode is protected against corrosion.
- The flow of current is caused by a potential (voltage) difference between the anode and the cathode.

This section gives operators with little or no experience in cathodic protection a review of the general principles and practices of cathodic protection. Common causes of corrosion, types of pipe coatings, and criteria for cathodic protection are among the topics. A checklist of steps which an operator of a small natural gas system may use to determine the need for cathodic protection is included. Basic definitions and illustrations are used to clarify the subject. This section does not go into great depth. Therefore, reading this section alone will not qualify an operator to design and implement cathodic protection systems or programs.

Although corrosion cannot be totally eliminated, it can be substantially reduced with cathodic protection (see FIGURE III-2).

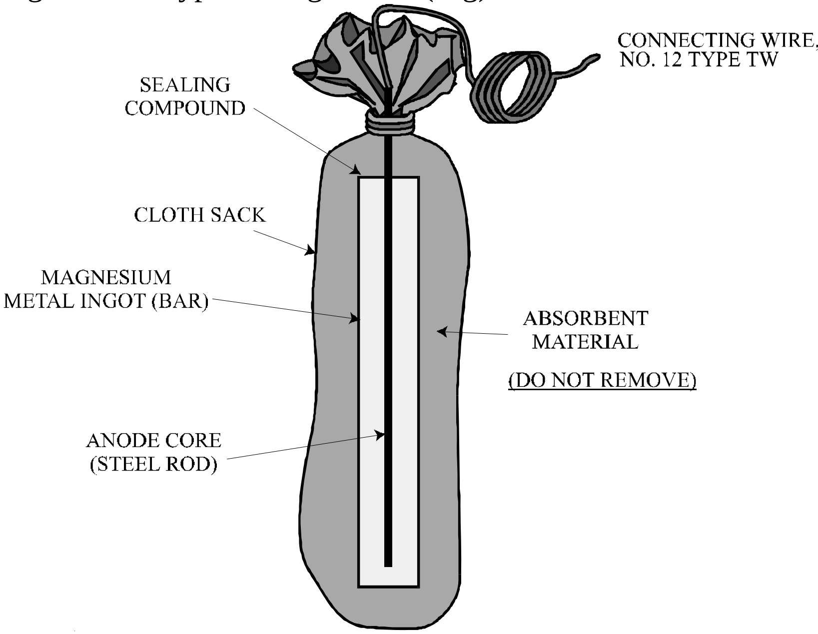
Figure III-2 Bare Pipe - not under cathodic protection

An example of bare steel pipe installed for gas service. Note that deep corrosion pits have formed. Operators should never install bare steel pipe underground. For both new and replacement pipe operators should use either polyethylene pipe manufactured according to ASTM standard D2513 or steel pipe that is coated and cathodically protected.

Cathodic protection is a process that protects an underground metallic pipe against corrosion. An electrical current is impressed onto the pipe by means of a sacrificial anode or a rectifier. Corrosion will be reduced where sufficient current flows onto the pipe.

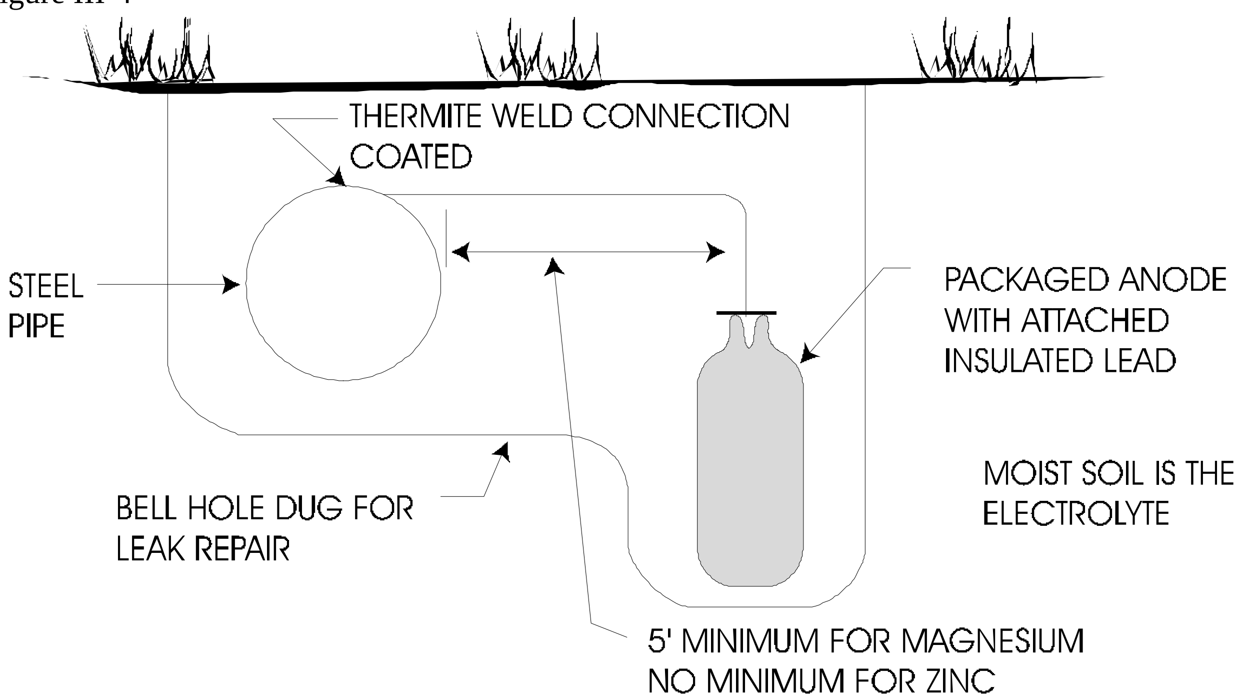
Anode (sacrificial) is an assembly consisting of a bag usually containing a magnesium or zinc ingot and other chemicals, which is connected by wire to an underground metal piping system. It functions as a battery that impresses a direct current on the piping system to retard corrosion (see FIGURE III-3).

Figure III-3 Typical Magnesium (Mg) Anode



Sacrificial protection means the reduction of corrosion of a metal (usually steel in a gas system) in an electrolyte (soil) by galvanically coupling the metal (steel) to a more anodic metal (magnesium or zinc) (see FIGURE III-4). The magnesium or zinc will sacrifice itself (corrode) to retard corrosion in steel the pipe.

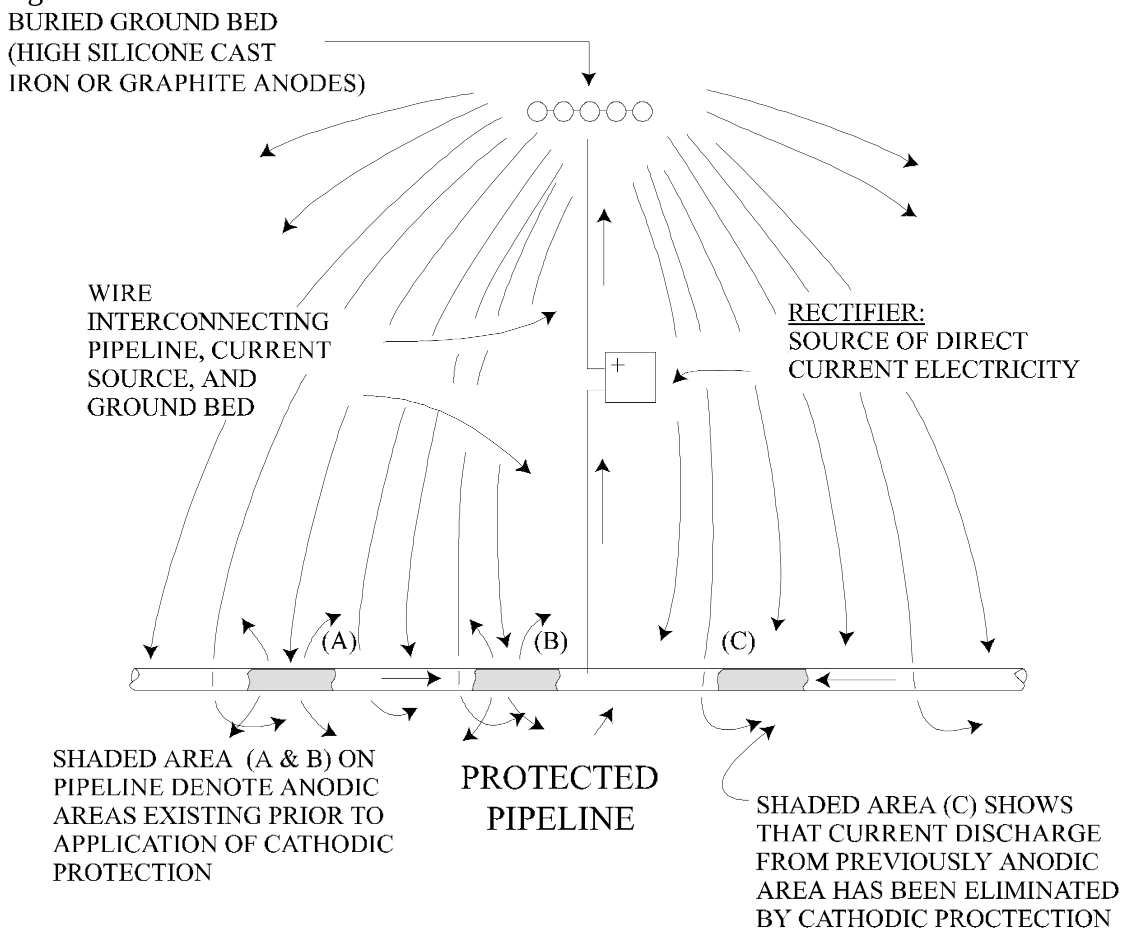
Figure III-4



Zinc and magnesium are more anodic than steel. Therefore, they will corrode to provide cathodic protection for steel pipe.

Rectifier is an electrical device that changes alternating current (a.c.) into direct current (d.c.). This current is then impressed on an underground metallic piping system to protect it against corrosion (see FIGURE III-5).

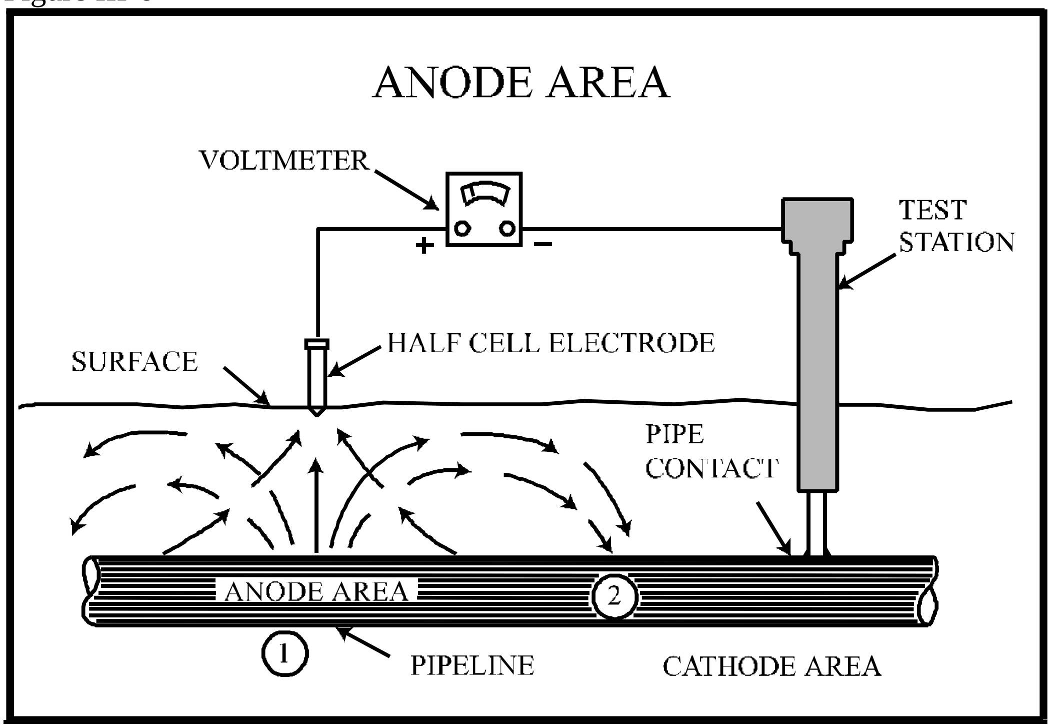
Figure III-5



This illustrates how cathodic protection can be achieved by use of a rectifier. Make certain the negative terminal of the rectifier is connected to the pipe. **NOTE**: If the reverse occurs (positive terminal to pipe), the pipe will corrode much faster.

Potential means the difference in voltage between two points of measurement (see FIGURE III-6).

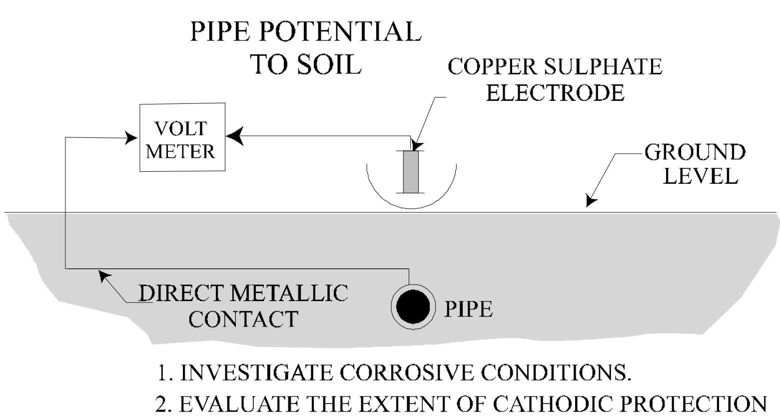
Figure III-6



The voltage potential in this example is the difference between points 1 and 2. Therefore, the current flow is from the anodic area (1) of the pipe to the cathodic area (2). The half-cell is an electrode made up of copper immersed in copper-copper sulfate ($Cu\text{-}CuSO_4$).

Pipe-to-soil potential is the potential difference (voltage reading) between a buried metallic structure (piping system) and the soil surface. The difference is measured with a half-cell reference electrode (see definition of reference electrode that follows) in contact with the soil (see FIGURE III-7).

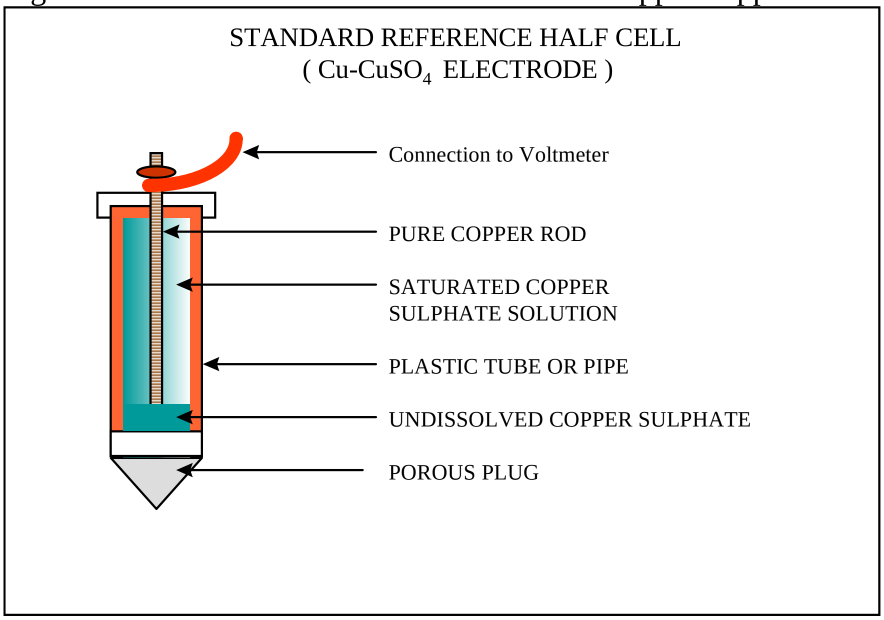
Figure III-7



If the voltmeter reads at least –0.85 volt, the operator can usually consider that the steel pipe has cathodic protection. **NOTE**: Be sure to take into consideration the voltage (IR).

Reference electrode (commonly called a half-cell) is a device which usually has copper immersed in a copper sulfate solution. The open circuit potential is constant under similar conditions of measurement (see FIGURE III-8).

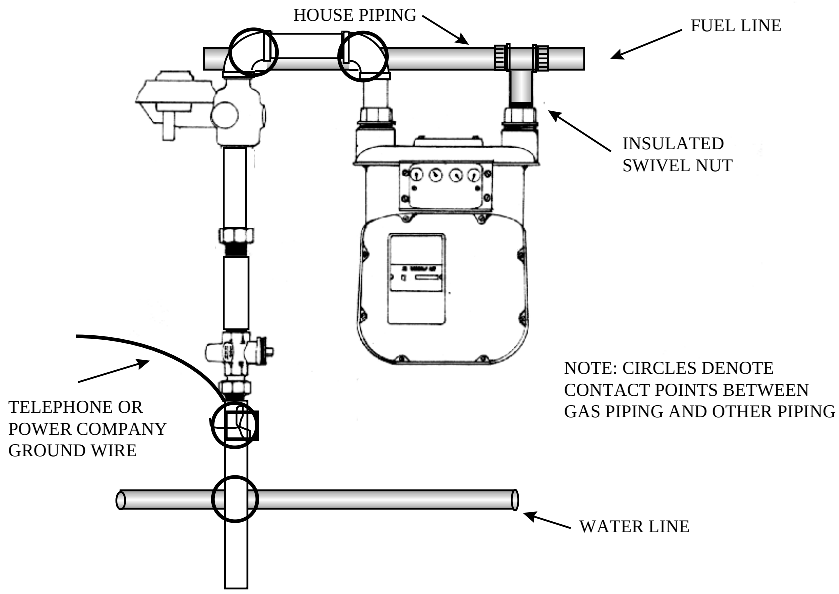
Figure III-8 Reference Electrode – A saturated copper-copper sulfate half-cell.



(Caution Copper-Copper Sulfate is Poisonous)

Short or **corrosion fault** means an unintended contact between a cathodically protected section of a piping system and other metallic structures (water pipes, buried tanks, or unprotected section of a gas piping system) (see FIGURE III-9). Shorts can divert cathodic protection current off of the gas piping and onto these other metallic structures, which can result in inadequate cathodic protection on the gas pipe and premature wearing out of sacrificial anodes.

Figure III-9 Typical Meter Installation Accidental Contacts
(Meter Insulator Shorted Out by House Piping, etc.)



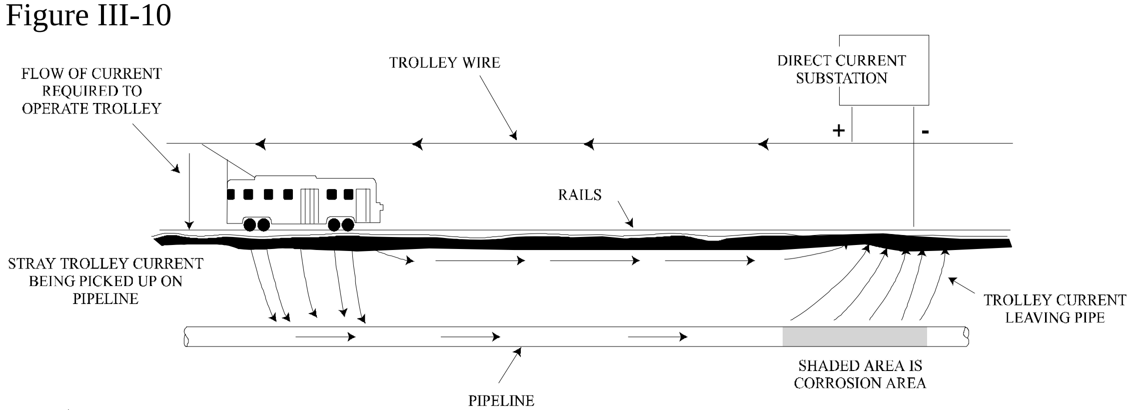
Unshaded piping shows operator's piping from service entry to meter insulator at location shown on sketch above. Shaded areas show house piping, electrical cables, etc.

The circled locations are typical points where the Operators piping (unshaded) can come in contact with house piping. This causes shorting out or "bypassing" of the meter insulator.

The only way to clear these contacts permanently is to move the piping that is in contact. (The use of wedges, etc., to separate the piping is not acceptable). If the aboveground piping cannot be moved, install a new insulator between the accidental contact and the service entry.

Stray current means current flowing through paths other than the intended circuit (see FIGURE III-10). If your pipe-to-soil readings fluctuate, stray current may be present.

Figure III-10



This drawing illustrates an example of stray d.c. current getting onto a pipeline from an outside source. This can cause severe corrosion in the area where the current eventually leaves the pipe. Expert help is needed to correct this type of problem.

Stray current corrosion means metal destruction or deterioration caused primarily by stray d.c. affecting the pipeline.

Galvanic series is a list of metals and alloys arranged according to their relative potentials in a given environment (see Table 1).

Galvanic corrosion occurs when any two of the metals in TABLE 1 (next page) are connected in an electrolyte (soil). Galvanic corrosion is caused by the different potentials of the two metals.

Table 1: Galvanic Series

METAL	POTENTIAL (VOLTS)	
Commercially pure magnesium	-1.75	Anodic
Magnesium alloy (6% A1, 3% Zn, 0.15% Mn)	-1.6	↑
Zinc	-1.1	
Aluminum alloy (5% zinc)	-1.05	
Commercially pure aluminum	-0.8	
Mild steel (clean and shiny)	-0.5 to -0.8	
Mild steel (rusted)	-0.2 to -0.5	
Cast iron (not graphitized)	-0.5	
Lead	-0.5	
Mild steel in concrete	-0.2	
Copper, brass, bronze	-0.2	
High silicon cast iron	-0.2	↓
Mill scale on steel	-0.2	
Carbon, graphite, coke	+0.3	Cathodic

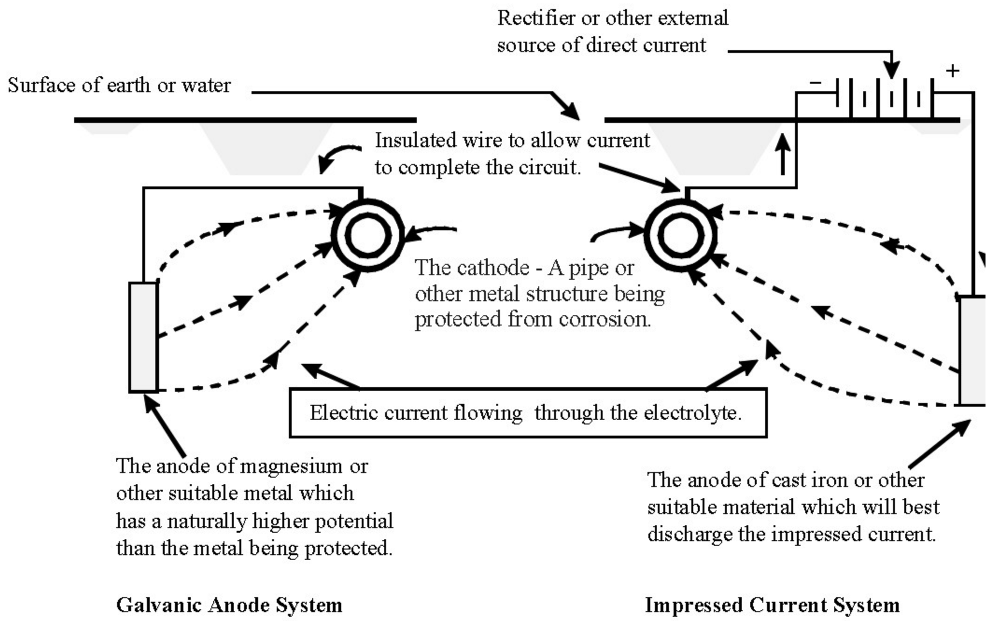
* Typical potential in natural soils and water, measured with respect to a copper-copper sulfate reference electrode.

When electrically connected in an electrolyte, any metal in the table will be anodic (corrode relative to) to any metal below it. That is, the more anodic metal sacrifices itself to protect the metal (pipe) lower in the table.)

There are two basic methods of cathodic protection: the galvanic (sacrificial) anode system and the impressed current (rectifier) system.

The preferred method of cathodic protection, when its application is reasonable, is an impressed current system. In other cases, galvanic anodes are used to provide cathodic protection on gas distribution systems. (see FIGURE III-11).

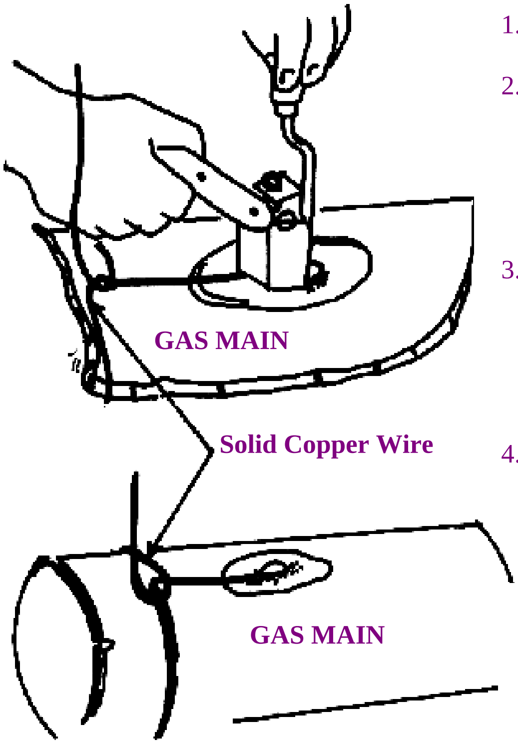
Figure III-11



Any current that leaves the pipeline causes corrosion. In general, corrosion control is obtained as follows:

Galvanic Anode System. Anodes are "sized" to meet current requirements of the resistivity of the environment (soil). The surface area of the buried steel and estimated anode life determines the size and number of anodes required. Anodes are made of materials such as magnesium (Mg), zinc (Zn), or aluminum (Al). They are usually installed near the pipe and connected to the pipe with an insulated wire. They are sacrificed (corroded) instead of the pipe (see FIGURES III-4, III-11, AND III-12).

Figure III-12 Typical Procedure For Installing A Magnesium Anode By The Thermo-Weld Process



1. Loop wire as shown to avoid strain on bond.
2. Insert conductor in mold-do not push end of conductor past center of tap hole. Drop metal disc over tap hole. Remove all starting power from cartridge by tapping the inverted cartridge on lip of mold.
3. Close cover, hold mold steady. Ignite starting power with flint gun as shown. When powder fires, remove gun immediately. Hold mold steady for 10 seconds. Remove slag from weld.
4. See the manufacturer's recommendation before proceeding.

After welding, all exposed pipe should be well coated and wrapped.

Impressed Current Systems. Anodes are connected to a direct current source, such as a rectifier or generator. The principle is the same except that the anodes are made of materials such as graphite, high silicon cast iron, lead-silver alloy, platinum, or scrap steel and the cathodic protection voltage and current is provided by the rectifier or generator rather than the difference in potential between the pipe and the anode.

INITIAL STEPS IN DETERMINING THE NEED TO CATHODICALLY PROTECT A SMALL GAS DISTRIBUTION SYSTEM

1. Determine type(s) of pipe in system: bare steel, coated steel, cast iron, plastic, galvanized steel, ductile iron, or other.
2. Determine the date the gas system was installed (steel pipe installed after July 1, 1971, must be cathodically protected in its entirety).

   Who installed pipe? By contacting the contractor and other operators who had pipe installed by same contractor, operators may be able to obtain valuable information, such as:
   - Type of pipe in ground.
   - If pipe is electrically isolated.
   - If gas pipe is in common trench with other utilities.
3. Pipe location - map/drawing. Locate old construction drawings or current system maps. Even if drawings are available, a metallic pipe locator should be used.
4. Before the corrosion consultant arrives, it is a good idea to make sure that customer meters are electrically insulated. If system has no meter, check to see if gas pipe is electrically insulated from house or mobile home pipe (see Figure III-13).

5. Contact a corrosion consultant or consulting firm that is experienced in gas pipelines and the requirements of 49 CFR Part 192. Try to complete steps 1 through 4 before contracting a consultant.
6. Use of Consultant -- A sample method, which may be used by a consultant to determine cathodic protection needs, is provided below:
   - An initial pipe-to-soil reading will be taken to determine whether the system is under cathodic protection.
   - If the system is not under cathodic protection, the consultant should clear underground shorts or any missed meter shorts (see below for a discussion of testing insulation).
   - After the shorts are cleared, another pipe-to-soil test should be taken. If the system is not under cathodic protection, a current requirement test should be run to determine how much electrical current is needed to protect the system.
   - Additional tests, such as a soil resistivity test, bar hole examination, and other electrical tests, may be needed. The types of tests needed will vary for each gas system.

   Remember to retain copies of all tests run by the corrosion consultant.
7. Cathodic Protection Design -- The experienced corrosion consultant, will design a cathodic protection system based on the results of testing, that best suits the gas piping system.

Figure III-13: Places where a meter installation may be electrically isolated.

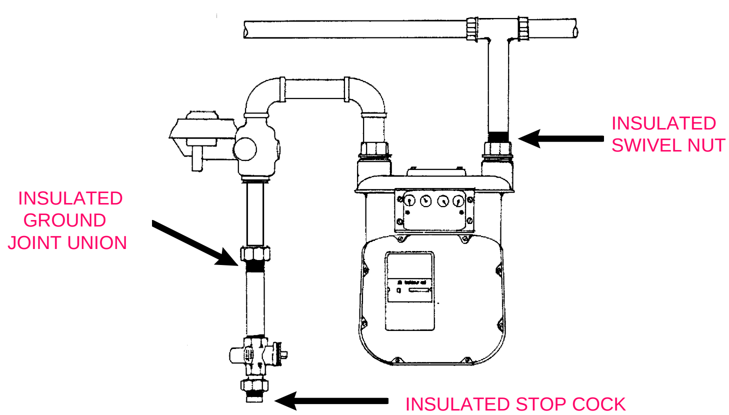


Figure III-14

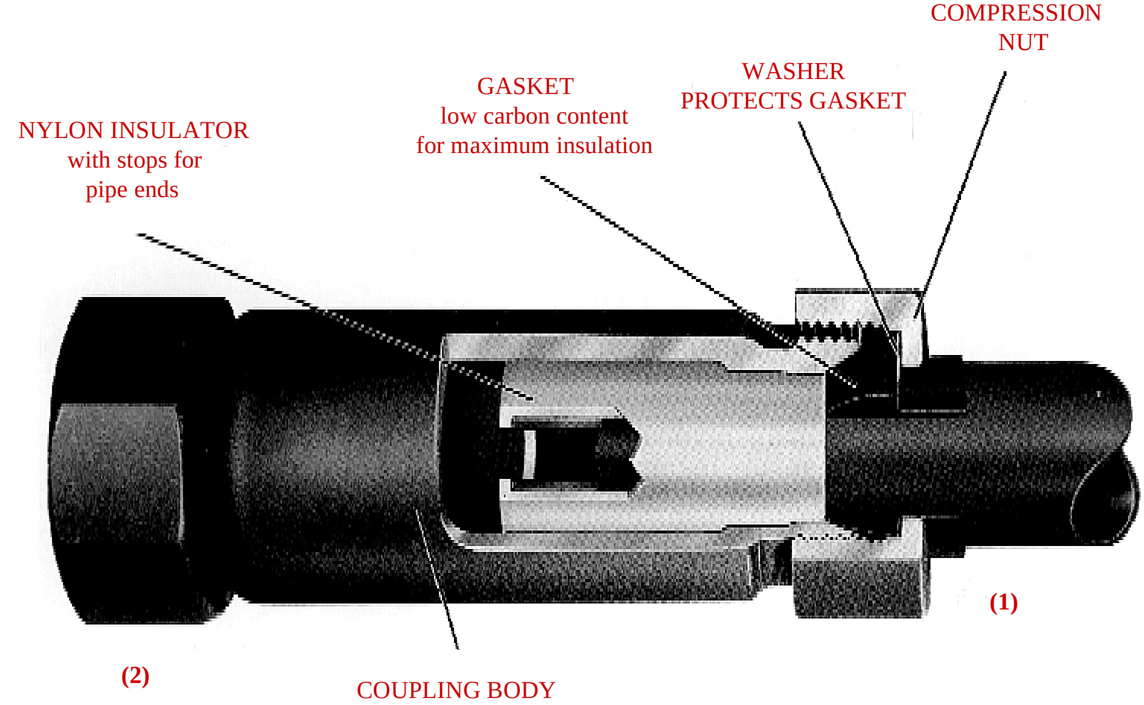
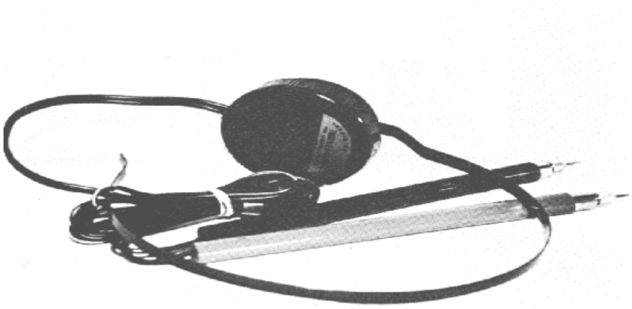


Illustration of an insulated compression coupling used on meter sets to protect against corrosion. Pipe connection by this union will be electrically insulated between the piping located on side one (1) and the piping located on side two (2).

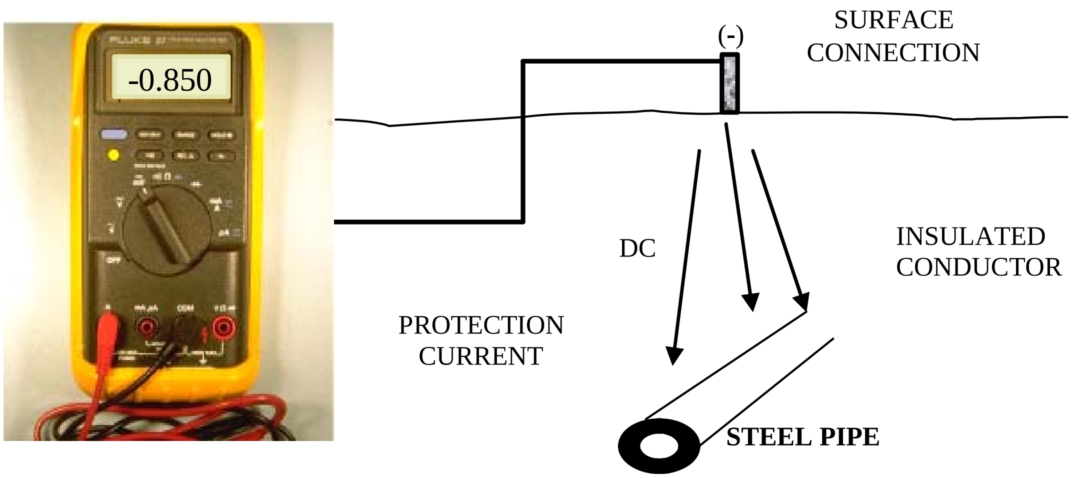
Figure III-15: Insulation Tester



This insulation tester consists of a magnetic transducer mounted in a single earphone headset with connecting needlepoint contact probes. It is a "go" or "no go" type tester which operates from low voltage current present on all underground piping systems, thus eliminating the necessity of outside power sources or costly instrumentation and complex connections. By placing the test probes on the metallic surface on either side of the insulator a distinct audible tone will be heard if the insulator is performing properly. The absence of an audible tone indicates a faulty insulator. Insulator effectiveness can be determined quickly using this simple, easy-to-operate tester.

There are five criteria listed in Appendix D of Part 192, to qualify a pipeline as being cathodically protected. Operators can meet the requirements of any one of the five to be in compliance with the pipeline safety regulations. Most systems will be designed to Criterion 1.
Criterion 1: With the protective current applied, a voltage of at least -0.85 volt measured between the pipeline and a saturated copper-copper sulfate half-cell. This measurement is called the pipe-to-soil potential reading (see FIGURE III-16). IR drop must be considered.

Figure III-16 Pipe-to-Soil Potential Reading.



This is a pipe-to-soil voltage meter with reference cell attached. This is a simple meter to use and is excellent for simple "go-no-go" type monitoring of a cathodic protection system. If meter reaches at least -0.85 volt or more negatively, the operator knows .that the 850 mv criteria is met at that location. If not, remedial action must be taken promptly. **NOTE**: Be sure to take into consideration the IR drop.

IR drop is a phenomenon that occurs when trying to check or conduct test to determine if the pipeline is being cathodically protected. When a reading is taken, the readings may appear to show that the pipeline is cathodically protected, but in actuality, the pipeline might not be protected. Each operator must take IR drop into account to ensure that the pipeline is really being protected.

To consider IR drop:

- For pipeline systems protected by a rectifier, the current is turned off while taking a reading and the "off" reading is considered to be the correct reading.
- For pipeline systems protected by magnesium anodes your corrosion consultant can determine how best to consider IR drop.

COATINGS

Coatings are used to electrically insulate the pipe from the electrolyte (soil), preventing the electrical flow that causes corrosion. Prior to July 1, 1971, metallic pipe could be installed without a coating. Any steel pipe installed since then must be coated. There are many different types of coating on the market. The better the coating application, the less electrical current is needed to cathodically protect the pipe.

MILL COATED PIPE

When purchasing steel pipe for underground gas services, operators should purchase mill coated pipe (i.e., pipe coated during manufacturing process). Some examples of mill coatings are:

- Extruded polyethylene or polypropylene plastic coatings,
- Coal tar coatings,
- Enamels,
- Mastics,
- Epoxy.

A qualified (corrosion) person can help select the best coating for a natural gas system. A local natural gas utility may be able to give master meter operators the name and location of nearby suppliers of mill coated gas pipe. When purchasing steel pipe, remember to verify that the pipe was manufactured according to one of the specifications listed in Chapter VI of this manual. This can be verified by a bill of lading or by the markings on mill coated pipe.

PATCHING

Special tape materials designed for pipe coating are available. Tape material is a good choice for external repair of mill coated pipe. Tape material is also a good coating for both welded and mechanical joints made in the field.

Some tapes in use today are:

- Polyethylene (PE) and Polyvinyl chloride (PVC) tapes with self-adhesive backing applied to a primed pipe surface,
- Plastic films with butyl rubber backing applied to a primed surface,
- Plastic films with various bituminous backings.

Consult a pipe supplier before purchasing tapes. Tapes must be compatible with the mill coating on the pipe. Household tape, masking tape, duct tape and other general purpose tapes are not suitable for pipe coating repairs.

COATING APPLICATION PROCEDURES

When repairing and installing metal pipe, be sure to coat bare pipes, fittings, etc. It is absolutely essential that the instructions supplied by the manufacturer of the coating be followed precisely. Corrosion may occur if the instructions are not followed.

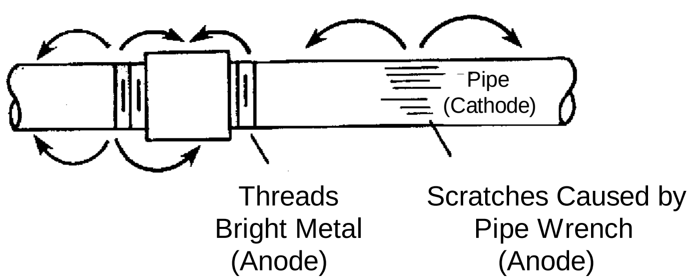
Some general guidelines for installation of pipe coatings:

- Properly clean pipe surface (remove soil, oil, grease, and any moisture),
- Use careful priming techniques (avoid moisture, follow manufacturer's recommendations),
- Properly apply the coating materials (be sure pipe surface is dry - follow manufacturer's recommendations). Make sure soil or other foreign material does not get under coating during installation,
- Only backfill with material that is free of objects such as rocks or debris capable of damaging the coating. Severe coating damage can be caused by careless backfilling when rocks and debris strike and break the coating.

Figure III-17 Shorted Meter Set.

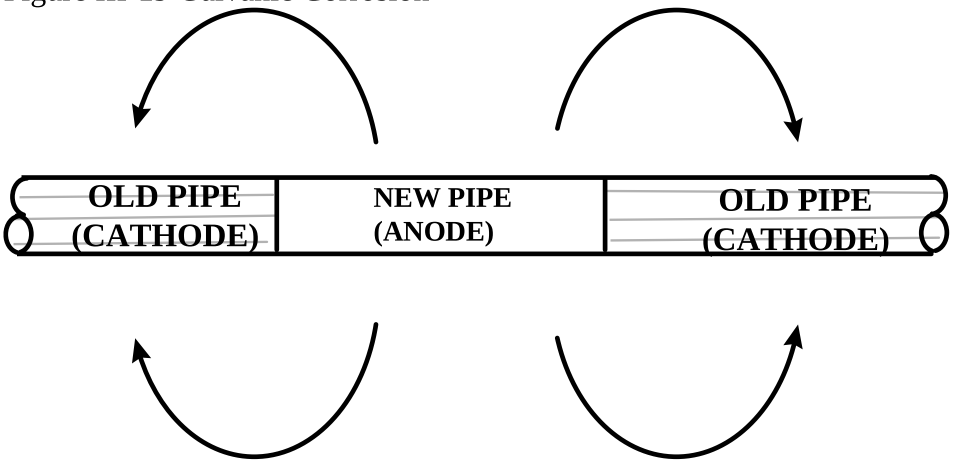
An example of a galvanic corrosion cell. The tenants of this building have "shorted" out this meter by storing metallic objects on the meter set. Never allow customers or tenants to store material on or near a meter installation. Also, do not allow clotheslines, fences, tools or other items to hang on meter installations as they may cause damage to the pipeline.

Figure III-18 Corrosion Caused by Dissimilar Surface Conditions.



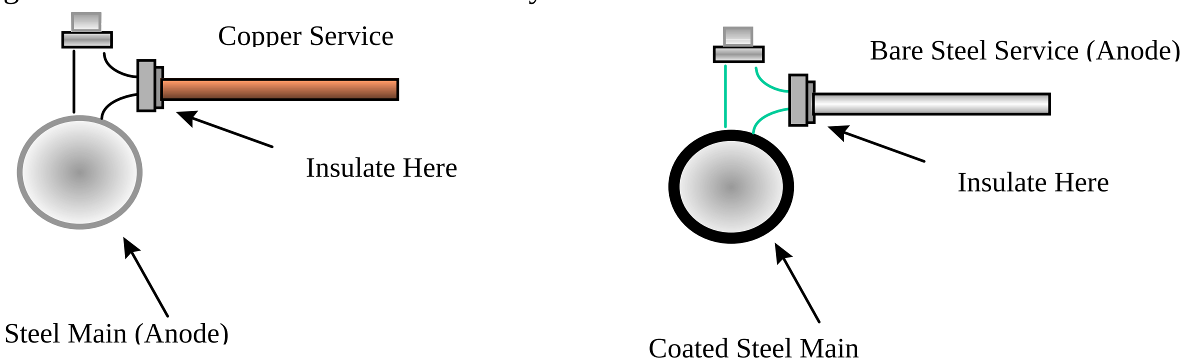
This pipe will corrode at the threads or where it is scratched. Remember to repair all cuts or scratches in the coating before burying the pipe. Always coat and/or wrap pipe at all threaded or weld connections before burying pipe.

Figure III-19 Galvanic Corrosion



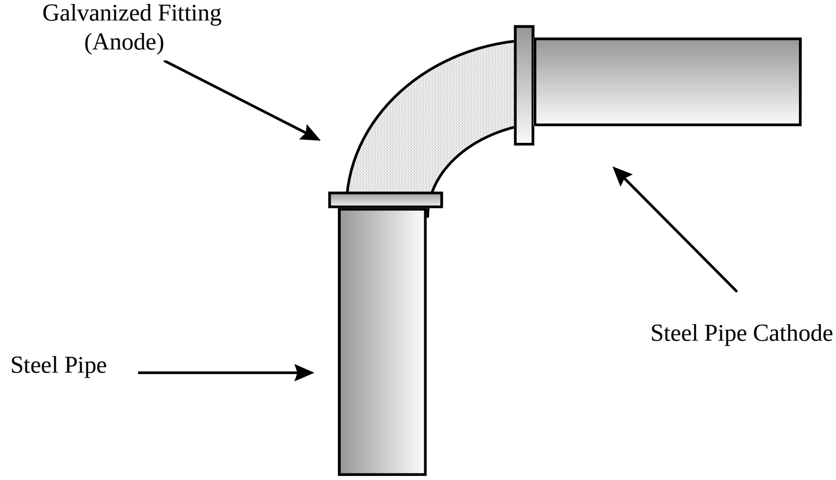
Remember, all new steel pipe must be coated and cathodically protected. The new pipe can either be electrically isolated from old pipe, or both the new and old pipe must be cathodically protected as a unit.

Figure III-20 Galvanic Corrosion Caused by Dissimilar Metals.



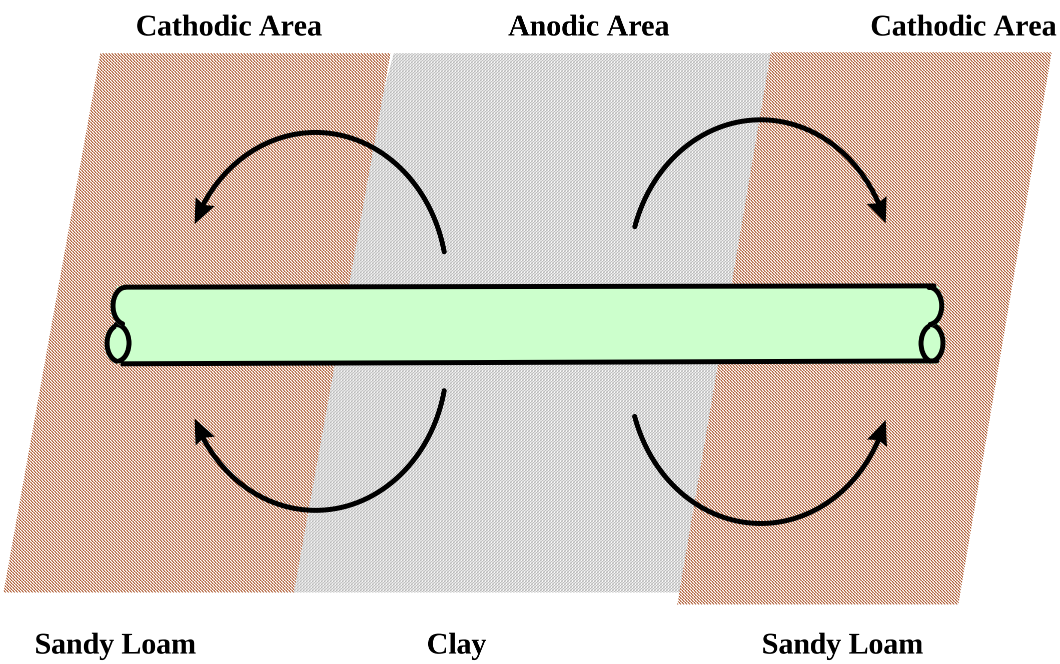
Steel is above copper in the galvanic series in TABLE 1 of this chapter. Therefore, steel will be anodic to the copper service. That means the steel pipe will corrode. The copper service should be electrically isolated from the steel main. Remember, steel and cast iron or ductile iron should be electrically isolated rather than tied in directly. Also, coated steel pipe should be electrically isolated from bare steel pipe.

Figure III-21 Galvanic Corrosion



The galvanized elbow will act as an anode to steel and will corrode. Do not install galvanized pipe or fittings in system, if possible.

Figure III-22 Galvanic Corrosion

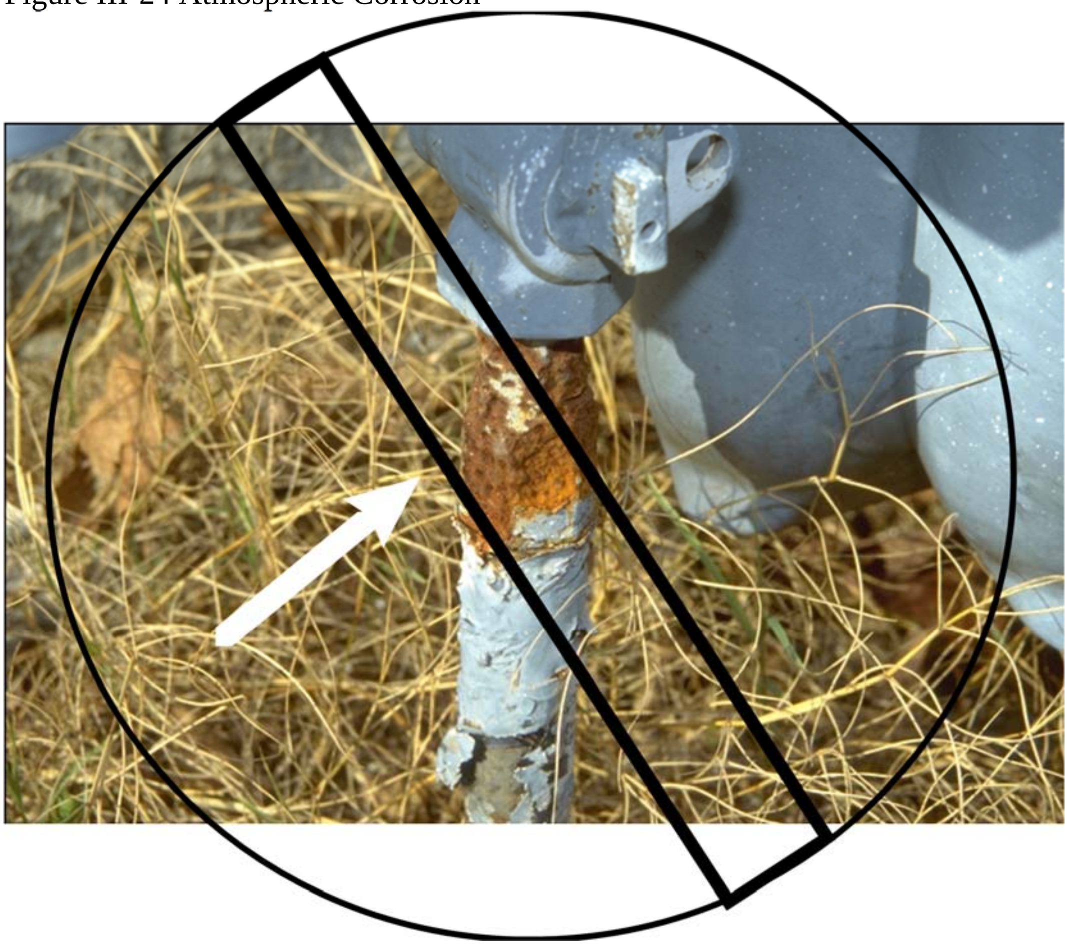


A corrosion cell can be set up when pipe is in contact with dissimilar soils. This problem can be avoided by the installation of a well-coated pipe under cathodic protection.

Figure III-23 Poor Construction Practice

Figure III-23 shows an example of a main which was buried without a coating or wrapping at the service connection. This corrosion problem could have been avoided by properly coating and cathodically protecting the pipe.

Figure III-24 Atmospheric Corrosion



Atmospheric corrosion at a meter riser, as shown above, can be prevented by either jacketing the exposed pipe or by keeping it properly painted. Corrosion is usually more severe at the point where the pipe comes out of the ground. Similar corrosion can occur anywhere pipe comes aboveground, such as regulator or metering stations.