7) Complete the following statement:
The approximate explosive limits of propane gas range from _________ _________ propane in air.
   a) 5% to 15%
   b) 2% to 10%
   c) 7% to 10%
   d) 2% to 15%

8) Indicate True or False:
Natural gas is heavier than air.
   a) True
   b) False

9) Indicate True or False:
Air is lighter than propane.
   a) True
   b) False

4. Protection of piping and tubing from corrosion

Overview

Purpose

A gas technician/fitter must know how to protect a gas piping system and its components from corrosion in accordance with applicable codes and standards.

Objectives

At the end of this Chapter, you will be able to:

- describe reasons for corrosion protection; and
- describe corrosion protection methods.

Terminology

Term	Abbreviation (symbol)	Definition
Anode		Electrode at which electrons leave the cell and oxidation occurs
Bonding		Connection of two or more conductive objects to one another by means of a conductor such as a wire
Cathode		Electrode at which electrons enter the cell and reduction occurs
Corrosion		Process that changes pure metals into their compound, while producing electric current
Electrode		Electrical conductor used to make contact with a nonmetallic part of a circuit
Electrolyte		Conductor of the electric currents
Grounding		Specific form of bonding involving the connection of one or more conductive objects to the ground by means of a conductor such as a wire or rod
Resistivity		Electrolyte's resistance to electric force within a cube measuring 1 cm

Reasons for corrosion protection

Corrosion

Corrosion is one of the ways that a pure metal can revert to a more stable compound. Some metals, when unprotected from the atmosphere, gradually corrode.

The metals used to make pipelines and piping systems are generally pure. However, you can also find metals as chemical compounds such as oxides, sulphides, and other salts.

Many metals are more stable in their natural compound than as a pure metal. For example, iron oxide (rust) is more stable than the pure iron used in pipes. It is more stable because the atmosphere has reacted with the iron to create the compound iron oxide. As a compound, iron oxide has no further chemical reaction to atmospheric elements and is therefore stable.

Causes of corrosion

Corrosive materials and conditions that can have an adverse effect on gas piping and tubing include:

- atmospheric and soil conditions;
- chemicals;

- cement;
- cinders and fly ash; and
- electrolytic action.

Corrosion protection and control

Corrosion protection and control is a highly specialized area. A qualified corrosion engineer or a firm specializing in this work should always supervise the design, installation, and testing of piping protection systems. (You can obtain a current list of corrosion specialists from the local gas authority.) Nevertheless, as a gas technician/fitter, you must fully understand the corrosion process so that you can take preventive measures when installing or repairing piping that may be exposed to corrosive conditions.

Gas system piping and tubing installed in locations where it may be exposed to corrosion must have protection, which can come in a number of ways, depending on the material to be protected and the type of corrosion to which it may be exposed.

The corrosion process

Corrosion is an electrochemical action that changes pure metals into their compound, while producing electric current.

Four things are necessary for corrosion to occur:

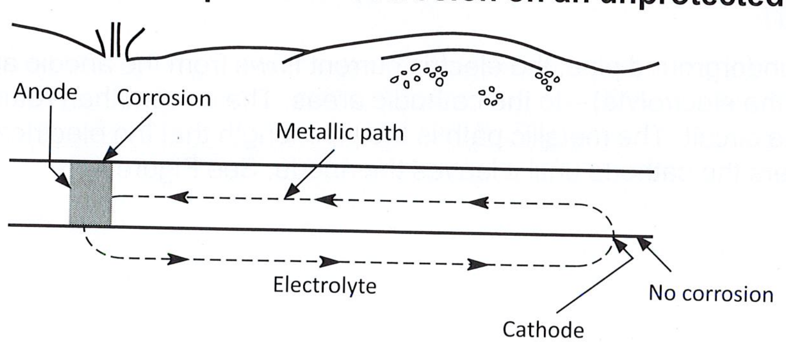
1) an anode;
2) a cathode;
3) an electrolyte; and
4) a conductive path.

Corrosion cannot occur if any of these is absent. The Subsections below explain each in detail.

Anode and cathode

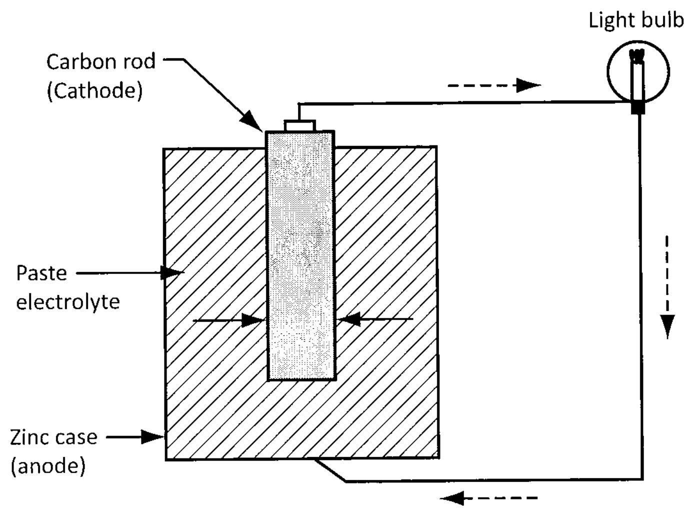
Metal corrodes when there is a complete electrical circuit. The electrical current travels from the anode to the cathode in the electrolyte. This is conventional current, the movement of positive charges you can find in a basic electrical circuit (see Figure 4-1). The anode and cathode are what you call electrodes.

Figure 4-1
Four elements required for corrosion on an unprotected pipe



An everyday example of how we benefit from this electrochemical action is the dry cell battery (see Figure 4-2). The dry cell battery produces an electric current because the zinc casing is an anode and the carbon rod is a cathode. The electric current runs from the anode to the cathode, passes through the light, and goes back to the anode.

Figure 4-2
Dry cell battery



Electrolyte

Dry metals, in general, do not corrode. Water is essential to the corrosion process, as it acts as the conductor of the electric currents. It is what you call the electrolyte.

Although pure water is a poor electrical conductor, traces of salts, acids, or alkalis increase its effectiveness as an electrolyte and greatly accelerate corrosion processes. Water and these contaminants are present in most soils and, with the oxygen that permeates the soil from the air above, all the corrosive agents are present.

Soils have varying abilities to resist current flow and therefore have varying abilities as an electrolyte. A soil with very high resistance to electrical current (dry soil, gravel) is a poor electrolyte. A moist soil with low resistance to electric current (loam, clay) is a more efficient electrolyte. Piping buried in moist soil is therefore more prone to corrosion.

Metallic path

In an unprotected underground pipe, the electric current flows from the anodic areas of the pipe —through the soil (the electrolyte)—to the cathodic areas. The current then returns through the pipe to complete the circuit. The metallic path is the pipe length that the electrical current travels from the time it enters the cathode until it leaves the anode. See Figure 4-1.

Metals with different potentials

All metals have a known electrical value on an electromotive scale. If two metals have different electrical potential, a current will flow between them. The current always flows from active metals (metals with higher potential) to less active metals (metals with lower potential).

The current flows between metals of differing potential regardless of whether the metals are close together or far apart.

Surface corrosion occurs when the differing metals are close together, for example, when there is mill scale on steel piping. On the other hand, when the soil quality changes from one end of a pipeline to another, the soil's resistivity may change the metal's potential. This again creates current flow and corrosion occurs.

Resistivity

Resistivity is the soil's (electrolyte's) resistance to electric force within a cube measuring 1 cm. It is expressed in ohm/cm.

Nearly all soils are corrosive to steel, and those below 10 000 ohms/cm are considered especially corrosive. Soils below 5000 ohms/cm are sufficiently corrosive to cast iron or ductile iron to warrant cathodic protection. Sharp changes in soil resistivity over a pipeline route can also cause severe corrosion problems.

The *Wenner four pin method* is the technique usually used for measuring resistivity. This method involves direct driving of four pins into the ground in a straight line at specific distances apart, imposition of a current between the two outside pins, and measurement of the voltage across the two inside pins. These readings are what you use to calculate the resistivity.

Corrosion protection methods

In general, piping and tubing is:

- covered with an approved corrosion-resistant paint or coating, when conditions require; and
- coated or wrapped where it passes through walls where it could sustain physical damage or be subject to corrosion.

Different types of pipe and tubing require different treatment.

Copper pipe and tubing

Copper pipe and tubing must have protection from corrosion under the following conditions:

Above ground	Underground
• Where it passes through concrete, cement block, or similar locations that would cause corrosive action if the copper came in direct contact with the material it passes through • Where the copper may contact a dissimilar metal • Where the copper may come in contact with corrosive chemicals or vapours	• All underground copper tubing installations require the use of Type L or G copper having an approved protective coating. The use of Type K copper is allowed. This type does not require external protection.

Copper protection methods

Above ground	Underground
• You may use uncoated copper pipe and tubing in above ground applications where it is not exposed to corrosive elements or physical damage. • Coat or double wrap copper pipe and tubing that passes through exterior concrete or masonry walls with an approved protective tape, with waterproof caulking applied at the entrance and exit points. • Coat or double wrap copper pipe and tubing that passes through interior concrete or masonry walls with an approved protective tape. Caulking is not required. • To avoid possible electrolytic action, do not allow copper pipe and tubing to come in contact with dissimilar metals. If this is unavoidable, double wrap the copper with tape or insulation to provide galvanic protection. Apply this corrosion prevention measure where copper is installed in metal protective sleeves. • Whenever possible, use only copper or plastic mounting clips to secure copper pipe and tubing to avoid dissimilar metal contact.	• Copper tubing used in underground applications must be Type K, L, or G copper. Type L or G copper must have an approved, external coating.

Steel and iron pipe

Steel and iron pipe must have protection from corrosion under the following conditions:

Above ground	Underground
• Where it passes through concrete, cement block, or similar locations that would cause corrosive action if the pipe came in direct contact with the material it passes through • Where the pipe may contact a dissimilar metal • Where the pipe may come in contact with corrosive chemicals or vapours	• Installations require protection for steel and iron pipe by means of an approved method or combination of methods, including: – protective coating; – corrosion-resistant wrapping; – cathodic protection; – electrical bonding; and – isolation of individual pipe sections.

Steel and iron protection methods

Above ground	Underground
• Steel and iron pipe used in above-ground applications where it is exposed to corrosive elements must have an approved protective coating or corrosion-resistant wrapping. • Coat, sleeve, or double wrap steel and iron pipe that passes through exterior concrete or masonry walls with an approved protective tape, with waterproof caulking applied at the entrance and exit points. • Coat, sleeve, or double wrap steel and iron pipe that passes through interior concrete or masonry walls with an approved protective tape. Caulking is not required. • To avoid possible electrolytic action, do not allow steel and iron pipe to come in contact with dissimilar metals. If this is unavoidable, double wrap the pipe with tape or insulation to provide galvanic protection. • Whenever possible, use only pipe clips of the same material to secure steel and iron pipe to avoid dissimilar metal contact.	• Steel and iron pipe is not usually used underground, because only welded joints are acceptable and because this pipe is vulnerable to corrosion. However, if the local inspection authority permits the use of steel and iron pipe underground, ensure that the pipe have a coating or wrap with corrosion-resistant material. In addition, where you use coated pipe, take the following protective measures: – Wrap all joints and risers with approved corrosion-resistant material. – Bond a correctly sized anode to the pipe by cadwelding. – Install a dielectric union or insulating flanges above grade at each end of the pipe run.

Plastic pipe

You may only use polyethylene pipe (plastic pipe) for underground installations.

Note that the material of all risers that extend above grade must be steel or copper.

Connectors must be approved transition fittings, and a tracer wire must follow the pipe for future locating.

Methods for protecting underground piping

There are three methods for protecting underground piping from corrosion, namely:

- protective coatings;
- electrical insulation; and
- cathodic protection.

Protective coatings

Protective coatings insulate a pipe from the soil (the electrolyte). A good coating has a high dielectric strength, that is, it is a good electrical insulator. It adheres tightly to the pipe and has the necessary mechanical strength to withstand handling, soil stresses, and any tendency towards cracking.

Yard applied coal tar and extruded polyethylene are the main coatings used. While most coatings absorb some water and allow some current to penetrate through to the steel surface, for most practical purposes, the steel is considered isolated from the soil.

In theory, this would be enough to prevent corrosion; however, it is virtually impossible to install a pipeline without some defects in its coating. The portions of pipe that become exposed to the soil because of damaged coating corrode quickly because the corrosion is concentrated in those areas.

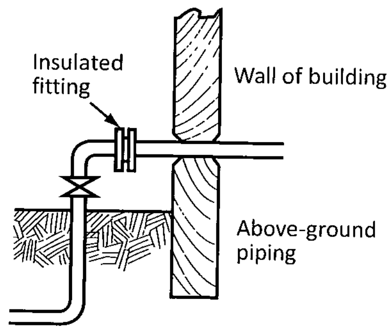
Repairing pipe that has a protective coating

When repairing or adding to a pipe that has a protective coating, ensure you use approved protective coatings such as Polyken tape or heatshrink sleeves.

Upon repairing the pipe, check the quality of the protective coating with the *Jeep Test*, an electronic testing Unit that finds imperfections in the coating so that you can repair them before burying the piping.

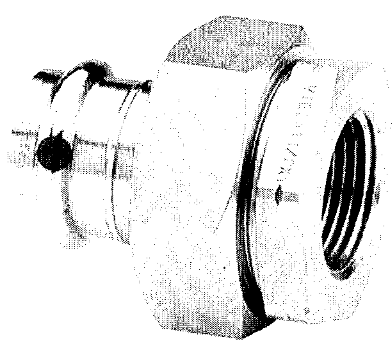
Ensure that a protected piping system is electrically insulated from other metallic structures by installing a dielectric fitting on the pipeline directly outside the building wall (see Figure 4-3). The fitting prevents electrical contact between protected piping (underground) and unprotected piping (above-ground). It is usually an insulated union, insulated flange, or insulated meter spud (see Figure 4-4).

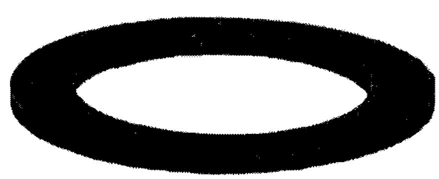
Figure 4-3
Dielectric fitting protects underground pipeline from above-ground piping



Additionally, insulated couplings separate long gas piping networks into individual electrical Units. In this way, long electric current lines are inhibited, and you can accurately assess the number of anodes required for each Unit.

Figure 4-4
Insulated fitting to protect pipe from contact with other pipe systems
Images courtesy of Viega





Bonding of piping

CSA B149.1, Clause 4.7.3 requires, "All interior metal gas piping that may become energized shall be made electrically continuous and shall be bonded in accordance with the requirements of the local electrical code, or in absence of such, the *Canadian Electrical Code, Part I*."

CSA B149.1 forbids the use of gas piping as an electrical ground, while the *Canadian Electrical Code, Part I* requires bonding of continuous metal gas piping systems in a building supplied with electric power. It is important to note that bonding and grounding are not the same. Bonding, as defined in the *Canadian Electrical Code*, is, "a low impedance path obtained by permanently joining all non-current-carrying metal parts to ensure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it."

Grounding, as defined in *Canadian Electrical Code*, is, "a permanent and continuous conductive path to the earth with sufficient ampacity to carry any fault current liable to be imposed on it, and of a sufficiently low impedance to limit the voltage rise above ground and to facilitate the operation of the protective devices in the circuit." Thus, code-compliant bonding of gas piping in the field will ensure the gas piping is made equipotential with the non-current-carrying conductive parts of electrical equipment.

It should also be noted that the requirement in Rule 10-700 c) of the *Canadian Electrical Code* to provide equipotential bonding to a metal gas piping system is not intended to apply to metal gas tubing, i.e., CSST. Attempts to bond metal gas tubing with conventional bonding means can create a hazardous situation where the tubing can be punctured by installation of the bonding means or by arcing between improperly secured bonding means during faults or lightning strikes.

The grounding conductor at a building connects to a grounding electrode, and CSA B149.1, as well as the *Canadian Electrical Code,* require the bonding of the gas piping to that system be installed in an approved manner. This bonding connection provides equipotentiality – the state in which conductive parts are at a substantially equal electric potential.

Assignment Questions – Chapter 4

1) Indicate True or False:
   Cement can have an adverse effect on gas piping and tubing.
   a) True
   b) False

2) What is necessary for corrosion to occur?
   a) Cathode, Anode
   b) Anode, Cathode, Conductive path
   c) Anode, Cathode, Electrolyte, Conductive path
   d) Electrolyte, Anode, Conductive path

3) What is an example of the benefit of electrochemical action?
   a) The light bulb
   b) The dry cell battery
   c) Corrosion

4) Which is a better electrolyte?
   a) Dry sandy soil
   b) Moist loamy soil

5) In which direction will the electrical current flow if an electrolyte is placed between two metals of differing potential?
   a) From the higher potential metal to a lower potential metal
   b) From the lower potential metal to a higher potential metal