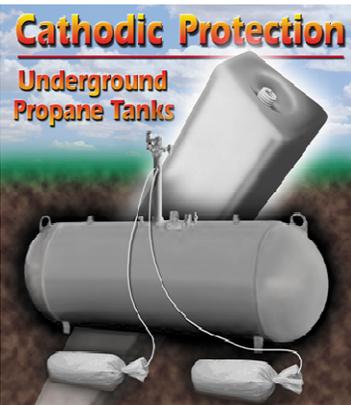




WHY TANKS CORRODE

Underground steel tanks corrode due to an electrochemical reaction between the tank and the surrounding soil. The process of corrosion occurs due to small voltage differences on the steel surface that result in the flow of DC current from one location to another. Where current flows from the tank into the soil, corrosion occurs.



This location is called the anode in a corrosion circuit. Where current flows from the soil to the tank, no corrosion occurs. This location is called the cathode. The progress of corrosion is determined by the amount of current flowing between the anode and the cathode and whether the locations of the anode/cathode remain constant over time. Corrosion rates are generally higher in wet soil environments since the conductivity of the soil promotes the flow

of DC current in the corrosion circuit.

Corrosion generally exhibits itself on underground tanks in either a general overall rusting or more commonly, a pitting attack. Pit locations may result from metallurgical conditions of the steel surface or soil variations such as rocks, salts, fertilizer, moisture concentration, oxygen concentration, etc.

PREVENTING CORROSION

Protecting underground tanks from corrosion is easily achieved by the use of two commonly applied protection methods: external coating and cathodic protection. These two methods are complementary and should be used in conjunction with the other. An effective external protective coating insulates the steel from the soil environment, thus preventing the flow of corrosion current from the anode to the cathode. An effective external coating can protect over 99% of the tank surface area. However, no coating is perfect. Damage from construction or soil stresses create tiny defects, which may result in accelerated corrosion at the defect.

Cathodic protection prevents corrosion at those defects by applying DC current from an external source, forcing the tank to become a cathode. Application of sufficient DC current to the tank will prevent any corrosion from occurring. The two general types of cathodic protection systems are sacrificial and impressed current. Sacrificial systems are used when the amount of current required for protection is small, such as in underground propane tanks. Impressed current systems are more commonly used for large structures such as large diameter pipelines.

Electrical isolation of the tank from metallic piping systems and electrical grounds is highly recommended for the cathodic protection system's effectiveness.

HOW SACRIFICIAL CATHODIC PROTECTION WORKS

Sacrificial systems work by creating a galvanic connection between two different metals. The most common anode material is magnesium, which when coupled to steel results in DC current flow from the magnesium to the steel. The open circuit potential of steel is about -0.50 volts referenced to a copper sulfate electrode. The open circuit potential of magnesium is about -1.55V to -1.80V. By connecting the two metals together, the difference of 1 to 1.25V volts results in current flow to the tank that overcomes the natural corrosion cells that exist on the tank. With this current available to the tank, no corrosion occurs.

MAGNESIUM ANODES

There are a variety of anode sizes and alloys used for cathodic protection. The two primary alloys are designated as H-1 (or AZ63) and High Potential. The H-1 alloy is produced from recycled magnesium and has an open circuit potential of approximately -1.55V. This alloy is well suited for protection of underground propane tanks. The High Potential alloy is 99% pure magnesium having an open circuit potential up to -1.8 V. This alloy should be used for soil applications over 10,000 ohm-cm resistivity.

The two most common anode sizes used for underground propane tanks are 9 lb. and 17 lb. The size designation relates to the metal weight. 10' of #12 TW insulated wire is attached to the anodes. Anodes are then backfilled in a mixture of gypsum, bentonite, and sodium sulfate to lower the electrical resistance of the anode to soil. The mixture is a low cost, nonhazardous, electrically conductive backfill. The anode and backfill is then packaged in a cotton bag and either a cardboard box or paper bag. Actual shipping weight of these anodes with backfill is 27 lb. and 45 lb.

Soil Type	Fertile Soils, Clay, Sandy Loam			Sand, Gravel, Rocky Areas		
	0 to 5000 ohm-cm			5000 to 10000 ohm-cm		
Tank Cap. (gal)	Size	Qty.	Alloy	Size	Qty.	Alloy
120	9#	1	H-1	9#	1	H-1
150	9#	1	H-1	9#	1	H-1
250	9#	1	H-1	9#	2	H-1
325	9#	1	H-1	9#	2	H-1
500	17#	1	H-1	9#	2	H-1
1000/850	17#	2	H-1	9#	4	H-1
1500	17#	2	H-1	9#	4	H-1
2000	17#	3	H-1	9#	6	H-1

*Based on 90% effective external coating, 2 ma/ft² current density, and 30 year anode life.

APPLICATION RECOMMENDATIONS

Magnesium anodes can protect underground tanks in most soil conditions. The H-1 alloy is generally very effective. The chart above provides size and quantity recommendations for various size tanks based on conservative design assumptions. This chart covers soil conditions up to 10,000 ohm-centimeter resistivity. Resistivities higher than 10,000 ohm-cm generally represent very dry soils. Verification of soil resistivity can be performed through soil analysis. Contact a corrosion specialist for design recommendations in locations where soil resistivities exceed 10,000 ohm-cm, or if there

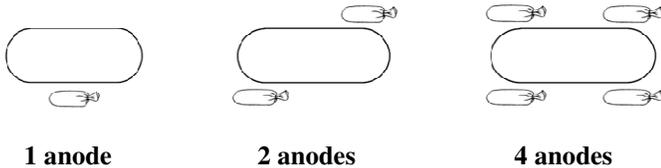
is no effective external coating on the tank.

The propane service line from the tank to the house also must be considered in the cathodic protection design, unless the service line is plastic. All underground steel pipe should be externally coated with a corrosion resistant material. The service line should be electrically isolated at the house with an insulating fitting or union. If service pipe is less than 50' in length, the tank anodes will provide sufficient current to protect both tank and pipe. For longer lengths of pipe, an additional anode may be required at the house connection.

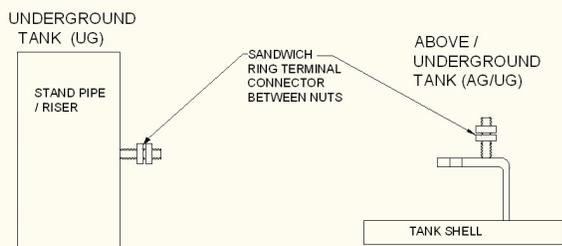
If another metallic material such as copper is used for service piping, the pipe should be electrically isolated from the tank at the fill pipe connection. Copper and steel create a galvanic couple that will accelerate corrosion of the steel tank when directly connected to copper piping. Generally, copper piping does not require cathodic protection.

ANODE INSTALLATION

1. Determine size and quantity of anodes from application chart.
2. When a single anode is installed, it should be located near the tank center on either side of tank.
3. When multiple anodes are installed, space them evenly around the tank. See examples below.
4. Anodes are shipped in either cardboard boxes or multi-wall paper sacks. Anodes may be left in their box or sack for direct burial in the excavation, but for faster anode activation, remove outer container and bury the cloth bagged anode. If anode is supplied in a plastic bag, remove plastic before installing.



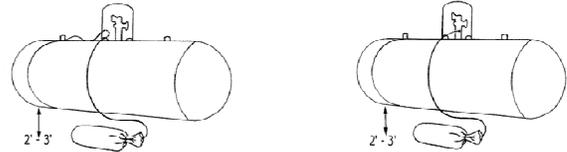
5. Install anodes approximately two to three feet from the tank and at least as deep as the centerline of the tank. Anodes work best in locations with permanent moisture, so generally the deeper the better.
6. After placing the anode, stretch out the anode connecting wire and extend over to the connection point provided on your Quality Steel tank, leaving slack in the wire so that it is not pulled apart when the excavation is backfilled.
7. Quality Steel underground tanks are provided with a threaded stud welded to the standpipe or riser and two threaded nuts. Leaving one nut on the stud, slip the ring terminal on the end(s) of the anode wire(s) on the stud. Put the second nut on the stud and tighten to sandwich the rings between the two nuts. Quality Steel aboveground/underground tanks are provided with the same connecting stud, welded to the dome bracket, and nuts for the same easy connection procedure. See the example below.



8. In all installations, make sure the ring connector is touching bare steel on the nuts so a proper connection can be made. This connection should then be coated with a moisture-proof material.

9. On Quality Steel tanks the anode connection is made inside the tank dome cover for a reason. This allows for easy access to the anode wire so subsequent testing can include measurement of anode output and verification of performance. Looping the anode wire through the dome will accomplish the same purpose.

10. Verify performance of the anode using an appropriate test procedure.



Welded Connection

Mechanical Connection

TESTING PROCEDURE

Measuring Tank-to-Soil Cathodic Protection Potentials On Propane Tanks

- Equipment:**
- Digital Voltmeter
 - Test leads
 - Reference Electrode (Copper/Copper Sulfate half cell)

STEP 1 Using a digital voltmeter select the 2 volt DC scale, Contact red test lead to the tank test point or an uncoated metallic area of the tank, preferably to the uncoated fill pipe. (Do not connect to shroud.) **Note:** If using a two-input analog meter, black lead will be connected to tank.

STEP 2 Contact the black test lead from the meter to a charged reference electrode. (see charging electrode below)

Note: If using a two-input analog meter, contact red lead to reference electrode.

STEP 3 Remove protective cap from porous plug at bottom end of electrode. Place porous plug end into native earth directly above buried tank. Moisten soil with water or dig plug into soil if difficulty is encountered obtaining a reading.

STEP 4 Observe meter reading and record at four locations along the top of the tank. Readings should be at least $-.850v$ or above. For other applicable criteria refer to NACE Standards RP0285-95 and RP0169-96, Corrosion Control of Underground Storage Tank Systems and Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

Note: It is recognized through NACE that all readings be recorded as negative.

Charging Reference Electrode:

STEP 1 Unscrew and remove porous plug end of new reference electrode. Add de-ionized or distilled water to the copper sulfate crystals, filling electrode completely. The solution will turn blue in color and there should always be excess crystals at the bottom of the tube. **DO NOT USE TAP WATER.**

STEP 2 Replace porous plug end of electrode and place in an upright position so that the porous plug end is facing in the down position and let stand for 15 minutes before use. This will allow the porous plug to become completely saturated before use.

Caution: Do not allow electrode to contact oil, road salts, or other substances that may contaminate the solution by absorption through porous plug. Do not allow electrode to freeze.