Anode Rods, Cathodic Protection and the Porcelain (glass) Lining

Corrosion can be defined as the destructive attack of a metal by an electrochemical reaction with its environment. Steel exposed to moisture and oxygen will rust and corrode. Corrosion is defined as the 'eating away' of metal by electrochemical means. There are four main factors affecting water's ability to corrode:

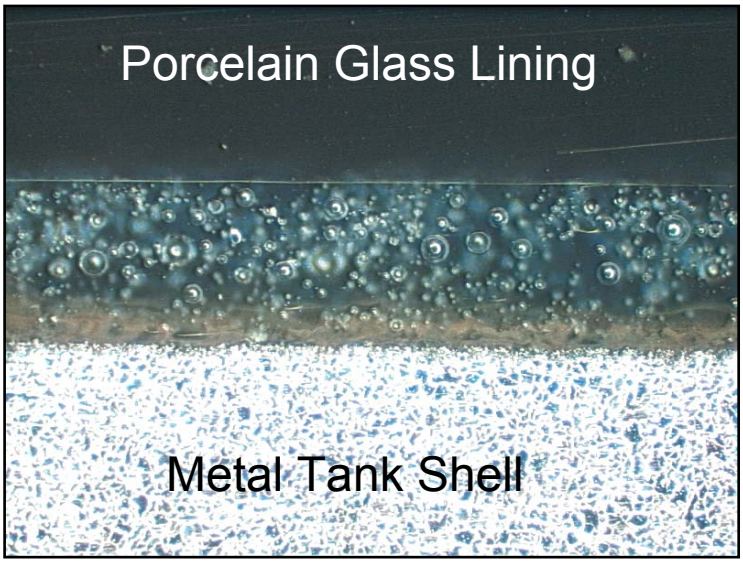
1. Acidity - Water is made acidic by naturally occurring dissolved gases such as carbon dioxide.
2. Temperature - Higher temperatures speeds up the corrosive process.
3. Amount of dissolved oxygen - Free oxygen dissolved in the water promotes corrosion.
4. Electrical conductivity - The more dissolved mineral solids in the water, the greater its ability to carry electrical current. When dissimilar metals are in the water:

   Electrical current flows between metals
   One of the metals gradually corrodes faster than the other

Dissimilar metals are present in the interior steel tank surfaces of all water heaters in several forms such as the drain nipples, heating elements, inlet and outlet nipples, and immersion thermostats. These metals, and others present in the water itself, combined with the oxygen content of the water and heat, establish an environment conducive to corrosion. The dissimilar metals create a corrosion cell that is enhanced by the conductivity of the water. The anode is installed to overcome (neutralize) the corrosive cell.

The Porcelain (glass) Lining

In a water heater, corrosion is protected by a glass (actually a porcelain enamel) lining in the steel tank, and the use of auxiliary anode rods. Porcelain enamel begins as a blend of minerals mixed in a manner to form liquid slurry. This slurry, resembling a thin mud, is sprayed onto the inner surfaces of the water heaters. During the manufacturing process, the inside water tank and both the top and bottom heads are sprayed with a slurry of glass material. After the tanks are sprayed, they are fired at very high temperatures - generally ranging from 1500 to 1600 degrees Fahrenheit. While in the furnace, the porcelain bonds with the metal to create more than a coating. It forms an inseparable compound merging the chemical makeup of the porcelain glass lining and metal resulting in a new, chemically unique, finish. This glass provides a long life to the steel tank; otherwise, the tank would fail or corrode in a relatively short time. Every glass lined water tank, no matter how carefully it is manufactured, has some bare metal exposed. This is due to the inability to effectively cover sharp corners and the radius around the fittings. There is a chance that a crack or chip in the porcelain lining will allow the water to come in contact with the steel tank. Over time, water, a universal solvent that becomes more aggressive with temperature, slowly dissolves the interior tank lining. This will create conditions for corrosion, pinholes in the tank and finally tank failure.



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Cathodic protection

(Partially sacrificed anode rod)

Cathodic protection is accomplished in the glass lined water heater by using an auxiliary magnesium anode. Due to the relative position of magnesium to steel in the electromotive series of metals, magnesium will corrode, producing an abundance of electrons which flow (much the same an electrical current) to the exposed steel surface and maintaining it in the electro-negative state. As current flow takes place, the anode rod reacts chemically to corrode at a rate faster than the steel inner tank. This process stops tank corrosion by substituting the sacrificial magnesium anode rod in place of the steel tank. As long as the magnesium anode rod remains in the tank, in an active state, there will be no corrosion of the minute areas of exposed steel inside the tank.

Anode Rods

The life of the anode, in turn, depends on water temperature, amount of water used, and the quality of the glass lining. However, the most important factor in the life of the anode rod is the water chemistry, the hardness or softness of the water. Water softeners contribute to the change in water chemistry. Indirectly, softened water acts to reduce the service life of the anode, since its current demand becomes drastically higher. Also, check the manufacture and installation date of the water heater. If the heater is more than five (5) years old, and the anode rod has not been replaced, inspect the anode rod. The anode should be replaced when there is six (6) inches or more exposed core wire at either end.

(Depleted anode rod)

From time to time, questions are raised as to the use of the R-tech, magnesium, and aluminum anode rods. Generally, these questions are raised in areas where some unusual water problems occur with resultant odors. For many years, the regular magnesium anode was and is the standard anode for use in water heaters tanks. In general, it is a very good anode; however, the performance is dependent on water chemistry. In waters where the conductivity is low, the anode operates at a very low current level. This means not much cathodic protection. Conversely, where the water conductivity is high, an excessive amount of current is produced with inefficient operation. This will sacrifice the anode sooner than predicted and require more frequent replacement.

In addition, some of these waters have excessive sulfate content along with various strains of sulfate reducing bacteria (see Document 1206). These bacteria, harmless to health, will grow in the presence of the highly active magnesium anode rod and using the hydrogen ion from the anode-cathode reaction, will produce hydrogen sulfide gas. The gas smells like rotten eggs. The greater the activity of the anode, the more hydrogen ions are produced – and the more hydrogen sulfide (smelly) gas. These bacteria can be killed with adequate additions of chlorine, such as with an automatic chlorine feeder.

Aluminum has often been used in these types of installations because of the lower activity level of the anode. This is brought about by the lower voltage potential of the anode. Due to these lower levels of activity, lower quantities of hydrogen ions are produced. This reduces or alleviates the odor producing potential of the sulfate reduction of the bacteria. While the problems are reduced with the aluminum anode rod, they are certainly not eliminated.

The R-tech anode rod was developed to operate in a broad range of waters without the sensitivity to the various water conditions. The anode, or a variation there of, has been used over 15 years in gas water heaters with minimal problems with odors. With the invention of the resistored electric heating element, Rheem now uses the R-tech anode rod in electric water heaters. In doing this, we are now able to efficiently utilize the R-tech anode in all

type of water conditions. Because the R-tech anode rod performance equals or exceeds the performance of the aluminum anode rod, we have eliminated the aluminum anode rod from our product line since 1993.

How to Replace the Anode Rod

CAUTION: Draining your water heater for this procedure may put you at risk of being scalded by hot water. Please be careful when working on your water heater.

1. Turn the power OFF to the water heater at the circuit breaker (electric heater) or main gas line (gas heater).

2. Fasten a length of garden hose to the drain valve at the bottom of the heater. Put the other end of the garden hose in the nearest floor drain or snake it outside the home.

3. Close the shut off valve at the cold water inlet line.

4. Open the temperature and pressure relief valve at the top of the heater. This will relieve pressure inside the tank. Now open the drain valve and allow about a gallon of the water to drain. You will probably notice some small white particles (called scale or sediment) during the early stages of the flow.

CAUTION: THE WATER WILL BE HOT.....BE SURE NO ONE IS NEAR THE DRAIN HOSE OR THEY COULD BE SCALDED.

5. After about a gallon of water, close the drain valve and remove the hose. Leave the temperature and pressure relief valve at the top of the heater open for the time being.

6. Remove the old anode rod with a 1 and 1/16 inch six-sided wrench or socket. Do NOT use a 12-point wrench or socket or you will strip the head of the anode. Get at least a 24-inch cheater bar. I keep a piece of 3/4 inch black iron pipe in the garage just for this purpose. Place the cheater pipe over the socket handle. Have someone hold the water heater while you slowly break the seal. Once broken, the anode removes quite easily.

7. Replace with a new anode rod. It is a 3/4-inch National Pipe Thread (NPT) part. You may find one at any plumbing house or home store. Use pipe sealer or Teflon tape to seal the threads. Snug it down tight. Remember the water heater builds up 150 PSI of pressure inside the tank.

7. Open a hot water faucet somewhere in the home. Open the shut off valve at the cold water inlet line. You will hear the heater start to fill.

8. When you have a steady stream of water from the temperature and pressure valve tube, close the valve; when you have a steady stream of water from the hot water faucet, turn the faucet off.

9. Turn the power ON to the water heater at the circuit breaker (electric heater) or main gas line (gas heater; relight pilot if required). Allow the water heater to recover. Check the anode rod one more time to make sure it is tight and there are no leaks.