CGA Standard Practice Series

California Groundwater Association
An NGWA Affiliate State
700 R Street
Suite 200 Sacramento, CA 95811
cga@groundh2o.org
916-231-2134

Article 510 - CORROSION PROTECTION

Adopted by the CGA Board of Directors on October 14, 2006

BACKGROUND

Water well casing, submersible pumps, and drop pipe can be subject to corrosion, often resulting in their premature failure. Where it exists corrosion may range from slight, to moderate, to severe. Although corrosion is possible in any water well environment, that potential can be increased by water quality, use of dissimilar metals, and chemical additives.

While it is important to minimize the effects of corrosion and increase the service life of groundwater well and pump equipment to the maximum extent possible, information has not been widely disseminated in the groundwater industry.

The purpose of this standard is to identify the factors that can contribute to corrosion, to suggest some mitigation measures that may be employed, and describe realistic expectations and limitations of those measures.

DISCUSSION

Corrosion describes the electrical and chemical degradation of metal components. In groundwater environments we may encounter both general corrosion, such as simple oxidation processes, and galvanic corrosion, sometimes erroneously called "electrolysis".

General corrosion is generally uniform in nature and often occurs in low pH water, either through natural dissolution such as rusting or as a result of oxidizing additives such as chlorine routinely used in disinfection procedures. In Stainless Steel products general corrosion results when there is an overall breakdown of the passive layer formed on the surface.

Galvanic corrosion occurs when two dissimilar metals are placed in close contact within an electrically conductive solution known as an electrolyte. A difference in electric potential exists between the two metals, with current flowing from the least noble or stable metal, which acts as an anode, to the more noble metal which acts as a cathode. Through this action, atoms are removed from the surface of the anode metal as positive charged ions

dissolve into the electrolyte, resulting in pitting.

Soil environments with differing salt concentrations, moisture content, oxygen content, or temperature can result in creation of a galvanic cell. Well casings that penetrate dissimilar soil layers can contain areas of both local anodes and cathodes. Under these situations a galvanic cell is created and well casing corrosion may occur, corrosion that can be increased if the well casing is connected to surface piping which will normally act as a cathode.

The potential for galvanic corrosion in wells is increased by the effects of electromagnetic frequencies and stray electrical currents from pump motors and drop cable; and by increasing the conductivity of the electrolyte, such as from chloride compounds.

Because galvanic corrosion involves the movement of electrons, its potential is measurable. For instance, in a water well environment, connecting a milliamp meter between the well and an anode allows a measurement of electron flow through the electrolyte and an indication of the direction of flow. This information can help determine the best type of corrosion protection.

General Considerations

The use of stainless steel has become widespread in groundwater components in recent years due to its superior corrosion resistance and the fact that it does not contain lead products. Stainless steel is often used to construct pump impellers and shaft components, for submersible pump discharge heads, and for blank casings and well screens.

Galvanized pipe is commonly used as drop pipe for submersible pumps, which results in a bimetallic coupling where the pipe and pump discharge head are joined. Likewise, because stainless steel is relatively expensive, to save costs mild steel casing is sometimes joined to 304 and 316 stainless steel well screen, again causing a bimetallic coupling. Cathodic action between the dissimilar metals has caused the mild steel to fail at or near the point of connection within a relatively short period of time.

Special Considerations

Although mild steel pipe and casing are generally the most susceptible to corrosion, any metal used in the groundwater industry can suffer from the processes of general or galvanic corrosion. Stainless Steel products, for example, while generally exhibiting superior corrosion resistance, rely on a very thin passive layer on the metal surface for this resistance. Stainless steel is available in different grades with various techniques used to apply the passive layer. Physical damage to the passive layer by scraping or abrasion can make the stainless steel more susceptible to corrosion. High concentrations of chloride compounds can completely destroy the passive layer, making the metal active and thereby enable or cause pitting of the material; and for this reason when used for disinfection purposes high concentrations of these chemicals should be applied with caution.

MITIGATION MEASURES

Limitations

Groundwater wells and pumping systems are constructed in complex environments with a wide range of water chemistry and soil types. While measures can be employed to minimize corrosion, complete control may be impossible to achieve. Corrosion engineers should be consulted by the owner of the well and pumping system when problems may be anticipated due to local conditions or when components are chronically failing. Specific cases and experiences will dictate what mitigation measures may be attempted.

Basic Means of Corrosion Control

The rate of corrosion is directly proportional to the current flow from the anode. Therefore anything that can be done to stop or reduce the current flow will reduce or stop the rate of corrosion. The fundamental methods of controlling corrosion are:

- Removing either the anode or cathode
- Coating the anode or cathode
- Eliminating the bimetallic coupling between dissimilar metals
- Reducing the relative size difference between the cathode and the anode
- Using heavy duty materials for the anode component, such as by increasing wall thickness of the anode relative to the cathode.
- Application of a counter protective current
- Use of a sacrificial anode
- Reducing fluid velocities

The simplest manner of minimizing the risks of corrosion in mild steel is to not use it at all. In spite of the relatively low structural strength of PVC pipe, during the past 20 years it has become popular for use as well casing in some areas because of its resistance to corrosion. PVC drop pipe is available to use for setting pumps in wells, even to significant depth. However, because of the weight and horsepower limitations of plastic pipe, or simply because of personal contractor or client preference, steel drop pipe is still used in many applications.

Eliminating the use of dissimilar metals will minimize corrosion. When that is not possible, electrically insulating two dissimilar metals from one another will reduce the rate of corrosion. At points of connection of dissimilar metals, including pipe to stainless steel pump discharge and pipe to brass check valve, coating the pipe by wrapping it with tape approximately 12 inches on all sides of the connection has proven to be effective in reducing or eliminating galvanic corrosion. When wrapping is employed it should also be done beneath stainless clamps commonly used to attach torque arrestors to metal drop pipe. Taping material used should comply with any applicable state and local standards.

Insulating two dissimilar metals can also be accomplished by the use of dielectric materials between the points of connection of dissimilar metals or by coating. Covering the anode, for example coating the inside and outside of the pump column with Epoxy when possible, will reduce contact with the electrolyte and effectively remove one of the components of galvanic corrosion. Coating the cathode component of groundwater equipment will effectively reduce its area and therefore the rate of corrosion of the anode.

Cathodic protection can be provided for groundwater equipment and components. For materials installed underground, the cathodic protection can be accomplished by supplying electrons to the metallic components of the system to be protected. As previously discussed, if current flows from the metal casing of a well to a more noble metal or to cathodic areas of the surrounding soil, then corrosion of the casing will be accelerated. Conversely, imposing a dc electrical current flow towards a metal casing from an anode in the surrounding groundwater or soil surrounding the casing will retard the rate of metal dissolution.

Cathodic protection can also be accomplished by use of a sacrificial anode. For example a zinc bar strapped to or near a pump bowl assembly, being less noble than the pump unit, will give up electrons to the electrolyte more easily, leaving the more valuable pump components protected. Anode packs, consisting of 25 to 50 pounds of magnesium, one of the least noble metals, can be buried below ground level and connected by copper wire to the casing or even through the casing to the pump column.

Because an electrolyte is a necessary component of corrosion as well as cathodic protection, to be effective the cathodic protection anode would need to be connected at a point below the pumping water level.

The passive layers on metal surfaces, primarily on stainless steel products but also including galvanized and paint coatings on carbon steel, are critical to reducing corrosion rates. High entrance and flow velocities can damage the passive film and should be kept to a minimum.

RECOMMENDATIONS

1. Corrosion engineers should be consulted by the owner when local conditions or past experience suggest potential problems

2. When steel casings are used for new well construction they should be of either all stainless steel or all carbon steel. If stainless and carbon must be joined for cost or structural reasons a dielectric coupling, insulating coupling, or extra heavy carbon steel should be used at the points of connection.

3. When Stainless Steel well casing is used, the exteriors of carbon steel bowl, pump column, and shaft enclosing oil tube should be coated with epoxy. Sacrificial anodes placed on or near the pump bowl should be considered wherever possible.

4. When Stainless Steel well casing is used, water lubricated shafting should be at least 416 Stainless Steel.

5. PVC well casing and pump column may be employed where severely corrosive conditions exist. Manufacturer's recommendations for product use should be followed.

6. Where corrosive conditions are known or suspected, carbon steel pump and pipe components may be insulated by coating or wrapping.

7. Cathodic protection devices may be employed, including imposed DC electrical current and sacrificial anodes. A corrosion engineer should be consulted by the owner.

To promote formation of passive film and reduce damage to it, well screen entrance velocities should be kept at about 0.1 feet per second for carbon steel screens and about 0.4 feet per second for 300 series stainless steel screens.

* * * *

Adopted by the CGA Board of Directors on October 14, 2006