European Sealing Association e.V.

How do I prevent galvanic corrosion in my packing gland?

By ESA member Maja Rotar

Galvanic corrosion is an electrochemical process that occurs between two dissimilar metals, or between a metal and a conductive non-metallic material, when both are exposed to an electrically conductive medium. In the case of a packing gland, it occurs between a metal component and the carbon or graphite packing. Under these conditions, the material that is closest to the anodic end of the galvanic scale will be corroded in preference to the one that is closest to the cathodic end of the scale (See Table 1). As the distance between materials on the galvanic scale increases, a corresponding rise occurs in the rate and the extent of the corrosion.

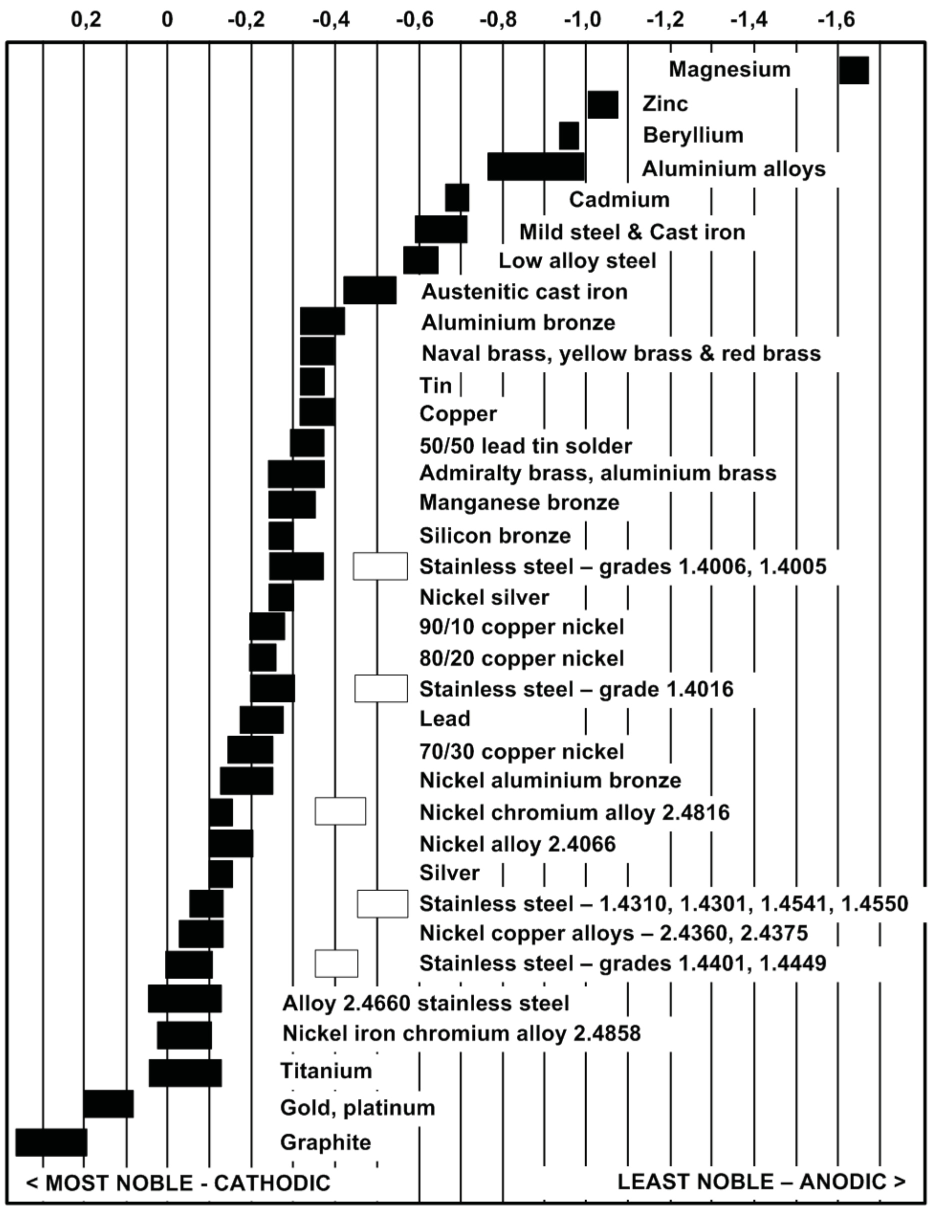

Table 1 Galvanic series.

In a valve or a pump using packings made of either graphite or carbon, a galvanic reaction may be initiated as soon as any electrically conductive fluid, such as water, is introduced. Since graphite is more cathodic than the metals that make up valves and pumps, it is the metal that may be subject to the corrosive attack.

Liquid phase needed

The fact that a valve or pump is packed with a graphite or carbon packing does not mean that galvanic corrosion of metallic parts is inevitable, because an electrically conductive fluid in a liquid state must also be present for the galvanic reaction to take place. For example the high temperature of a superheated steam valve prevents the accumulation of any significant amount of water, thereby nullifying the possibility of galvanic corrosion.

Stainless Steels

Another example of when galvanic corrosion protection may not be necessary is when the equipment is constructed of austenitic stainless steels (e.g. 1.4567, 1.4301, 1.4541, 1.4550, 1.4401 and 1.4449). These stainless steels are much more resistant to galvanic attack. On the other hand, the martensitic stainless steels (e.g. 1.4005, 1.4006 and 1.4016) are highly susceptible to galvanic attack. If a valve or pump is constructed of martensitic stainless steel and if it is going to be exposed to an electrically conductive fluid for any period of time, then consideration should be given to incorporating a galvanic corrosion inhibitor system into the carbon or graphite packing sets used to seal it.

When Are Corrosion Inhibitors Needed?

The following are several examples in which corrosion inhibitors would be

Typical pitting corrosion of a valve stem.

recommended to prevent corrosion in equipment made of less resistant alloys such as martensitic stainless steel:

- Valves and pumps that are hydrostatically tested and then stored in a wet condition
- Steam service valves that will undergo cold downtime periods because, depending upon the valve's position within the piping system, some may be exposed to water or condensate during the cold exposure period
- Equipment that is located in an outdoor environment in which rain water can collect in the top of the stuffing box between the gland follower and the stem
- Valves, such as fire mains, that are under constant water exposure due to their intended service conditions

Corrosion Inhibitors

Two galvanic corrosion inhibitor systems are commonly available for use in compression packings. Whilst they have the common goal of nullifying the effects of galvanic corrosion, they are based upon two different protection mechanisms.

Active Inhibitor

Active or "sacrificial" inhibitor systems are based on the principle that the galvanic reaction will preferentially attack the material that is most anodic. As long as this most anodic material remains in contact with the conductive fluid, it will be attacked and corroded in preference to the other metals or materials present in the stuffing box. The active inhibitor systems therefore incorporate a metal of a more anodic nature than that of the material used in the construction of the valve as part of the packing set.

The most common active inhibitor system used today is zinc powder. Being located near the extreme anodic end of the galvanic scale, zinc is more anodic than the metals that are commonly used in valves and pumps.

A zinc powder coating can be easily applied to the surface of many different types of compression packing products including die-formed flexible graphite rings and nearly any type of braided carbon or graphite packing. When zinc powder is applied to the surface of a packing material, it appears as a light grey coating. Care should be exercised in the case of equipment that may see service temperatures that exceed the 419°C melting point of zinc. At temperatures above its melting point, zinc may contribute to the liquid metal embrittlement of the base metal.

Passive Inhibitor

Passive corrosion inhibitor systems protect the metal surfaces of equipment by forming a barrier film on the more anodic metal component. The graphite packing and the metal surfaces must be exposed to each other through an electrolytic fluid medium for a galvanic corrosion reaction to occur. The passive inhibitor creates a continuous thin barrier film through which the galvanic reaction cannot occur.

Several manufacturers make grades of flexible graphite that incorporate phosphorus as a passive corrosion inhibitor. These inhibited materials can be used in many forms for both compression packing and gasketing products. The phosphorus is dispersed throughout the material during processing of the flexible graphite sheet from which the packing is fabricated, not just on the surface of the packing.

Phosphorus based corrosion inhibitors can be used for applications in which zinc is precluded, such as high temperature services above its melting point or cases where zinc is not compatible with the process fluid.

Advantages and Disadvantages

While the presence of zinc powder inhibitor can be confirmed visually, uniform dispersion can be a challenge. Unlike the grey surface of zinc powder inhibited packing materials, phosphorus is not visible. This is both a benefit and a disadvantage. Handling zinc coated packing rings will sometimes leave the installer with a residue on his hands, but the visibility of the zinc readily identifies that the protection system is in place. The invisibility of the passive phosphorus protection systems on packing rings is definitely cleaner from a handling standpoint, but the only way to tell if the phosphorus is in place is through chemical analysis.

Another benefit of using phosphorus is that it not only acts as a corrosion inhibitor but it also inhibits oxidation, increasing the material's ability to withstand very high temperatures without losing significant mass by oxidation.

Corrosion Testing

The importance of a packing's ability to resist causing corrosion to valve stems and its impact on fugitive emission performance is recognised by a variety of test methods. Two of the most useful and relatively easy tests are detailed in API Standard 622 (Second Edition October 2011) – 'Type Testing of Process Valve Packing for Fugitive Emissions'. This standard specifies both ambient temperature and high temperature tests and provides a means for evaluating the effect of inhibitor systems / valve stem metallurgy combinations with respect to corrosion rate and weight loss.

Conclusion

By understanding the conditions under which galvanic corrosion can occur and by using readily available compression packing products with appropriate corrosion protection, galvanic corrosion is a problem that can be eliminated from your packing gland.

"The European Sealing Association (ESA) has produced this article as a guide towards Best Available Techniques for sealing systems and devices. These articles are published on a regular basis, as part of their commitment to users, contractors and OEM's, to help to find the best solutions for sealing challenges and to achieve maximum, safe performance during the lifetime of the seal. The ESA is the voice of the fluid sealing industry in Europe, collaborating closely with the Fluid Sealing Association (FSA) of the USA. This article is derived in part from an original FSA paper which first appeared as a Sealing Sense article in Pumps and Systems magazine. We are very grateful to our colleagues in the FSA for their assistance. For more information, please visit www.europeansealing.com"