

# Tank Talk<sup>®</sup>

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## OSHA to Change Confined Space Regs

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Currently for confined space entry applications, most employers follow the OSHA requirements found in the General Industry Standards, 29 CFR 1910.146 (“Permit Required Confined Spaces”). However, OSHA is in the process of adding a confined space standard for the construction industry. The standard was originally proposed in the Federal Register on November 28, 2007. Hearings and regulatory reviews have been conducted on the standard, and OSHA has deemed

in its Semiannual Regulatory Agenda for Fall 2013 that the regulation is in the “Final Rule Stage.”

Currently, General Industry



standards divide confined spaces into two groups, “Nonpermit Required” and “Permit Required.” However, for work applications meeting the new Construction Standards, they will be divided into four categories,

“Permit Required Confined Spaces,” “Continuous System Permit Required Confined Spaces,” “Controlled-Atmosphere Confined Spaces,” and “Isolated Hazard Confined Spaces.” The latter being the most similar to the current “Nonpermit Required” space and the other three being divisions of what are now considered “Permit Required” spaces.

Definitions of the four new categories follow on page 4.

## AWWA to Revive Tank Inspection Standard

The AWWA D101 standard, “Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage” was last revised in 1953. The standard was reaffirmed

without revision in 1986, and withdrawn by AWWA in December of 1998. In 2013, the AWWA Standards Council authorized the formation of a Revision Task Force to completely re-write D101. **Chip Stein,**

**TIC’s Managing Principal,** chairs the **D101 Revision Task Force** that is in the process of revising the standard.

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# Corrosion Protection for Water Storage Tanks

by: Chip Stein, P.E., Managing Principal



Coatings applied to the water storage tanks provide a protective barrier between the steel and the moisture in the atmosphere.

This article will explain the corrosion process and methods for mitigating the damaging effects of corrosion on steel water storage tanks.

Each year, infrastructure corrosion has significant impact on the US economy, both its prevention as well as its remediation. What most people don't know is that corrosion is a naturally occurring process. But unlike other naturally occurring destructive forces such as floods and hurricanes, corrosion is controllable.

## Corrosion Theory

Metals found in their neutral state, prior to being excavated or removed from the ground, do not corrode. They exist in nature in a state of chemical and electrical equilibrium. When these metals are mined or harvested from the ground, they will often times have energy added to them due to purification, heating, shaping and forming processes. These processes that are necessary to turn the ore into a usable piece of metal result in potential energy in the metal, which will gradually release over time through a process we call corrosion if left unchecked. In fact, the more processing energy required to turn an ore into a usable piece of metal, the more potential energy that metal has, and the quicker that metal is going to want to corrode. Shapes that require more energy to form (i.e., nuts and bolts) than other shapes (i.e., plate) made of the same grade of metal will corrode more quickly in the same environment due to the increase of potential energy that shape has as a result of the energy required in forming it.

Some metals come out of the ground relatively "pure," and require less processing energy to turn them into usable materials. These metals have a slower corrosion tendency and are considered cathodic relative to anodic materials, which are those that are not as "pure" and require more processing energy. Most materials science reference books will provide Galvanic or Electromotive listings of materials based upon their corrosion rates.

There are four essential elements of the corrosion process: an

anode, a cathode, a metallic pathway, and an electrolyte. If any one of these elements is missing, corrosion may be prevented. Conversely, corrosion may be accelerated the further apart the anode and the cathode are on the Electromotive Table. It naturally follows, then, that the way to prevent corrosion is to eliminate one or more of the elements required for corrosion to take place.

**Anode** – The anode in a corrosion cell is the metal that corrodes. The anode releases electronic ions into the electrolyte and will lose its material properties.

**Cathode** – The cathode is the non-corroding metal. Ions in the cathodic material do not release into the electrolyte.

**Electrolyte** – The electrolyte is the solution that is capable of transmitting electricity.

**Metallic Pathway** – The metallic pathway, sometimes referred to as the "closure path" or "return current path" is the metal that connects the anode and the cathode.

Not all corrosion is bad or undesired. For example, dry cell batteries are an example of an intended corrosion cell. As corrosion occurs and electrons flow from the anode to the cathode, the potential energy released is captured as voltage.

## Types of Corrosion and Metal Loss

Corrosion is a reduction of material properties in an anode which results in metal loss. Metal loss is typically found in three forms on a steel water storage tank: uniform or general metal loss, spot pitting, or vertical groove pitting.

**Uniform metal loss** is caused by impurities located within microscopic grain boundaries located within the cross-section of a steel piece. If exposed to an electrolyte such as water, one area of the steel will be anodic relative to another, and metal loss will occur.

As the steel corrodes another grain boundary is encountered, which then may be cathodic relative to the surrounding steel, which results in metal loss surrounding the cathodic grain. Due to the many impurities and grain boundaries located throughout the thickness of the steel piece, the resulting metal loss will appear uniform or consistent over the entire exposed surface area.

Typically this type of metal loss is not of immediate structural concern, and is generally discovered through the use of an ultrasonic steel thickness gauge.

**Spot pitting** is another common result of the corrosion process on a steel water storage tank. Spot pitting is usually the result of a holiday, or small exposed surface of steel, in a coating system. Pit depth measurements can be measured with a variety of different types of gauges, and commonly are not of significant structural concern to the integrity of the tank.

**Vertical groove pitting** is a less common form of the metal loss as a result of corrosion on the interior surfaces of a steel water storage tank below the high water level. Vertical groove pitting is a result of pits becoming aligned vertically. Groove pitting is almost always of significant structural concern to the water tank as it impacts the tangential stresses (or hoop stresses) of the cylinder, which is the limiting design stress of a tank. When evidence of vertical groove pitting is found, the tank owner should have a structural integrity evaluation performed on the tank.

## How to Prevent Corrosion with Coatings

The primary prevention of corrosion in a steel water storage tank focuses on isolating the anode (steel structure) from the electrolyte (water) by the use of a coating or lining. Additional preventative steps can be taken on the interior steel surfaces through the use of a cathodic protection system.



Cathodic protection, if used and maintained properly, can protect surfaces below the water level from corrosion and metal loss.

Coatings and linings are the best first-line of defense in protecting steel from corroding as they economically isolate the water from the underlying steel. Remembering the four required elements of corrosion, essentially removing the electrolyte from the corrosion cell by applying a barrier coating will prevent corrosion from occurring. The steel tank itself acts as the metallic pathway. Although it should be discouraged and avoided, sometimes dissimilar metals are used during the water tank fabrication process which results in anodes and cathodes being present. However, even if one grade of steel is used to erect a tank, there are impurities in that steel that will be either anodic or cathodic to the rest of the steel. Therefore, isolating the water from contact with the steel is the best and most economical way to prevent corrosion from occurring on the interior and exterior surfaces of a steel water storage tank.

AWWA D102 is the industry reference standard for acceptable coatings that can be applied to the exterior and interior surfaces of a water storage tank. Coating and lining systems to be applied to the interior surfaces are selected primarily for their permeability ratings as their primary function is to provide a barrier between the steel and electrolyte. Other interior coating selection factors should include chemical resistance, abrasion resistance and wetting/flow ability. If the tank stores potable water, the coating must also be NSF 61 approved. The most common types of coatings used on the interior of tanks include two-component polyamide epoxies as well as 100% solids coatings such as polyureas.

The exterior coating system's primary function is to provide a barrier between water and the underlying steel as well. However, other important factors such as aesthetics (color and gloss retention), and ultraviolet degradation, must be considered as well.

Interior and exterior systems are typically either 2 or 3 coat systems, consisting of a prime coat, possible intermediate coat, and a finish coat. Whether it is an exterior or interior system, the main objective of the prime coat is to tightly adhere to the steel substrate and provide a suitable surface to be topcoated. Prime coats can be formulated to provide a measure of galvanic protection to the underlying steel as well by the use of an anodic metallic dust, such as zinc, resident in the coating. If an intermediate coating is specified, its primary objective is to add an additional permeability barrier to the system as well as to provide a suitable surface for the finish coat to adhere to. Finish coatings on the interior surfaces of water storage tanks are selected for the permeability, chemical and abrasion resistance. Exterior finish coats are selected for their ability to protect the underlying coatings from ultraviolet degradation as

well as the tank owner's aesthetic objectives.

Once properly selected, the most relevant contributing factor to the success of a coating system and its ability to achieve its intended service life lies in the surface preparation and application of the coating. Proper surface preparation includes achieving the necessary steel cleanliness and profile as required on the product data sheet of the coating manufacturer. Similarly, the coatings need be applied in strict accordance with the coating manufacturer's published product data sheet. Attention to detail, such as coating mixing, induction times, pot life, proper use of thinners, gun tip size, brush and roller nap size, and most importantly a high level of quality workmanship is critical to a successful coating application.

The use of a "stripe coat" is generally accepted industry practice in the coating of welded steel water storage tanks. A stripe coat is accomplished by applying a thinned prime coat along the weld seams (or other irregularly contoured surfaces) by brush or roller after the tank surface has been primed. This additional application of a thinned prime coat allows the coating to wet and flow more readily into the crevices, nooks and crannies of rough-contoured steel surfaces.

Finally, a critical component to a successful interior coating application on a water storage tank is adequate ventilation. Many coatings contain a solvent vehicle component that must release from the wet coating film in order for the coating to properly cure. If the air inside the tank is saturated with solvent, there is no place for the coating's solvent to release to. Therefore, the air inside a water tank must be constantly moved and replaced, or exchanged, with fresh "solvent-free" air to allow the volatile organic compounds present in the coatings to escape from the coating to cure.

#### **How to Prevent Corrosion with Cathodic Protection**

Interior steel surfaces of a water storage tank may be protected from corrosion through the use of a cathodic protection system. There are two common forms of cathodic protection systems used in water storage tanks: galvanic/sacrificial systems, or impressed current systems. It is important to know that only the steel below the water level can be protected with a cathodic protection system as the water must serve as an electrolyte through which the electrons can flow. Secondly, only steel which is exposed to the water will be protected.

Typically, cathodic protection systems are used in concert with an interior coating system to protect the steel once the coatings start to

break down and holidays or voids in the coating occur and the underlying steel is exposed. A galvanic cathodic protection system prevents corrosion from occurring inside a water storage tank by introducing a material into the tank that is anodic relative to the grade of steel used in the construction of the tank. The anode strings placed in the tank will sacrifice their material properties and allow the steel tank to react in a cathodic manner. There is no external power source required in a galvanic cathodic protection system as the energy required is inherent in the dissimilar and anodic material being used. However, since this is a sacrificial system the anodes will deteriorate and require replacement on a regular basis.

An impressed current system is a newer technology system that was developed to offset the maintenance burden of anode replacement of the galvanic system. An impressed current system anchors a metallic wire below the high water line. This metallic wire is typically made of a material that has a long service life (typically 30 years or more) and is cathodic relative to the anodic steel water tank. In other words, the steel tank is anodic and has more residual potential energy relative to the wire. However, electrical current provided by an external power source is run through the wire and the introduction of this energy reverses the flow of electrons back to the steel tank. The cathodic protection system is equipped with reference electrodes located in the tank, which continually monitor the current flow in the tank and communicate to a electrical potential rectifier. This potential rectifier, located on the tank exterior at ground level, can be either equipped with manual controls, or automatically controlled electrical rectifier, so that the current sent to the interior wire is just enough for the flow of electrons to reach a state of equilibrium, thus effectively preventing corrosion.

If an impressed current system is installed in a water storage tank when the tank is repainted, it is recommended not to energize the system until after the AWWA D102 recommended First Anniversary Evaluation has been conducted.

#### **CONCLUSION**

Quality coating design and application, in conjunction with cathodic protection, can — and does — protect water storage tanks from destructive and costly corrosion and prolong the service life of the coatings applied.

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## OSHA'S NEW CONFINED SPACE CATEGORIES

**Continuous System Permit Required Confined Space:**

- All of the following:
- Is part of, and contiguous with, a larger Confined Space, such as sewers
  - Cannot be isolated from larger confined space
  - Potential hazard release from large confined space that would overwhelm PPE and/or other hazard controls resulting in IDLH

**Permit Required Confined Space:**

- One of the following:
- Hazardous atmosphere
  - Inwardly converging, sloping, or tapering surfaces that could trap or asphyxiate an employee
  - Engulfment or other physical hazard

**Controlled-Atmosphere Confined Space:**

- All of the following:
- Contains no physical hazards or only isolated physical hazards
  - Uses ventilation alone to control atmospheric hazards to safe levels

**Isolated Hazard Confined Space:**

- Employer has isolated all physical and atmospheric hazards with the conditions of "isolation" being further defined within the standard.

## D101 Tank Inspection Standard

*Continued from page 1*

The new standard D101, "Inspection of Water Tanks and Related Facilities" is currently under development by the Revision Task Force. When published, the new standard will include several changes from the previous version. The standard will potentially address a number of types of water-related structures, not just steel water tanks. As envisioned, the standard will also include requirements and guidelines for inspection of new tank construction and tank rehabilitation, inspection of existing structures, and qualifications of engineers and inspectors.