



Improve System Integrity through Corrosion Prevention Training

The cost of corrosion to a plant's operations could be immense. Visible spots of rust and unseen stress cracks in a plant's miles of stainless steel tubing could easily lead to a safety issue or costly downtime.

According to the National Association of Corrosion Engineers (NACE), corrosion costs the combined oil and gas exploration and production; petroleum refining; and chemical, petrochemical, and pharmaceutical industries more than US \$6.8 billion annually.¹ Fortunately, some corrosion damage can be prevented with the right measures.

Addressing stainless steel tubing systems is a good place to start, as corrosion prevention can make a major difference here. Tubing systems are used everywhere throughout a plant, serving a variety of critical functions. An escape of fluid or chemicals from tubing due to corrosion can create an unsafe work environment, including the potential for a system failure.

So how do you minimize your risk of tubing corrosion when nearly every metal will corrode under certain conditions? Start by training your team on corrosion basics to understand what it looks like, where it occurs, and for what reasons. By doing this, they'll know where to look for hidden corrosion and can visually identify it before it becomes a larger issue. In addition, train your team on the basics of materials selection and system design. They can then anticipate corrosion and make the best choices for your operations.

Knowledge: The First Step in Controlling Corrosion

Corrosion can often be controlled when a team understands:



Corrosion: Know what it looks like, where it occurs, and for what reasons.



Design Principles: Minimize locations where crevice corrosion can occur and minimize the contact of noncompatible metals.



Materials Selection: Learn how to specify everything from the supports and clamps to the tubing itself to reduce corrosion in the first place.

Understanding the Types of Corrosion

Before your team can take steps to prevent stainless steel tubing corrosion, it helps to understand the common types. Primarily, two forms of localized corrosion affect stainless steel tubing.

- **Pitting Corrosion:**

Pitting corrosion causes small cavities – pits – to form in the surface of a material. It occurs when the protective layer (chromium-rich oxide in stainless steel) of a metal breaks down, allowing the exposed metal to give up its electrons easily, resulting in corrosion. As the pits grow deeper, they can penetrate the tube entirely. Pits can also initiate cracks in stressed components of a system.



- **Crevice Corrosion:** Similarly, crevice corrosion results from the breakdown of the protective film and begins as shallow pits. Rather than occurring in plain sight, crevice corrosion happens in localized areas (pockets, corners, under tubing supports and brackets, etc.) in stainless steel tubing. This is troublesome, particularly in very tight crevices. The shallow pitting that initially occurs can rapidly accelerate because corrosion-causing ions cannot readily diffuse out of the crevice. Therefore, the entire surface within the crevice can corrode at a very fast pace.





In addition, several other types of corrosion can create problems, including:

- **Galvanic Corrosion** occurs when two dissimilar metals come into contact with each other in the presence of an electrolyte. Not only galvanic corrosion, but all forms of corrosion are based on an electrochemical reaction. The compatibility of metals can be determined via the anodic index, which states the voltage measured between a metal and a standard electrode. To avoid galvanic corrosion of the less noble metal of a pair of metals, select the metals so the potential difference between them is no more than 0.2 Volts.
- **Stress Corrosion Cracking** is not a form of corrosion in itself. Rather, it's a combination of corrosion and tensile stress that results in the brittle fracture of a metal. This tensile stress can rupture the protective oxide layer in stainless steel, exposing fresh metal. Pitting/crevice corrosion then follows, and in combination with the stress, cracks can initiate and propagate through the metal.
- **Sulfide Stress Cracking (SSC)**, or sour gas corrosion, is common in oil and gas production when seawater has been injected for enhanced oil recovery, in sour gas applications, and in sulfur compound-rich environments. SSC occurs as the metal deteriorates due to contact with hydrogen sulfide (H_2S) and moisture. H_2S becomes severely corrosive in the presence of water, which can embrittle the material, resulting in cracking under the combined action of tensile stress and corrosion.



- **Intergranular Corrosion (IGC)** is common in welding operations, heat treatments, and high-temperature applications. IGC attacks a component or product along the grain boundaries of the metal. Exposure to heat enables chromium carbides to nucleate and grow on these boundaries. Corrosive fluids can attack the chromium-depleted zones next to the grain boundaries, creating intergranular cracks that propagate throughout a sensitized metal.

Teaching the Basics

A best-in-class approach for minimizing the risk of corrosion of tubing systems involves in-depth training. Classroom learning and hands-on experience in the following areas can be invaluable for operators and technicians.

- **Design Principles:** Understanding sound design principles can help minimize potential areas for crevice corrosion and minimize the contact of noncompatible metals susceptible to galvanic corrosion.
- **Materials Selection:** Training your team on the choice of materials for tubing applications – from supports and clamps to the tubing itself – can help them build a deeper understanding of which corrosion-resistant alloys will perform better in harsher environments.

Learning more about the principles of corrosion can help your engineers, operators, and technicians prevent a wide array of corrosion-related problems that could result in a safety risk – and potentially save your facility time and money.

To learn more about corrosion training opportunities, contact your local [Swagelok sales and service center](#) or sign up for a [Swagelok materials science training course](#).

¹Corrosion Costs and Preventive Strategies in the United States, Report FHWA-RD-01-156. Springfield, VA: National Association of Corrosion Engineers (NACE), 2002.