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The Promises and Perils of Reactive Metals

The reactive metals titanium and zirconium are some of the most corrosion-resistant materials of construction, making them attractive options for severe-service applications. Reactive metals have a high affinity for oxygen and other interstitial elements at elevated temperature, which enables the formation of a corrosion-resistant oxide barrier that resists many different types of severe environments. They have been used in the chemical process industries (CPI) for more than a half a century — specified by engineers for use in heat exchangers, reactor vessels, columns, piping systems, pumps, valves, and other equipment in severe chemical environments to extend equipment life and reduce maintenance and downtime.

Despite the impression that titanium and zirconium alloys are invincible, they do age and are particularly vulnerable to corrosive attack in certain operating conditions. They can prematurely fail without proper maintenance and monitoring.

Depending on the severity of the environment and the time in service, reactive-metal components may be susceptible to general corrosion attack, weld attack, erosion, or hydriding (*i.e.,* hydrogen pickup) that often require *in situ* repair and/or replacement.

Knowing the limitations of metals and alloys is critical, according to Rick Sutherlin, who will give a presentation on reactive metals monitoring at the Managing Aging Plants (MAP USA) Conference in Houston, TX, Nov. 9–10. “You can’t just place these alloys in applications and think, ‘We can put them in there and leave them alone,’” Sutherlin warns. “They’re not invincible! They will take a lot of abuse, but they are not totally resistant to all forms of attack in every application and condition. This is one of the problems I have seen in scenarios of past equipment failures,” he explains.

Reactive metals may perform differently in different applications. For example, Grade 2 commercially pure (CP) titanium might work well in one application and deteriorate in another; chloride-media environments at temperatures above 80°C can cause crevice corrosion and localized corrosion attack. “You have to know the alloys,” says Sutherlin. “These materials are good, but they’re not good at everything. You may have to use a different alloy in a family of alloys that performs better in a particular environment.”

Procedures specific to the materials of construction are used to determine whether process equipment is degrading. Procedures for titanium and zirconium can differ from those used with other more-common materials. Degradation-monitoring procedures for pressure vessels or other equipment include visual, ultrasonic, and/or dye-penetrant examination, as well as positive material identification (PMI) using X-ray fluorescence or optical emission spectrometry. Knowledge of the degradation mechanisms of reactive metals employed is also useful in diagnosing potential problems.

Another challenge is proper maintenance of equipment. “Some people think that since these metals are indestructible, they don’t have to clean the equipment,” laments Sutherlin. “You still have to clean the equipment, especially heat exchangers, where fouling and plugging can occur,” he continues. “In heat exchangers, in a nitric acid environment for example, zirconium should be invincible,” he says. “But if it is fouled or the tubes become plugged, the equipment has no way to transfer heat, and you are going to experience corrosion, shorter equipment life, and potential equipment failure.”

Monitoring titanium or zirconium equipment is critical. Sutherlin explains, “Reactive metals work very well with very little repair and maintenance, but you have to treat them right. The key is to understand how to monitor and take care of heat exchangers, vessels, and other aging equipment composed of reactive metals.” According to Sutherlin, plant operators need to work with an inspector or consultant who is knowledgeable about the equipment and alloy and can help identify potential problems. If a vessel fails, Sutherlin warns, “It’s an environmental issue, it’s a production issue, and it’s a safety issue!”

Yet, critical equipment still breaks down. “It’s surprising because the plants rely on this equipment to function and make product, but some people don’t know enough about the materials,” says Sutherlin. Without the proper knowledge of the material and possible failure mechanisms, managers of plants often hire inspection companies, but these experts do not always fully understand the alloy employed either, and misdiagnose the problem. Misdiagnoses often result in improper repairs that cause additional problems.

Sutherlin recommends learning as much as you can about reactive metals before planning a project or major maintenance. He emphasizes the importance of hiring fabricators and inspectors that have worked with reactive metals and possibly consulting resources to help support the project. He concludes, “If you build it correctly, specify the right alloy, and maintain the equipment, it can last for many, many years. Reactive metals work very well with very little maintenance, but you have got to treat them right!” CEP

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