Engineering Consulting & Training Services

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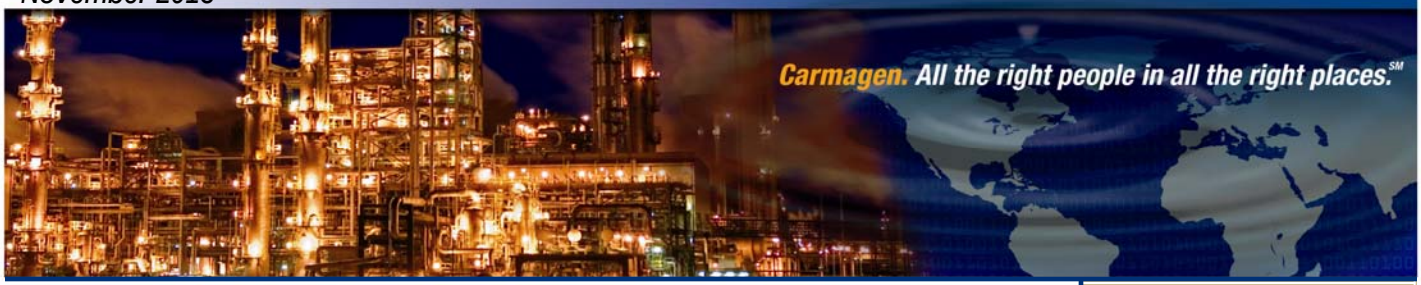

Galvanizing Isn't Always a Good Way to Stop Corrosion

By Michael J. Humphries, Ph.D.

Galvanizing is widely used as a way to prevent corrosion of structural steel, and for piping used in water service. A layer of zinc is applied to the surface of the steel, usually by dipping the component into a bath of molten zinc. Zinc is anodic to steel and, at any exposed areas of the steel, it provides sacrificial cathodic protection when the steel is exposed to aqueous corrosion. It is this galvanic protection at breaks in the coating that makes galvanizing such a useful and widely-used corrosion control measure. The driving force providing the protection is the difference in electrochemical potential between the steel and the zinc layer. At ambient temperature, this is about 300 Mv.

However, the potential difference between zinc and steel is strongly temperature dependent and above about 160°F the difference is reversed, with steel becoming the anode in the couple. This has a disastrous effect at breaks in the zinc layer because the small exposed areas of steel are anodic to the large zinc cathode. Even though the zinc layer may be rapidly consumed, the steel continues to pit rapidly when the zinc is gone. As an example, galvanized pipe used to carry hot water (180°F) developed leaks after a short service life, typical of failures that have been common in domestic water piping in recent years due to an increase in the temperature of the hot water system.

As another example, use of galvanized tubing in heat exchangers and zinc anodes in close proximity to steel exchanger tubes in a worm cooler immersed in hot water have led to premature failures. When the component will be exposed in water above about 120°F, galvanizing should not be used.

A quite different form of damage that can be caused by galvanizing is liquid metal embrittlement, particularly of austenitic stainless steels. Though galvanizing is not applied to stainless steels, there have been incidents where, during a fire, zinc from galvanized materials has dripped onto stainless steel piping, causing embrittlement by penetrating the grain boundaries of the alloy. This type of attack occurred during a fire at Flixboro in the UK in 1977, contributing to a serious incident. It is good practice to avoid the use of galvanized components in close proximity to austenitic stainless steel. Zinc can also embrittle carbon steel during welding and the galvanized layer must be completely removed from any area of steel that is to be welded.

About the Author

Mike Humphries has over 40 years experience as a Materials Engineer in the power generation and petroleum industries, including both the refining and pipeline sectors. His areas of specialty include corrosion, metallurgy, materials engineering, pipeline engineering, heavy wall vessel fabrication, water treating, inspection, and general fabrication. Please contact Vince Carucci (vcarucci@carmagen.com) if you'd like more information on Carmagen's expertise in this area.

Work Highlights

Mechanical Engineering

- *Onsite mechanical engineering consulting support provided during an FCCU turnaround. Equipment inspections were made with a view to evaluating the engineering aspects of equipment performance and identifying repair or replace options. Recommendations were made to address recurring maintenance items in order to improve overall unit mechanical reliability.*

Process, Operations & Safety

- *Performing litigation technical support for a legal team defending a major engineering contractor.*
- *Provided upstream unit operating manual review/upgrade support for an engineering contractor in Europe.*
- *Supported a major licensor on fixed bed reactor design and scale-up research and reactive chemistry.*
- *Provided long-term operator support to a foreign refiner involved in the startup of a new Flexicoker in Greece.*

Project Management

- *Full time, onsite project management consulting support being provided for a major expansion project at a refinery located in Texas. Responsibilities include review of execution plans, cost and schedule control planning, interface with contractor and refinery personnel, etc.*