MATERIALS PERFORMANCE
CORROSION PREVENTION AND CONTROL WORLDWIDE

CORROSION RISK ASSESSMENT OF ELECTRIC POWER TRANSMISSION AND DISTRIBUTION STRUCTURES

Vehicle Emission Testing with Corrosion Sensors
Corrosion Rate Monitoring in Pipeline Casings
Nanotechnology – The Future of Coatings

Special Feature: Corrosion Testing and Inspection Supplier Guide
This two-part article covers corrosion risk assessment of electric power transmission and distribution structures. It spans the design, manufacturing, shipping, storage, construction, and service stages. At each stage, there is a risk of corrosion that must be considered. Part 1 covers the metallurgy of steel and galvanizing. Part 2 (to be published in the April 2014 issue of MP) will address corrosion of buried galvanized steel, soil testing, and a corrosion risk assessment strategy.

The North American electric system includes more than 4,000 electric distribution utilities, 15,000 generating units, 300,000 miles (482,700 km) of transmission and distribution (T&D) lines, millions of customers, and grid assets valued at more than $1 trillion.1 The United States operates over 157,000 miles (252,613 km) of high-voltage (>230 kV) electric transmission lines (Figures 1 and 2).2 Galvanized steel and weathering steel lattice towers and poles comprise a substantial portion of metallic structures for electric transmission lines. Millions of these have been in service since the early twentieth century and are aging.

Understanding corrosion is critical for asset owners to anticipate and manage its effects. It is important also to realize that corrosion occurs out of sight below ground and in the absence of oxygen under certain conditions. Table 1 demonstrates the typical determination cycle for a galvanized steel structure.

The key considerations to make a quantitative assessment of corrosion risk are:
- Electrochemical field considerations
- Oxidizing and reducing soil environment considerations
- Soil layer(s) corrosion activity and resistivity can be determined
- Interference and stray current can be measured and controlled

Entropy (disorder) tends to increase when systems such as physical assets in service are left to their own devices. To minimize or offset the effects of entropy, energy must be injected into the system and since this will not happen spontaneously, product engineers, scientists, and asset managers should have a plan, otherwise the system will become increasingly disordered and unstable.
A well thought out corrosion risk assessment process enables utility asset owners and managers to carry out effective risk management by providing specific actions/tasks that can reduce risk. The intention of the corrosion engineer and asset manager is to minimize risk to the lowest practical level such that no unacceptable risks remain. It is generally not practical to completely remove all risks because of feasibility, time, and cost.

Corrosion risk assessment of T&D structures must rely on a variety of test methods and techniques to determine their physical condition and to measure the probability and consequences of all the potential corrosion-related hazards. In addition, the function of a structure, its design, and in-service utilization must be considered. An overview of the galvanizing process and potential hazards is presented in this article. Part 2 will discuss the methods that are used by field inspectors to determine the below-grade condition of a structure and its projected serviceability or life expectancy.

Galvanized Steel

Galvanized steel is one of the most-often specified materials for poles, lattice towers, and other T&D assets commonly used in the electric power industry (especially for high-voltage transmission line and substation structures). Galvanized steel structures are protected from corrosion attack by a barrier effect and the galvanic action of zinc. The applied galvanized coating typically does a fine job of protecting steel located in moderately corrosive and oxidizing soils. In a recent field project in Texas, galvanized lattice towers dating back to the early twentieth century were found to exhibit an intact galvanized layer even after 100 years of service.

Not all galvanizing facilities are the same, however. Sometimes the quality of the galvanized layer is compromised by lack of adequate quality control, poor specifications, shoddy materials selection, and inadequate application. Factors often associated with corrosion failure are improper thickness, excessive brittleness of the inter-
corrosion, which can even-
the same time avoid intermetallic rust for decades.

The microstructure of hot-dip galvanized steel depends on the composition of steel and the galvanizing bath composition. In general, silicon composition less than 0.04% or between 0.15 and 0.25% is recommended. Si and P act synergistically, increasing the rate of the iron/zinc intermetallic reaction, which leads to thick coatings. Phosphorus less than 0.04% or manganese less than 1.35% are beneficial. Excessive silicon accelerates the reaction between Fe and Zn, resulting in a coating that can consist completely of Fe-Zn intermetallic layers. Higher Si concentrations can also lead to coatings that are much thicker overall than coating specifications require.

According to an American Galvanizers Association document, such coatings may “have a lower adherence when compared to the ‘typical’ galvanized coating. This type of coating tends to be thicker than the ‘typical’ galvanized coating. As the thickness of this coating increases, a reduction of adherence may be experienced.”

Thick galvanizing on the order of 7 mils (178 µm) or more depending on free zinc layer thickness are especially brittle and will crack and peel off under mechanical stress or crack if severely impacted or subjected to cyclic loads. This may lower the fatigue resistance of pole components in general; however, experience indicates that cracking of embedded poles and lattice towers are rare.

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References
4 CSA G40.20-13/G40.21-13, “General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel” (Toronto, ON, Canada: CSA Group).