Effects of Coating on Corrosion and Cathodic Protection

The four basic elements of a corrosion cell are an anode, a cathode, and the metallic and electrolytic pathways between them. Corrosion control can be achieved by eliminating (or reducing) any of these elements. One such method is to modify the electrolytic pathway by introducing a barrier between the threatened metal surface and the corrosive medium (i.e., by applying some kind of coating). If all metal surfaces could be coated with a material that was absolutely waterproof and absolutely free of flaws (holidays), all attack would be stopped. It should be noted that these two properties would have to be permanent without degradation.

Unfortunately, no combination of coating materials and painstaking application can ensure a perfect coating indefinitely. However, there are modern coatings that approach perfection, at progressively higher costs. It is often most practical to accept the inevitability of some coating flaws, where corrosion can be controlled by cathodic protection (CP). The costs associated with CP for various ranges of coating efficiency are well known. Therefore, it is possible to select a cost-effective combination of reasonably good coating and CP, bearing in mind that generally, it is not practical to increase the investment in higher-quality coating beyond the related savings in CP costs. Therefore, several questions arise about the use of imperfect coatings:

- How good are they when used alone?
- What effect do they have on the progress of corrosion?
- How do they affect the need for CP?

**Unregulated Pipelines Without CP**

Compared with a bare pipeline in the same environment, a coated line can be expected to have fewer leaks during its service life; however, the coated line may have its first leak sooner because corrosion activity may be concentrated at the limited surface area of small holidays.

Under special circumstances, this effect can be even more pronounced. Suppose that after some years in operation, a bare line develops a leak at the most aggressive location, requiring repair or replacement. The corrosive environment would be compounded by the tendency of new steel to be more active (anodic) with respect to older steel, and the unfavorable ratio of anodic and cathodic surface areas results in a concentration of corrosion current and a greater corrosion rate. The decision to avoid this predictable situation by coating the replacement piping actually makes matters even worse! Because the coating is not perfect, some new steel will be in contact with the electrolyte, and the remaining corrosion current is further concentrated at a small surface area where failures may occur in a short time.

Limited CP installations using sacrificial anodes, often called “hot spot” protection, can provide an inexpensive solution for this situation. In areas influenced by stray current, it is extremely important that a good coating be applied to the line in the area of current pickup (which is cathodic and not subject to attack) to increase electrical resistance and thus minimize the amount of current that will consume pipe metal when it discharges elsewhere. In cases of static stray currents (e.g., cathodic stray currents), the identification of pickup areas is relatively simple. However, where dynamic stray currents are involved (e.g., near direct current-powered transit systems), locations near tracks that accumulate stray current when a train is nearby may actually discharge current back to the rails when no load is in the area. Indiscriminately coating these locations without a full understanding of the stray current activity patterns can concentrate the reduced total current to intolerable densities.

**With CP**

The effect that coating has on CP requirements is simple and can be stated briefly: application of a coating greatly reduces the amount of current required to obtain protection. The reduction may run from as much as 99.8% for an extremely good coating to as low as 50% for a very poor, old, damaged coating. In addition, a good coating can significantly improve attenuation characteristics along a pipeline, greatly increasing the effective range for an individual source of protective current.

This article is adapted by MP Editorial Advisory Board Member Norm Moriber from *Corrosion Basics—An Introduction, Second Edition*, Pierre R. Roberge, ed. (Houston, TX: NACE International, 2006), pp. 178-179. **MP**