Improved Grounding Causes Minimal Impact on CP Systems

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This article presents a case history of an integrated cathodic protection (CP) and electrical grounding system design. It clearly shows the benefits of the integrated design to the CP system.

Electrically interconnecting many dissimilar metals in the soil can lead to significantly increased corrosion rates on some underground structures.[1-4] On most industrial or power plant projects, when the corrosion engineer begins design of the cathodic protection (CP) system, the piping and electrical grounding design of the basic facility design has been "frozen in stone." All too frequently, the grounding grid consists of a massive bare copper grid with copper-clad steel ground rods; this represents the major CP current demand for the entire facility.[5-6] Corrosion engineers rarely have the opportunity to design an integrated CP and electrical grounding system. This article presents a case history of one such integrated design.

Case History—Airline Maintenance and Engineering Base

BASE FACILITIES

The American Airlines Alliance Maintenance & Engineering Base (M&E) at Fort Worth (Texas) Alliance Airport was designed and constructed from December 1989 through mid-summer 1992. The M&E is a wide-body jet aircraft overhaul facility capable of hangaring seven wide-body jets simultaneously. Figure 1 shows the site under construction. Typical of most aircraft overhaul and other industrial facilities, the underground metallic matrices at M&E consist of the following components:

- High-density polyethylene plastic natural gas lines with welded steel, dielectrically coated risers on the larger service lines, and "anodeless risers" on the smaller service lines
- Welded steel, dielectrically coated compressed air lines
- Ductile iron pipe (DIP) firewater and potable water lines with dielectric-bonded coatings. The smaller-diameter lines are polyvinyl chloride (PVC) with DIP risers, valves, tees, and 90s. All DIP lines and fittings were constructed with mechanical joints and were provided with electrical jumper bonds across each joint in order to maintain electrical continuity.
- Welded-steel, dielectrically coated jet fuel (JP-4) lines and several underground day tanks
- Various control lines and electrical conduits
- Foundation rebar
- Grounding electrodes and insulated copper cable grounding grid.

GROUNDING SYSTEMS

The author was commissioned to design the CP systems for all underground utilities and to design the facility electrical grounding grid. For this particular grounding scheme, all building steel was tied into the grounding grid. The grid was designed as a complete network of PVC-insulated copper cables with a few driven stainless steel (SS) ground rods at selected locations. By taking full advantage of building steel and foundation rebar, the maximum acceptable plant grounding grid resistance of 1 was easily met in the low-resistivity 1,000 -cm (10 m-) soil environment typical of North Texas. This type of grounding system is very compatible with CP. The CP design current for bare steel in typical North American soils generally is in the range of 1 to 3 mA/ft^2 (10.8 to 32.3 mA/m^2). Current demand for SS grounding electrodes is generally in the range of ~1 mA/ft^2 (10.8 mA/m^2) of surface area exposed to the soil. Current demand for structural steel members encased in concrete generally is in the range of ~0.1 mA/ft^2 (1.1 mA/m^2) because the portland cement concrete creates a passivation effect on the steel. In contrast, the current demand of bare copper grounding electrodes is 10 to 20 times higher than bare steel.[3]

CATHODIC PROTECTION

The impressed current CP system consists of vertically installed distributed anodes powered by transformer/rectifier units situated in individual buildings throughout the facility. In the case of large-diameter DIP firewater/potable water mains, distributed anodes were installed in the middle of the company streets. Distributed anodes were also installed in areas of congested piping, around underground jet fuel day tanks, and around the perimeter of aboveground water storage tanks. In other areas, conventional remote vertical anode groundbeds were employed.

A total of 11 CP rectifiers were installed at the M&E facility to protect the underground plant piping. The total output capability of these 11 rectifiers is 439 A. At the time of the most recent survey, these rectifiers were putting out a total of 137.3 A. The facility covers a surface area of ~199 acres (80.5 ha). Therefore, the average current density (CD) per unit area is ~0.69 A per acre (0.28 A per ha). This figure is appreciably less than the average CDs of 6.46 A per acre for a power plant[3] and 6.658 A per acre for an oil and gas production facility, as previously reported in the literature.[4]

FIGURE 1

The American Airlines Alliance Maintenance and Engineering Base under construction.

Conclusions

From a corrosion control/CP perspective, using an integrated design approach to CP and electrical grounding yields significant benefits. There are economies to be gained with both systems and, in the long run, the owner benefits. However, the owner will realize these benefits only if advanced planning is employed during the early stages of project design.

References

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