Surviving the Elements with Corrosion Resistance

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Performance-critical electrical equipment—typically fabricated from a variety of metals—must withstand years of challenging outdoor conditions to support the flow, supply, and management of electricity. The design emphasis for transformers, electrical enclosures, switchgear, and exterior lighting is typically focused on its sensitive instrumentation, controls, and operation. Few consider how critical it is to protect the metals that house these vital components and ensure their reliability.

According to the Electric Power Research Institute (EPRI), the cost of corrosion-related problems in the electrical industry exceeds $17 billion.[1] This represents an estimated 7.9 percent of the total cost of electricity to consumers in the U.S. Incredibly, roughly 20 percent or more of these corrosion costs are avoidable. Electrical component manufacturers and their customers bear a significant portion of these costs, yet the best design and coating strategies for protecting these devices from corrosion often are an afterthought.

Finished electrical components are about 70 percent metal and 30 percent nonmetal substrates, yet nearly 100 percent of electrical equipment manufacturers view painting metal as outside their core competency.

1 https://www.epri.com/#/pages/product/1004662/

That means an average-sized switchgear manufacturer running 10 to 15 million square feet of coated metal through its facility is staking a lot of its reputation on work considered outside its core competency.

Building a Great Specification

Most electrical equipment has a minimum life expectancy of 20 years, yet many components are expected to survive 50 years or more in extreme conditions and operating environments. Unfortunately, when it comes to painting and protecting new equipment, many manufacturers still combine old "cut-and-paste" specifications that date back 20 to 30 years with current industry-standard regulatory requirements written by IEEE, UL, CSA, and ASTM.

Equipment manufacturers may write paint specs solely on achieving a minimum industry standard or according to a specification written by a paint supplier. Paint manufacturers may contribute to the problem by designing coatings systems that merely meet old specifications or achieve industry standards dictated by customers instead of featuring the latest technologies to provide better field performance.

If the goal of an electrical equipment manufacturer is to build next-generation components that exceed performance mandates while protecting its brand reputation, paint specifications should be reviewed and updated regularly. In addition to product scope and substrate type, manufacturers should address the following criteria:

- **Paint type.** Avoid using a specific manufacturer's product code, which can be ambiguous or difficult to find. Instead, detail the technology the equipment demands (liquid, powder, or electrocoat) and the resin chemistry (e.g., TGIC polyester, epoxy, or urethane).
- **Substrate preparation and protection.** In addition to cleaning and removing oils, lubes, and coolants from the fabrication process, the specification should spell out chemical and mechanical cleaning methods.
- **Color.** Detail an acceptable range of color variation and have a proven method for determining that the color of painted parts falls within specification.
- **Gloss.** Like color, the gloss range may affect a product's finished appearance. Provide a specific gloss range, as variations may cause the same color to appear as different shades.

- **Texture.** In the electrical industry, some orange peel (minor paint dimpling) is considered preferable, as it tends to hide flaws and to wear well over time. Even so, firm rules for texture types and variation should be written into the paint spec.
- **Cure.** This section establishes paint curing parameters for oven- or air-drying paint.
- **Product handling and storage.** Manufacturers suggest specific rules for handling and storage in their product data sheets, including an acceptable range of temperature exposures and fixed expiration dates for proper rotation of inventory.
- **Performance.** Regulatory standards such as UL 1332 are written to include a range of acceptable results for products undergoing laboratory-based performance tests.

Performance Testing

While many coatings systems are robust enough to pass industry-accepted performance tests, they can sometimes fail in the field because real-world conditions are more difficult to survive. For that reason, it is critical to write into the paint specification the tests that most accurately reflect a product's ability to fulfill a warranty or an expected service life. For example, does a specific impact test predict paint chipping once installed in the field? Or does an accelerated weathering test depict the real-world color fade or breakdown of a coating?

Performance testing also must correspond to field troubleshooting. If a coating fails in the field, correlating the failure to a specific testing method will enable the equipment and paint manufacturers to identify the reason for the failure more quickly, which also can lead to quicker solutions for corrective action.

Some of the most common performance tests written into an electrical equipment paint specification include:

- Salt spray, the most commonly specified test in the electrical industry. UL 1332 requires 600 hours of salt-spray exposure for electrical enclosures and switchgear. Many transformers require between 1,000 and 2,000 hours of exposure
- Ultraviolet accelerated weather testing, which is designed to predict how a coating will fade outdoors over time
- Simulated corrosive atmospheric breakdown (SCAB), which predicts how well a coating will maintain its integrity when subjected to a succession of regular and extreme performance environments
- Humidity testing
- Impact resistance
- Gravelometer, which predicts a coating's ability to withstand road gravel and chip resistance

Other tests that are occasionally used and built into specifications for electrical equipment include those that test for adhesion. There also are many types of chemical tests, including one for insulating fluids to determine a coating system's ability to resist exposure to certain types of chemicals.

Specifying Success

When creating a paint specification, it is critical to correlate a device's expected service environment and service life to the testing methodology that most rigorously replicates the performance challenges it will face. Not only will this help a product perform reliably throughout its lifetime, but it may also lessen maintenance requirements.

Equipment manufacturers should evaluate paint specifications on a regular schedule to confirm that they incorporate the most targeted and technologically advanced coating systems and testing methodologies for a specific application. They also should involve paint and pretreatment suppliers in the design process as early as possible, preferably with a proven coatings company that can offer both pretreatment and paint capabilities as an integrated package.

Integrated, full-service coatings suppliers typically have a deep understanding of the coatings process from start to finish, along with a wide range of products and resin chemistries that have been tested according to industry-standard criteria.

Suppliers can act as a partner in identifying potential vulnerabilities to corrosion and help customers select the right products to prevent it. Most integrated coatings suppliers have dedicated lab resources that enable them to recommend the best methodologies to measure a product's potential service life as well as complete testing services to verify lab results, identify potential reasons for a product failure, suggest potential solutions to correct a failure, and troubleshoot general coatings-related production problems.

Visit the NEMA Standards Store for standards related to transformers, electrical enclosures, switchgear, and exterior lighting.