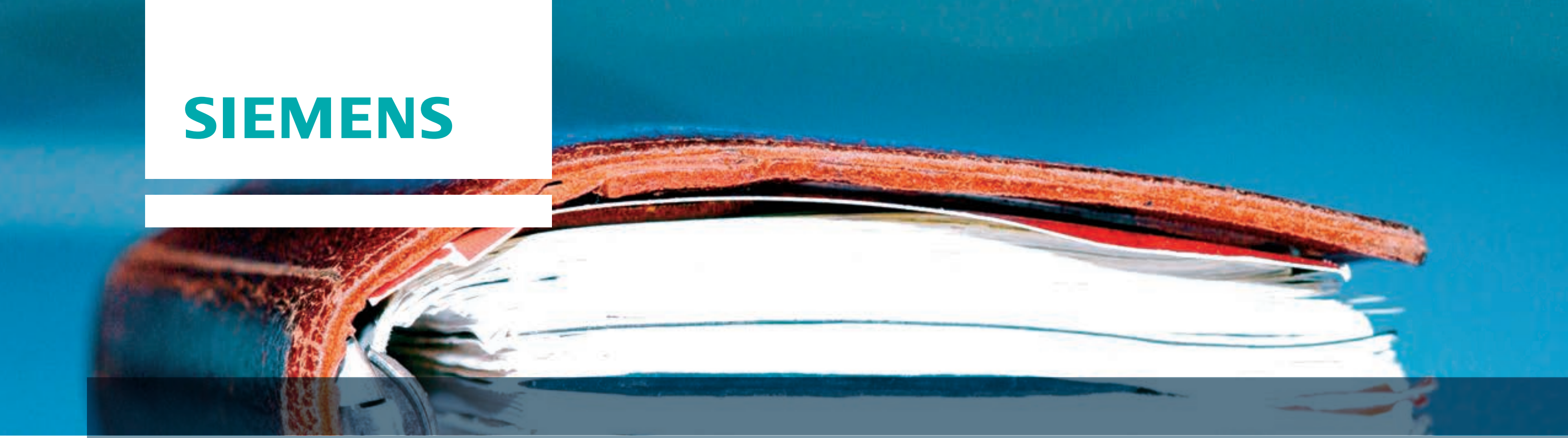

SIEMENS

# TechTopics No. 110

## Corrosion prevention effects on electrical equipment life

In TechTopics No. 15 - Expected life of electrical equipment, the subject of the expected life of electrical equipment was discussed with regard to the environmental conditions users can control. Items, such as attention to cleanliness, conservative equipment loading, regular maintenance and sufficient ambient-temperature controls, were all described as contributing factors in keeping electrical equipment in good working order.

To further illustrate the influence environmental conditions have on the expected life of electrical equipment, TechTopics No. 84 - Space heater - sizing and application principles discussed why Siemens recommends the use of space heaters for humidity control to reduce the likelihood of insulation failures due to the formation of condensation (moisture). This issue of TechTopics discusses another detrimental effect that condensation may have on the life expectancy of electrical equipment – corrosion.

Corrosion is, by definition, the destruction of material by electrochemical oxidation due to reactions with an oxidant. For steel, one of the metals most commonly used in electrical equipment, corrosion manifests itself as the rust on your car and is caused when iron oxides form when iron and oxygen come into contact with moisture.

For indoor electrical equipment, the normal (usual) service conditions defined in the IEEE standards define the conditions of humidity (moisture in the air) as follows:

1. The average value of the relative humidity, measured over a period of 24 hours, does not exceed 95 percent.
2. The average value of the relative humidity, over a period of one month, does not exceed 90 percent.

Under these conditions, without applying any environmental controls, condensation formation in electrical equipment leading to corrosion is likely. Once corrosion begins, it degrades the useful properties of the base metal, including strength, surface finish and permeability to liquids. This permeability reduction in steel is why, given enough time, the rust spot on the car becomes larger as the metal converts to rust and flakes away. For copper, the other metal most common in electrical equipment, corrosion presents itself as that green hue (tarnish) that needs to be scrubbed off of cooking pots. In either case, corrosion in electrical equipment could lead to thermal, mechanical or structural issues, which have the potential for equipment failure and/or personnel injury.

In addition to the proper use of space heaters, appropriate ventilation and temperature controls, the most widely used methods for controlling corrosion are through the use of rust-resistant alloys or the application of a finish or surface treatment to isolate the base metal from the environment.

As discussed in TechTopics No. 18 - Bus joint and primary disconnect plating, silver- and tin-plated copper buses are used by Siemens to maintain good conductivity in the bus structure. This is because even though both will tarnish over time, the oxides formed by both metals are still quite good conductors.

For steel components in high-speed or rotating mechanisms like circuit breaker operators, racking mechanisms or safety interlocks, Siemens typically uses rust-resistant steel alloys like stainless steel. The chromium in the steel forms a passive layer of chromium oxide, blocking oxygen diffusion into the base steel.

Because this layer is inherent to the steel and not just a surface treatment, the ANSI/IEEE standards do not require any tests to demonstrate the corrosion-resistant properties of components made from these alloys.

For general purpose or enclosure components, Siemens either finishes the steel with thermosetting polyester-powder paint or zinc galvanization.

For finishing with powder paint, the steel is prepared before painting by a seven-stage wash system. The thermosetting polyester-powder coating is then applied with electrostatic equipment at a nominal 4 mils dry-film thickness, and cured at 374 °F (190 °C) for 30 minutes. The completed parts have a textured appearance that exhibits excellent flexibility and durability. Additionally, the salt-spray (fog) performance of the finish is more than double the requirements found in the latest ANSI/IEEE and ASTM standards for organic coatings. However, long-term exposure to ultra-violet (UV) light can cause some level of fading. Depending upon the desired finish color (ANSI 61 gray is standard), the compartments internal to the equipment enclosure can appear dark requiring additional illumination to increase visibility.

To ensure proper enclosure continuity to ground, the finish needs to be penetrated at connection points usually with star washers or the like.

When galvanizing, the sheet steel has a layer of metallic zinc applied to the surface. This is either done to the completed component part by electroplating or hot-dipped galvanizing, or by using commercially available sheet steel commonly referred to as "galvanized steel" to create the component part. Galvanized steel has a zinc coating applied as part of the manufacturing process. Galvanizing steel protects against corrosion in two ways: as a physical barrier and by cathodic protection.

As a physical barrier, the zinc coating provides a barrier to moisture and oxygen interaction with the base metal. This barrier is effective mainly due to zinc's ability to form a dense, adherent corrosion by-product known as zinc patina, which leads to a rate of corrosion up to 10 to 100 times slower than untreated iron-based materials according to the American Galvanizers Association (AGA). Cathodic protection references zinc's ability to electrochemically sacrifice itself because it is a less resistant to corrosion and oxidation than steel. Basically, the zinc will corrode before the base steel and at a much slower rate. The amount of zinc applied to the steel surface establishes the minimum coating weight per unit area as determined by specific ASTM tests and determines the level of corrosion protection. Commercial galvanized steel is designated with the letter "G" followed by a two-digit number representing the weight of zinc applied in $oz/ft^2$.

Since coating weight directly affects the coating life (higher coating weight used increases the service life of the equipment), Siemens uses G90 galvanized steel. According to the AGA, in industrial environments (where electrical equipment is typically applied) not only do acid, soot and other pollutants tend to settle on steel surfaces, but also dampness due to condensation may be present and the G90 weight is appropriate for these applications. In addition to the corrosion-resistant properties, galvanized steel is more resilient (scratch resistant) than painted steel and does not require penetration of the finish to ensure ground continuity due to the conductivity of the zinc. The sheared and/or punched edges tend to be sharp and care must be taken to minimize the potential for injury to operating personnel. The zinc patina has a tendency to have a white powdery appearance, which may prove aesthetically unappealing to some users.

In addition to user-controllable environmental items, such as cleanliness, equipment loading, proper maintenance and ambient temperature, corrosion can have a detrimental effect on the life expectancy of electrical equipment. There are a variety of methods of combating corrosion in electrical equipment, including the selection of materials and coatings suited to specific environments. Based on our technical expertise and experience, Siemens selects finishes matched to the application in order to meet or exceed expectations of product functionality and life.



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