STORM POWER COMPONENTS

Applications Note

Cracking the Code on Epoxy-Coated Busbar Design

Basic guidelines ensure superior results and reliability for the epoxy powder coating to provide critical electrical and mechanical protection for busbars.

Busbars play an important role in high-current/high-voltage installations. Made of copper of aluminum, they carry electrical power ranging up to hundreds of volts and amps and even higher within cabinets and across external distribution assemblies, and do this with low voltage-drop resistive losses.

For example, the single-voltage busbar is widely used in switchgear, switchpanels, and substations, or to connect battery cells, among many other applications.

Busbars can also be "sandwiched" as laminated bus bars with a variety of insulating materials between layers, to carry multiple voltages within the same assembly.

While it is possible to install a bare busbar using only air-spacing for insulation, they generally require insulation to protect users and other components from the voltage and current. This protection works both ways, as the outer coating also protects the busbar itself from potential corrosion, normal abrasion, and even abuse, and improves appearance as well. Among the options single bus bar or a multilayer laminated bus bar are heat-shrink tubing, insulators such as Mylar (PET), and epoxy powder coatings.

What is powder coating?

Epoxy powder coatings (also called dielectric epoxy powder coating) are often the preferred option for insulating and protecting the busbar. Although there are different formulations, these coatings are based on polymer resins combined with curatives, pigments, leveling agents, flow modifiers, and other additives.

The powdered-coated busbar is placed in an oven to be cured, and once it has passed its transition temperature, the powder chemically reacts by fusing to produce long molecular chains. These chains, which also fuse to the busbar copper or aluminum substrate, have high cross-link density and molecular weight which makes them very resistant to material breakdown.

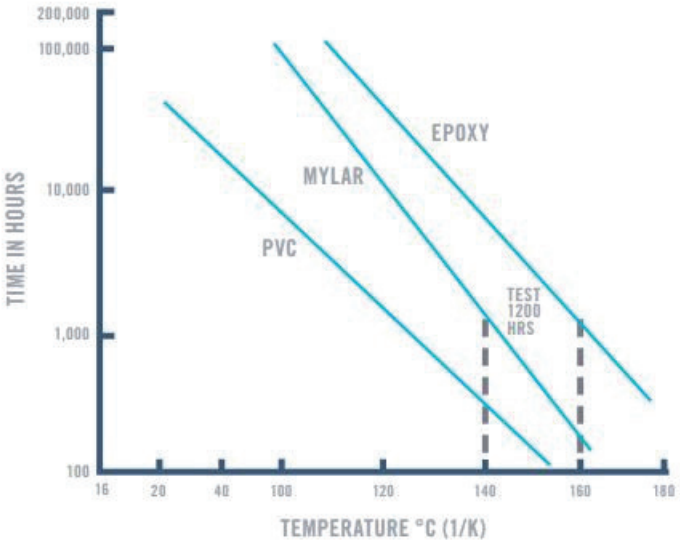
When applied properly, powder coating offers multiple advantages: smooth and continuous crack-free coverage; high dielectric strength, and long-lasting insulating properties. It is also resistant to heat and flame, impact, abrasion, moisture, corrosion, many chemicals, ultraviolet light, and weather extremes. In short, it provides and maintains a coating integrity as it forms a "skin-tight" covering around the bus bar surface. Powder coating is not just a "paint" with a fancier name – it is a superior conformal coating technique providing chemical, mechanical, and electrical benefits.

Applications Note: Epoxy Coated Busbars

Why use powder coating?

Powder coating is especially well-suited to the needs of bus bars. As a coating, it uniformly covers the surface, even for busbars with tight geometries and complex shapes often needed for tight spaces or complex systems. Further, the coating adds minimal weight and bulk, with a typical thickness ranging from 6 to 120 mils (0.006 to 0.120 inches). Since the epoxy powder is applied after all bending, contouring, punching, and milling of the bus bar, it offers a consistent application across and along the entire surface.

Electrically, powder coating also has attractive specifications. It offers a typical insulation rating of 800 volts per mil while the dielectric strength depends on application process, coating thickness, and bus bar preparation.

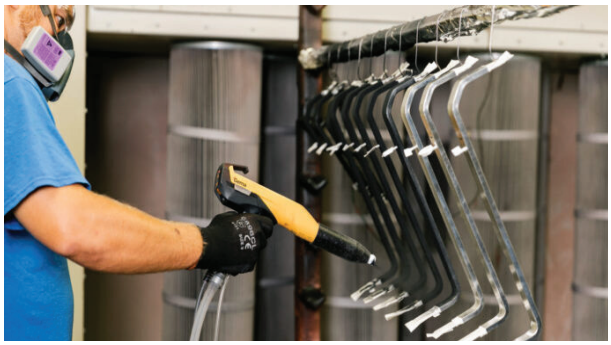


The useful insulation life of the powder coating is impressive in comparison with other common insulating materials. Further, as a bonded conformal coating, it reduces the risk of flashovers and partial discharges as there is no air gap between conductor surface and insulation.

Temperature ratings for powder coatings are also high, with a typical value of 130°C as characterized by relevant UL standards (94 V-0 Flammability standard), depending on the specific formulation of the coating material and application factors.

As an additional feature, the coating is offered in wide range of standard color which is useful where a system has multiple bus bars in close proximity; custom colors can be formulated if desired.

Powder coating can be applied two ways: by electrostatic spray of the powder or by immersion in a fluidized bed of powder, with both followed by oven curing. The decision of which application technique to use is based on the busbar's size and shape as well as electrical requirements. Busbars with fairly flat geometry are better suited for spraying, while bus bars with many turns and tight bends are a better fit for fluidized powder coating.



Electrically, the spray approach works well at lower voltages, up to 600-100 V with a coating which is 10-20 mil thick. Immersion in fluidized bed is a better choice for higher voltages such as 5 kilovolts (kV) and even up to 35 kV where coating thicknesses of 50-120 mils are needed.

Take Steps to Avoid Cracking

As with any sophisticated technology, there are design and production factors which affect short- and longer-term coating performance and integrity. For busbars with powder coating, cracking of the coating is a potential issue. This cracking can occur within minutes during the cooling process and removal of masking tape around holes, or it can also occur days later as the material is stressed because of adhesion issues or improper curing. These problems can be avoided by careful control of the coating process.

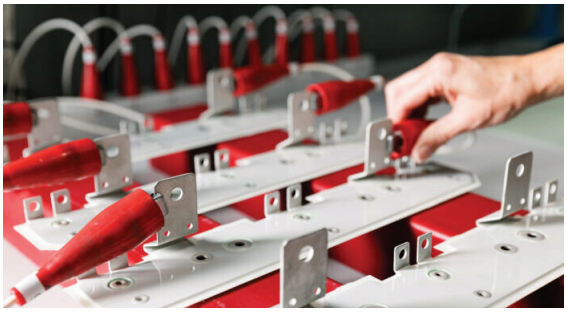
However, there are key standard guidelines which busbar makers need to follow in the design phase to minimize potential for cracking, prior to actual production. These include:

- Round all material edges with generous radii at those edges and corners (at least 1 millimeter for thin bars); otherwise, the coating will be thin out and be uneven at edges and may not "stick" properly.
- Provide two sets of mechanical drawings, one which shows the dimensions of the copper or aluminum busbar substrate by itself and one which shows the final coated thickness. This avoids misunderstanding of how thick the coating should be, which could result in a coating that is too thin.
- Countersink and condition (debur) all busbar holes.
- Properly size hole versus busbar thickness; all hole should have a diameter at least 1.5× to 2× of bus bar thickness. Holes which are too small will fill with powder which will eventually crack after curing. Also, small cut-outs and holes are difficult to "edge condition" properly and can create weak areas which are prone to premature failure.
- Examine all hardware (nuts, bolts, washers) which go through busbar holes, and be aware of the impact of improper or excessive torquing as it may cause cracks in underlying coating (unless the area has been masked for "no coating").

Test to Verfiy Powder Coating Integrity and Performance

To ensure that the powder coating process meets the needed performance objectives, the coated busbars must be tested for mechanical and electrical characteristics. In addition to visual inspection, the coating is measured using an ultrasound instrument to provide a quantitative indication of coating application thickness and uniformity.

To verify electrical integrity and conformance to standards, the dielectric strength test (usually referred to as a high-pot test) is a basic pass/fail test which stresses the insulation and ensures that no current flows. There is also an advanced leakage-current test which measures how well the bus bar is insulated and can point to abnormalities that may appear during subsequent testing.



For multilayer laminated bus bars, additional tests include the partial discharge test which looks for localized dielectric breakdowns, and the insulation-resistance test which measures the layer-to-layer resistance.

Summary

Use of power coating on basic busbars and laminated busbars is the preferred technique to address issues of electrical insulation, physical protection, and busbar integrity. By following guidelines provided by a knowledgeable vendor, and by leveraging the vendor's know-how and production expertise, issues such as coating cracking can be avoided, resulting in reliable, long-life busbars that meet all performance objectives.