TECHNICAL PAPER [GE LEGACY DOCUMENT]

# Spectra Series™

## Busway's durable insulation

**GE legacy product**
documentation

# DURABLE, LONG-LIFE EPOXY INSULATION USED IN GE BUSWAY SYSTEMS

Insulation life is a key factor in the design, manufacture and use of busway. This technical data paper is a review of the epoxy insulation developed, tested and selected for use in GE Armor-Clad® feeder busway and now in use with the new GE Spectra Series™ busway.

The test data gathered during the original selection process for epoxy insulation plus its successful use in Armor-Clad feeder for the past twenty years, with absolutely no problems or failures, demonstrates both the superiority of epoxy over other busway bar insulation systems, and why it was chosen as the bus bar insulation for GE's new Spectra Series™ Busway, both feeder and plug-in.

Armor-Clad and Spectra Series busway are rated 600 volts maximum, up to 5000 amperes with copper bus bars, and 4000 amperes aluminum bars. It is a totally enclosed system without ventilating slots. The bus bars are sandwiched together for intimate thermal contact between the bus bars and busway housing, providing conductive heat dissipation.

During the design state for Armor-Clad busway, GE engineers were looking for an insulation that was strong, and durable to resist damage or deterioration during shipment, job site storage and installation. Epoxy was determined to be an excellent electrical insulation, with good wear aging characteristics, and a 130°C Class B rating. It is a thermoset with excellent strength, toughness and resistance to chemicals. If epoxy was to be used, a uniform thickness of the insulation had to be maintained in order to obtain good heat transfer. And, to prevent corona formation, air voids from overlaps or double insulation thickness had to be eliminated.

To determine its acceptability for use in Armor-Clad feeder busway, epoxy insulation life was hypothesized as follows:

1. The busway would carry rated current 14 hours a day, six days a week, for 50 years.

2. The ambient would be 25°C 50 percent of the time, and 40°C 50 percent of the time.

3. Over the 50-year period, the busway would be subjected to 109,000 hours at 80°C and 109,000 at 95°C, which is equal to 140,000 hours at 95°C.

The classical Arrhenius reaction rate theory was used with an accelerated aging time of 1200 hours at 160°C. Short busway lengths with epoxy insulation were subjected to aging tests of 10 weekly cycles, each consisting of:

> **Five days of 120 hours at 160°C with 150-percent (900-V) service voltage, and two-day exposure to relative humidity sufficient to cause moisture to collect on the busway.** The corona starting voltage and corona extinction voltages were measured, and a 2200-V high potential test was conducted before the test and after each cycle.

Figure 1 shows the corona starting voltage, and Figure 2 shows the corona extinction voltage, both as a function of service voltage plotted against aging time at 160°C. Both the CSV and CEV stay well above the service voltage. In Figure 3, the ratio of CSV to CEV is essentially constant and indicative of a stable material.

At the end of the aging, the busway was disassembled and a high potential test conducted. The insulation was in good condition with a minimum breakdown voltage of 5.2kV.

Test lengths of insulation used by other manufacturers were constructed and also subjected to similar aging tests (See Figure 4). One consisted of two layers of mylar 10 mils thick, and another with two layers of 35 mils PVC rated 105°C, and with 5 mils mylar.

The PVC insulation failed after 72 hours at 140°C with serious cracking around the bar edges and the mylar sample failed after 540 hours at the same temperature.

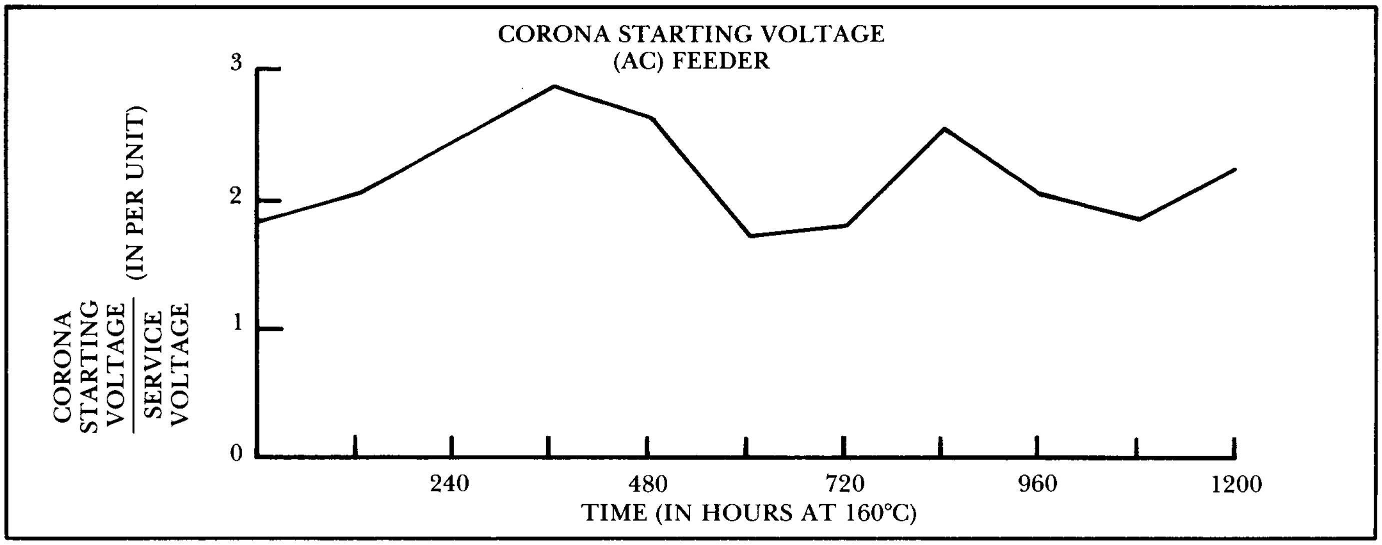


**Figure 1. Corona starting voltage of epoxy is a function of service voltage plotted against time at 160°C.**

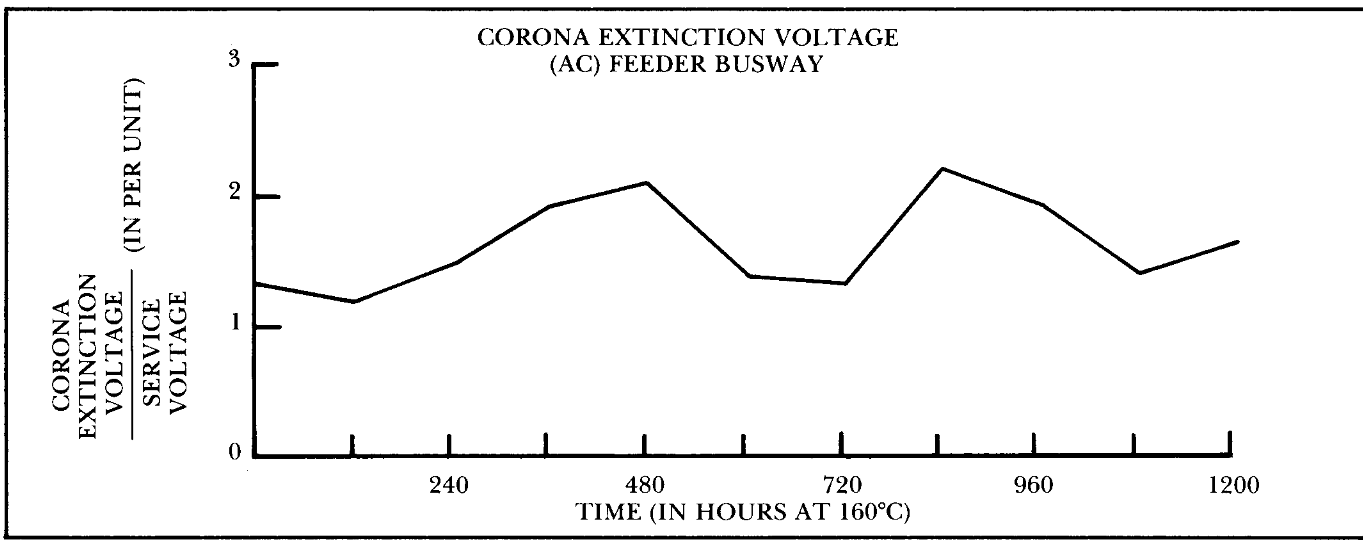


**Figure 2. Corona extinction voltage of epoxy plotted the same as the corona starting voltage in Figure 1.**

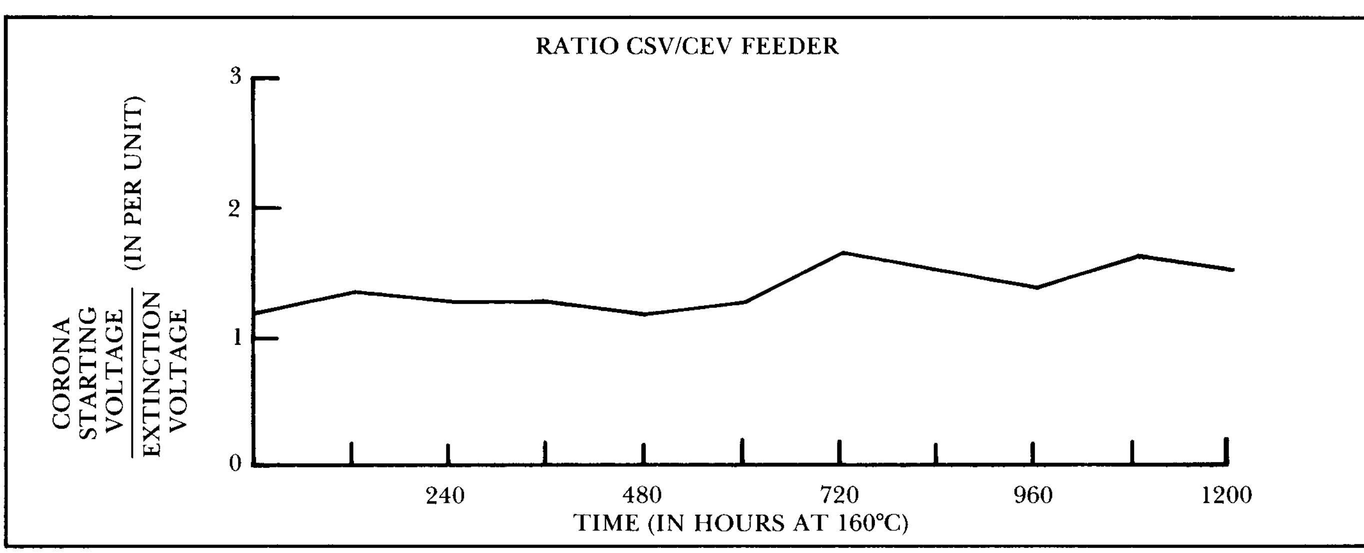


**Figure 3. The ratio of corona starting voltage to corona extinction voltage for epoxy is essentially constant and indicative of a stable material.**

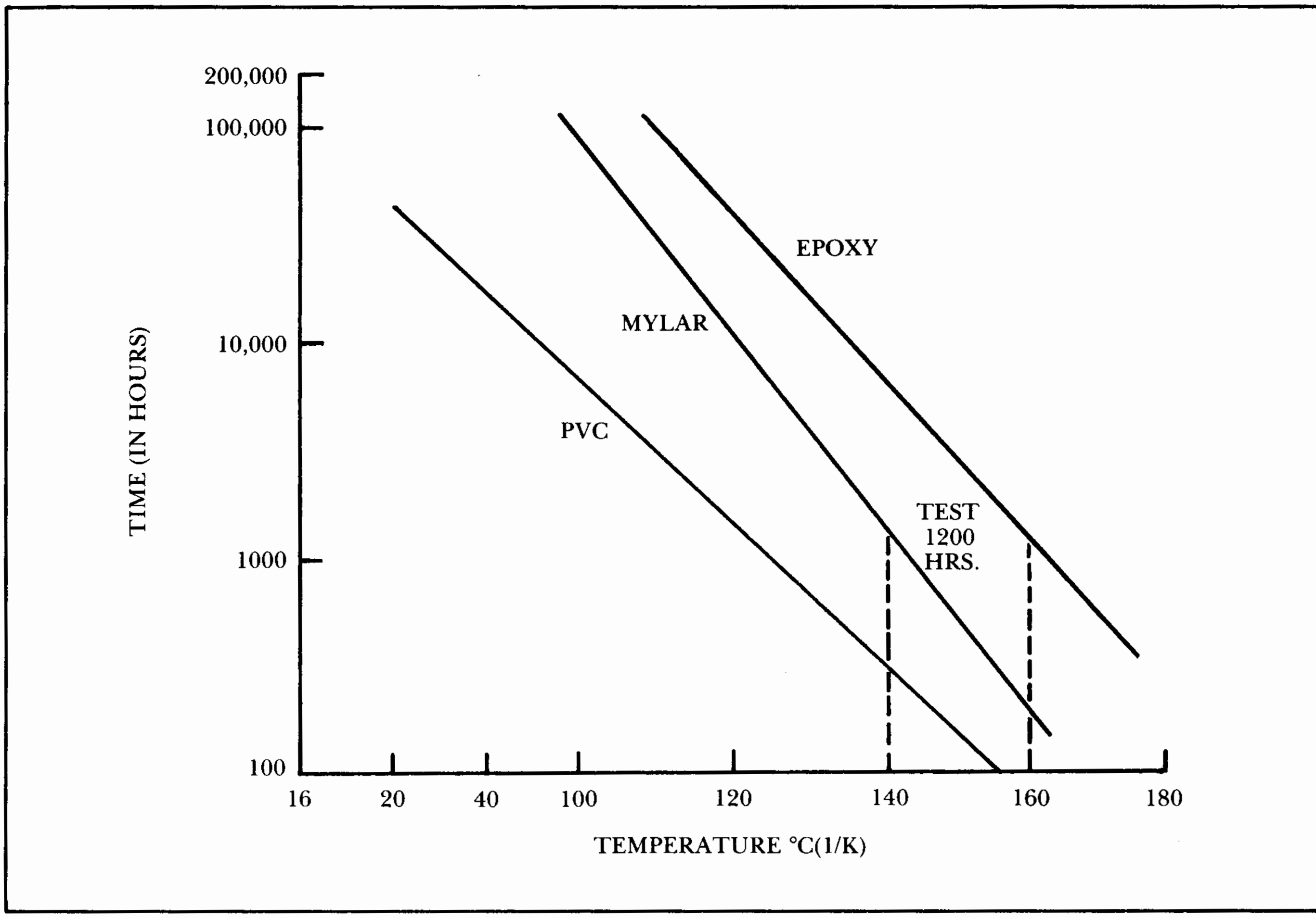


**Figure 4. Insulation life curves plotted according to the Arrhenius reaction theory.**

## ADDITIONAL TESTS

In addition to the accelerated aging, there were many other requirements the epoxy insulation had to meet. These included thermal overload, water absorption, impact strength, cold shock, thermal cycling and flammability.

In the thermal overload test an insulated bar assembly is subjected to a force of 300 psi and overload current of 12 times continuous current rating is applied until a temperature of 175°C is reached in approximately 35 seconds. The current is removed and the bar is cooled to room temperature.

A dielectric test is conducted after the bar assembly has been subjected to three overload heating and cooling cycles, and the minimum acceptable value is 12kV phase-to-phase and phase-to-ground.

Water absorption characteristics are important since GE Busway can also be used outdoors. Epoxy-coated bars are placed in 180°F water and 150 percent of service voltage (900V ac) is applied between the bars and water. The bars are left in water for 1000 hours. If there is no dielectric failure and the insulation adheres to the bar, epoxy-coated bars pass the test.

Epoxy-coated bars have five times the impact strength of PVC and three and a half times that of glass tape. In comparison with these other materials, epoxy withstood a minimum of 150 inch-pounds and glass tape at 40 inch-pounds. Epoxy is a tough material capable of withstanding constant handling during manufacture, shipment and installation.

During the cold shock temperature test, epoxy-coated bars are cooled to −40°C. After exposure, they must pass a 3500-V ac brush-type electrode high potential test.

For thermal cycling tests, epoxy-coated bars were subjected to repeated cycles with temperatures ranging from −20°C to +175°C in a two-minute period. After 40 cycles, the impact strength was 150 inch-pounds and the dielectric strength was 11 kV.

Epoxy-coated bus bars tested for flammability were rated self-extinguishing by Underwriters Laboratories, and were UL Listed as a 130°C material.

When compared to PVC and mylar, insulation used on other busways, test results indicated epoxy has significantly longer life, impact strength and resistance to water, and was selected because of its superior characteristics.

General Electric chose to apply epoxy by the fluidized bed process because it permits the application of a uniform coating of insulation without overlaps, voids and air gaps. The operation is efficient, mechanized and requires no hand assembly. The insulated bars produced have a consistent, uniform quality that is repeatable day after day.

Using a fluid bed system to apply epoxy with a high degree of quality on a production line basis required many years of development.

The manufacturing steps in the fluid bed system are as follows:

- **The preparation phase,** where the bus bars which have been fabricated and formed to final shape are mechanically deburred, masked, and hung on a conveyor for transport.

- **The cleaning phase,** where fabrication oil is removed before they are insulated.

- **The insulating phase,** where the bus bars are insulated. The epoxy has excellent adhesion to the bus bars, which prevents entrance of moisture or chemicals during plating operations and provides optimum mechanical strength to the insulation.

- **The fluid bed coating.** The bus bars are pre-heated to a temperature higher than the melting point of the epoxy insulation and lowered into a fluidized bed container with a porous platebottom. Cool, moisture-free air is forced through the plate and the dry epoxy powder in such a manner that it resembles a boiling liquid. Hence, the name "fluidized bed." The epoxy particles contact the heated bars and melt and fuse together to form a uniform, homogeneous and continuous film on the bars. Insulation thickness is controlled by the dipping time which varies with bar thickness and material. Use of the fluidized bed coating method to apply epoxy to bus bars eliminates insulation voids, air gaps and thickness build ups.

- **Oven curing.** Finally, the insulated bars are oven cured and then removed from the conveyor.

Each bar is inspected and hi-potted with a wire brush electrode at 5000 Volts to ensure against any possible defects.

Quality control bars are insulated at least once daily in the system and then tested for cure, dielectric strength, impact strength and edge coverage.

After complete busway assembly, a high-potential test is conducted at 5000 V dc phase-to-phase, and phase-to-ground.

**SUMMARY**

Epoxy insulation applied by the fluidized bed process has proven over time to be a superior insulation, and is now being used on every length and fitting in GE's new Spectra Series™ Busway.

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9AKK108467A9255 DE-171 JULY 2023