Using Insulation on Low-Voltage Bus

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If you've looked inside the Powell FlexGear low-voltage switchgear design, you will observe that much of the bus is insulated using an epoxy coating similar to the medium-voltage products. The natural assumption would be that this insulation is required to meet the equipment dielectric requirements found in IEEE C37.20.1, but that is not the case.

There is no requirement in C37.20.1 for bus insulation.

Low-voltage switchgear is governed by IEEE C37.20.1 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear, ANSI C37.51 Standard for Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies, and Underwriters Laboratories UL 1558 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear. Additionally, the FlexGear equipment is rated for internal arcing faults and tested to the requirements of IEEE C37.20.7 Guide for Testing Switchgear Rated up to 52kV for Internal Arcing Faults.

The Powell design was tested in both our own facility and in independent accredited laboratories and all testing was witnessed and approved by Underwriters Laboratories.

Specific concerns about the phase-to-phase clearance of the uninsulated heat sink are addressed by the successful completion of both design and production dielectric testing. Further, the clearance between heat sinks is 1.3 inches on the Line side bus and 1.8 inches on the Load side bus; exceeding the UL requirement of 1 inch between uninsulated conductors.

The design meets all regulatory requirements. However, it is understandable why someone would question the design based on appearance. The following is offered to further explain of how the specific combination of bus, heat sinks, and insulation were determined.

In order to meet the arc resistant requirements for limiting the emission of fault gases, the equipment must be constructed with limited ventilation and closer tolerances on mating surfaces. Additionally, it was discovered the effects of the arc could be limited by restricting arc movement inside the equipment. Metal-Enclosed Low-Voltage switchgear has no requirements for phase barriers, compartmentalization, and bus insulation in any of the governing standards, but by adding insulation and barriers in specific locations, it is possible to improve the arc fault performance. These techniques are now the subject of numerous papers and research projects.

The performance of the insulation and barrier design was so successful it became difficult to sustain the arc during testing. In fact, it was the research made by Powell that led to the use of a different shorting wire types and the mandatory full voltage testing requirements currently found in IEEE C37.20.7. It became necessary to create artificial conditions to meet the required arc fault duration and fully evaluate the designs. Later versions of the testing guide recognize that with LV switchgear it is possible to take advantage of insulation and barriers to create conditions where the arc cannot sustain, so by adding the appropriate insulation, better performance was achieved.

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These efforts to provide a better performance during an arc fault unfortunately tended to reduce the air flow through the equipment. During product development testing for continuous current it was found that designs for 2000A or higher required additional measures to adequately cool the circuit breaker to the IEEE required 65°C rise limit. The measure employed was the placement of radiators, heat sinks, on bus entering the circuit breaker. This helps draw heat conductively away from the circuit breaker and then dissipate that heat in the bus compartment where there is less restricted airflow.

Low Voltage equipment bus is not required to be insulated by the standards, but the improvement in arc fault performance was a strong motivation to add this feature. Unfortunately, not all points on the bus a easily accessible for insulating. To facilitate manufacturing and assembly, the Line side bus is not insulated for the short length between the cradle and vertical bus. Masking the bar for fluidized bed application would be extremely difficult because of the bar shape and support assembly. For the same reasons, the bar cannot be easily insulated after assembly. The Load side bus is larger and can be partially insulated. It is masked during the insulation process to maintain clear surfaces for mounting radiators and making other bus connections. It is not possible to attach the radiator and then insulate as insulating the radiators would reduce their efficiencies and require larger components which could compromise the dielectric performance or invalidate previous thermal testing.

In the unlikely event that an arc fault is initiated in the uninsulated areas, the arc remains constrained at the back of the circuit breaker or at either of the radiator locations. It does not run the bus as it would in a normal uninsulated Metal-Enclosed design. Controlling the location of the arc improves the overall performance of the equipment.

It is completely understandable that the lack of insulation on some of the bus and the presence of uninsulated radiators looks unusual and may cause some questions, but be assured the design has been thoroughly tested. The current design meets all the requirements of IEEE C37.20.1 and is approved as a Listed design by Underwriters Laboratories. Altering the design to correct what is simply a visual perception and not a design issue would very likely alter the equipment performance in an adverse way.

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