Capacitance Graded Bushings

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Bushings or similar structures are used in medium voltage switchgear to carry a conductor from one side of a grounded barrier to the other side. Typical uses are roof entrance bushings, to bring conductors from outside the switchgear through the roof to the switchgear interior; primary disconnect spouts, to bring the primary connections of a circuit breaker from the bus or cable compartment to the circuit breaker compartment; and main bus penetration from one unit of switchgear to the next unit.

In its simplest form, a bushing consists of a conductor, some surrounding insulation, and a mounting provision of some kind. If the voltage isn't too high, and the configuration of the conductor, the insulation, and the ground plane isn't too bad, a bushing with suitable insulation characteristics and long life can be made with only these basic ingredients.

However, sometimes the spacing is very tight, or the ground plane has sharp corners or protruding hardware so that the local stress on the insulation is excessive. In this case, a capacitance graded bushing may be the answer. In a capacitance graded bushing, layers of conductive or semi-conductive material are placed in the thickness of the insulation in such a manner that these layers serve as a built-in capacitor and the stress on the insulation is equalized and controlled. Proper use of capacitance grading can control both through-insulation and over-surface stress. This technique has long been used in medium voltage switchgear. For instance, GE's vertical lift Magne-Blast circuit breakers, first manufactured nearly 60 years ago, use capacitance graded top-mounted bushings to control the stress where the bushings penetrate the top frame of the circuit breaker.
The figure above, shows a section view of the capacitance graded primary disconnect spout used in Powell's PV System 38® switchgear. Each line in the thickness of the insulation represents a conductive layer. The innermost layer is connected to the primary conductor, and the outermost layer is connected to ground. In addition to controlling the stress in the insulation, this particular construction provides an area around the spout shielded from the electrical field, for mounting current transformers.

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