

TechTopics No. 52

Insulation of switchgear terminations

Siemens occasionally receives queries from users or their installation contractors regarding the need for insulation of the user's power connections to metal-clad switchgear. The user's power connections must be insulated to the same performance levels as are required of the switchgear itself. The user's power connections are typically insulated with tape in accordance with the manufacturer's instructions, or may be insulated with optional, preformed boots available from most switchgear manufacturers.

ANSI/IEEE C37.20.2 for metal-clad switchgear defines "metal-clad" as, among other things, switchgear in which the "primary bus conductors and connections are covered with insulating material throughout" (clause 3.1.5.e). The standard goes on to explain the rationale for requiring that primary conductors and connections be insulated in clause 7.9, which says (in part):

This insulating covering is a requirement of metal-clad switchgear (see 3.1.5) and is provided to minimize the possibility of communicating faults and prevent the development of bus faults that would result if foreign objects momentarily contacted bare bus. This insulating covering is usually only a part of the primary insulation system, and in such cases the outer surface of this insulating covering will not be at ground potential. It should not be assumed, therefore, that personnel can contact this insulating covering with complete safety.

This paragraph contains multiple "nuggets" of wisdom on the subject of insulation in metal-clad switchgear, in general, and on insulation of user's power terminations.

Connections must be insulated

C37.20.2 uses the term "connections," which includes any connection to the primary bus, and specifically includes the user's power connections (cable terminations, bus duct connections, or the like) to the switchgear. All connections must be insulated.

Reduction of fault likelihood

ANSI/IEEE metal-clad switchgear requires insulated primary conductors. It is usually assumed that this is to allow the equipment to be more compact, but this is only a minor consideration. The real intent of having insulated conductors in metal-clad switchgear is to reduce the likelihood of occurrence of arcing faults. There have been many technical papers that emphasize the value of insulated conductors in reducing the likelihood of an arcing fault.

Insulation is a component of the insulation system

In ANSI/IEEE switchgear, the insulation covering is not the entire insulation system of the switchgear, but is actually one part of a coordinated system of insulation, supports and the air surrounding the conductors. The insulation covering the bus bars is required to withstand rated line-line voltage between the conductor and the outside surface of the insulation for one minute (clause 6.2.1.3, Test for bus-bar insulation). To understand this requirement in the context of the overall design, think of this requirement as a one-minute power frequency test for the insulation itself. For 15 kV switchgear, this would require a one-minute test withstand of 15 kV across the bus or conductor insulation.

The complete equipment has a requirement of 36 kV for the one-minute power-frequency withstand voltage test. Therefore, the standards require that the insulation, by itself, have at least 15 kV/36 kV, or just over 40 percent of the total insulation capability of the system. This means that in 15 kV switchgear, as much as 60 percent of the insulation integrity is contained in the air surrounding the conductors. So, if the user's power terminations are not covered with insulation, something in the vicinity of 40 percent of the dielectric strength of the insulation system is lost.

Outer surface of insulation not at ground potential

The last portion of the paragraph reminds the user of the standard that the outer surface of the insulation is not at ground potential, and is therefore not safe to touch. Energized insulated conductors in switchgear must be treated as energized conductors.

Other considerations

The dielectric capability of a switchgear design is a carefully considered balance between dielectric performance, manufacturing cost, equipment size, ease of assembly and installation and a host of other factors. The manufacturer seeks to minimize the variations between various designs (for example, between 1,200 A, 2,000 A, 3,000 A and 4,000 A configurations) and to maximize the use of standard components across various designs. Phase-phase conductor spacing is standardized in each manufacturer's design, with the size of the conductor varying to suit the continuous current rating. Because of this, lower continuous current designs may appear to have sufficient clearance so that they do not require insulation of the user's power terminations. However, this is unwise, as seemingly adequate phase-phase clearance between energized parts does not necessarily imply adequate phase-ground clearance.

In addition, the manufacturer has to consider power-frequency voltage withstand capability (as discussed earlier in this issue), and must also consider impulse withstand capability. The manufacturer conducts lightning impulse withstand tests to verify the performance of their designs. Equipment designed to have insulated user power terminations is not likely to meet the lightning impulse withstand performance levels of the design if the terminations are not insulated.

Some users request special designs to accommodate uninsulated user power terminations, such as by installing insulating barriers between the phases, and between the outer phases and ground in the user's power termination areas. This can be done, but is generally undesirable for these reasons:

- Since the terminations would not be insulated, it causes the switchgear to fail to comply with ANSI/IEEE C37.20.2 standards for metal-clad switchgear.
- Addition of barriers increases the cost of the equipment.

- The manufacturer may add barriers but may not have performed design tests to ANSI/IEEE C37.20.2 to verify that the equipment meets the dielectric performance requirements of the standard, including both the power frequency (one-minute) withstand voltage and the lightning impulse withstand voltage levels.
- Addition of interphase/outerphase barriers increases the "clutter" in the termination area. If the barriers must be removed to provide access for examination of the main bus, the barriers make the operation more difficult, and may also make it less likely that the main bus area will be periodically inspected. Moreover, if the barriers are removed during maintenance and are not replaced, the dielectric capabilities of the equipment are compromised.

Summary

- Insulated user power terminations are required by the standards for metal-clad switchgear.
- Insulation reduces the likelihood of occurrence of arcing faults.
- Insulation is required to meet the dielectric performance levels of the standards.

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