

TechTopics No. 88

Application of maintenance grounds in switchgear

This issue of TechTopics is one of several on the subject of protective grounding in switchgear assemblies. TechTopics No. 87 discussed ground and test devices used in metal-clad switchgear. This issue of TechTopics discusses other means of applying safety grounds in switchgear.

Temporary personal protective grounds (often called “safety grounds”) are a very important element of the process of creating an electrically safe work condition as defined by NFPA 70E, the Standard for Electrical Safety in the Workplace, and as required by the Occupational Safety and Health Administration (OSHA) regulations.

Under the concept of NFPA 70E, achieving an electrically safe work condition requires:

1. Identification of all possible energy sources for the equipment
2. Opening and isolating each of the identified sources
3. Where possible, visually verifying that sources are isolated
4. Applying lockout/tagout devices to all identified sources
5. Using appropriate voltage test device to verify absence of voltage
6. Applying grounds to the phase conductors before contacting them.

Today, many specifications for switchgear products include requirements for temporary grounding, with most specifications calling for ground and test devices, and other specifications requiring grounding switches (or as termed in IEC standards, “earthing switches”), ground studs or similar devices. Regardless of the means specified, the intent includes the desire to be able to establish a ground condition on the primary conductors, to achieve what NFPA 70E® calls an “electrically safe work condition”.

This involves establishing a ground connection that is capable of carrying the available system fault current for the duration that upstream protective devices (e.g., circuit breakers, fuses or other devices) would allow the fault current to flow.

Many steps must occur before the safety grounds are applied. In essence, grounding is the last step in a coherent process. If the entire process is not followed, including all of the first five steps, there is a risk of shutting down a live system and disrupting the production process, and a significant risk of injury to personnel.

In the application of safety grounds to the electrical system, it is imperative that the user develop comprehensive operating instructions to implement the requirements of NFPA 70E. These are needed to avoid unintended shutdown of the electric system, and to reduce the hazards that the operating personnel and others near the equipment may be exposed to.

There are a number of ways that safety grounds can be applied:

- Ground and test device
- Grounding switch (earthing switch)
- Ground studs, or ground bails, or ground pads.

Let us examine each in turn.

Ground and test device

Unless used with grounding studs or ground bails, a ground and test device has been tested to carry the rated short-circuit current of the switchgear for a duration of two seconds. See TechTopics No. 87 for a more complete discussion.

Grounding switch (earthing switch)

Grounding switches are a popular option in equipment constructed to IEC standards, principally IEC 62271-102 (replacement for IEC 60129), but have generally not been favored in markets based on ANSI/IEEE standards. Figure 1 shows a grounding switch in switchgear, with the left hand photo showing the switch in the normal service position (not grounded) and the right hand photo showing the switch in the grounded position.

The interphase barriers have been removed from the grounding switch for the photos of Figure 1. Most often, these switches do not have a fault-making capability, although fast-acting switches with a making capability are available. If the switch has a making capability, the minimum capability is two making operations, with an optional extended capability of five making operations. In short, IEC earthing switches have a limited electrical endurance. In addition, the available ratings for IEC earthing switches are often relatively limited.

A grounding switch, as can be seen, has bare conductors. Therefore, installation of a grounding switch in ANSI/IEEE metal-clad switchgear violates one of the principles of metal-clad switchgear, that all conductors in the switchgear structure are insulated. The purpose of the insulation is to decrease the likelihood of faults in the switchgear, particularly arcing faults.

Ground studs, ground bails or ground pads

These types of grounding means are very similar, so we will discuss them as a group. Figure 2 shows an example of ground studs, both with and without the available grounding stud cover. The ground stud shown is probably the most commonly used type, usually referred to as a ball-stud type. The equipment should be designed to meet the equipment dielectric ratings even when any grounding stud cover on ground studs is removed. Whether ground studs or ground bails, the short-circuit capability of the ground stud or ground bail is limited to the capabilities of the grounding cable and/or grounding clamp, whichever is lower.

In the case of ground pads, the situation is somewhat different. A grounding pad, such as can be supplied in a manual ground and test device, is simply a NEMA four-hole pad to which multiple cables per phase can be connected. With multiple cables, the short-circuit capability can approach the rated short-circuit current of the switchgear. However, with ground pads, when only one cable per phase is used, the same short-circuit limitation applies as with ground studs or ground bails.

What are the limits imposed by cables? These limits are contained in ASTM F855, "Specifications for Temporary Grounding Systems to be used on De-energized Electric Power Lines and Equipment", and are essentially determined from the physical limits of the cables themselves. For the most commonly used grounding cable, a 4/0 cable, the limitation is 43 kA for 15 cycles. This equates to about 15.2 kA for two seconds, based on simple I-squared-T comparison. The rated short-time duration in most switchgear assemblies is two seconds, as is the rated permissible tripping delay of circuit breakers to ANSI/IEEE C37.04.

Figure 1: Grounding switch - left in normal (non-grounded) position, right in ground position

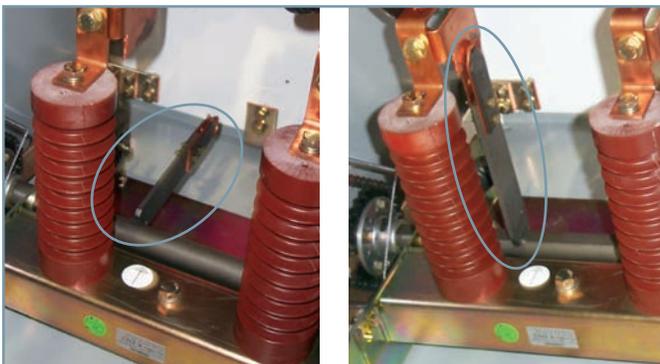
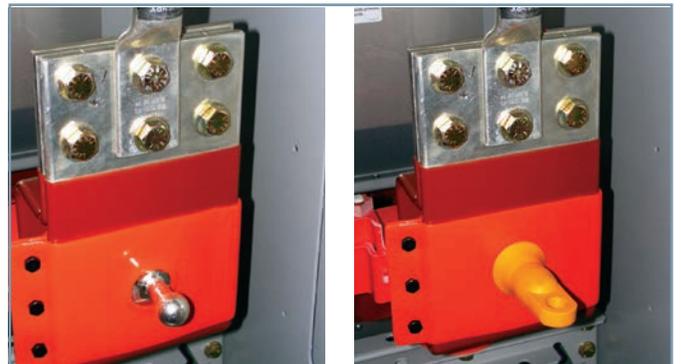
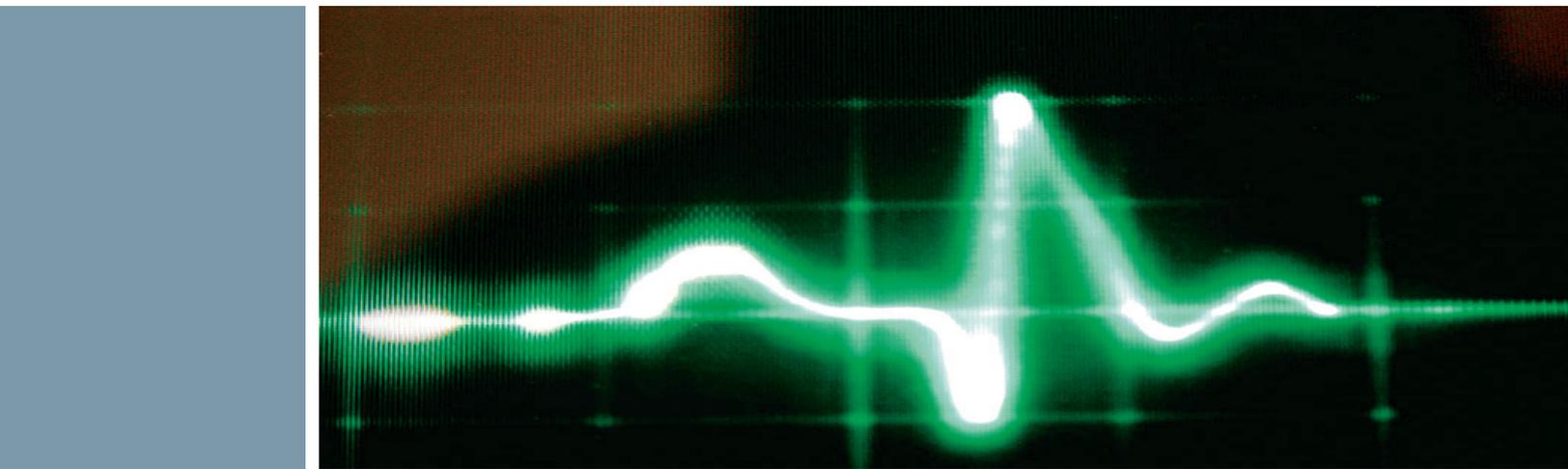


Figure 2: Ball-type ground stud - left with cover removed, right with cover in place





So, for a typical switchgear assembly rated 40 kA short-circuit, three 4/0 cables per phase would be required to achieve 40 kA short-time current capability for two seconds of the grounding path. This is possible only with multiple cables per phase, which in turn requires ground pads. With ground studs or ground bails, the most commonly used ground cable is capable of only a small fraction of the short-circuit current available on the system.

A significant issue with the use of ground studs, and with ground clamps, is that the devices must be properly installed on the equipment to achieve the performance for which the ground cable and clamp system is capable. A number of years ago, one of our customers investigated various grounding clamps and grounding systems in the short-circuit laboratory, using grounding clamps from a variety of grounding system vendors. The results made it quite clear that an excellent clamp/cable system, installed improperly, would not deliver the performance intended.

When grounding cables and grounding clamps are employed, the user must be sure that the system short-circuit capacity and fault duration are within the capabilities of the grounding cables and ground clamps used, to avoid any possibility that a system could become re-energized with the grounds in place, which could result in the failure of the grounding system to protect the personnel as intended.

NFPA 70E provides the process to achieve an electrically safe work condition. A key element of the process is the installation of temporary personal protective grounds. Siemens recommends that ground and test devices be used in metal-clad switchgear. We recognize that grounding cables and grounding clamps (to ASTM F855) are widely used and may be the only option available outside of the switchgear, such as in terminal chambers, manholes, and similar locations.

Regardless of the system used, the user must have a comprehensive process to achieve the level of protection for the operator as contemplated by NFPA 70E.

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