

TechTopics No. 70

Arc-resistant switchgear accessibility types

This issue of TechTopics discusses the “accessibility types” for arc-resistant switchgear. Accessibility types define the placement of cotton indicators used during internal arcing tests of switchgear. The condition of the indicators following an internal arcing test is one of the major determinants as to whether a test specimen has met the requirements of the standard for a successful test.

The most commonly referenced standards for arc-resistance are ANSI/IEEE C37.20.7-2007 and EEMAC G14-1 (1987). Both documents are derived from concepts established in Annex AA of IEC 298 (1981), which was the pioneer document that defined internal arcing tests.

EEMAC G14-1 (1987) was very similar to the IEC 298 document and reflected lessons learned in the years since the IEC document was issued. ANSI/IEEE C37.20.7 was first issued in 2001, revised in 2007 and incorporated improvements over both the IEC and EEMAC documents. CSA issued a new standard, C22.2 No. 0.22 in 2011, adopting much of the language of ANSI/IEEE C37.20.7-2007. The new CSA document effectively replaces the old EEMAC G14-1, as EEMAC is no longer operational.

The accessibility types defined in ANSI/IEEE C37.20.7 are paraphrased below:

- Type 1: Arc-resistant functionality at the front of the equipment only.
- Type 2: Arc-resistant functionality at the front, rear and sides of the equipment only.

In addition, modifiers (or suffixes) may be added to these type designations:

- Suffix A: A suffix used if no other suffix applies
- Suffix B: Arc-resistant functionality is maintained in designated low-voltage compartments
- Suffix C: Arc-resistant functionality in compartments adjacent to the compartment in which the arc occurs
- Suffix D: A modification of type 1 in which one or more of the enclosure surfaces is excluded from the arc-resistant category. For example, type 1D-SR would indicate a design with arc-resistant functionality on the front and the right side only, with the rear and the left side considered inaccessible to personnel.

The working group for ANSI/IEEE C37.20.7 chose not to adopt the accessibility type scheme of IEC or EEMAC for several reasons. First, the accessibility types in the various documents differ, and the working group wanted to make it clear that an accessibility type in one document might not be identical in performance to that in another document. In addition, the EEMAC document identified types A, B and C, but types A and B concerned personnel safety whereas type C related to the amount of damage to the equipment during the test. Type C was thus considered as irrelevant to personnel safety.

The type designations determine where flammable cotton indicators are placed around the test group of switchgear in the high-power test laboratory when an internal arcing test is conducted. Indicators are placed around the equipment as follows:

- Vertical indicators are placed 100 mm from the enclosure walls, from the floor to a height of 2 m (79”), facing areas thought to be likely to emit gases during the test. The indicators cover approximately 40 to 50 percent of the area of the switchgear wall being evaluated.
- Horizontal indicators are placed at a height of 2 m (79”) above the switchgear mounting surface and cover essentially the entire area from 100 mm to 800 mm from the switchgear wall.
- In both cases, the indicators extend beyond the switchgear by at least 300 mm so as to evaluate the effect of gases escaping at an angle from the enclosure.

Tests are conducted on a number of test specimens so that all of the switchgear configurations utilized for production orders have been evaluated in the test laboratory. The criteria for success in testing are summarized as follows:

- Criterion 1: Properly secured covers and doors do not open. Distortion may occur.
- Criterion 2: The enclosure remains essentially intact. Small parts (up to 60 g) may be ejected.
- Criterion 3: No openings in the enclosure wall are created by the arcing in the areas being evaluated (essentially in the area of the vertical indicators). Openings above the 2 m (79”) elevation can occur provided that they do not cause ignition of the cotton indicators.
- Criterion 4: No indicators ignite due to escaping gas. Indicators may be ignited by other causes, for instance, as a result of a label that ignites and causes the cotton indicator to ignite, but this must be clearly documented (usually with high-speed video).
- Criterion 5: The grounding connections are maintained.

The new CSA C22.2 No. 0.22 (2011) document uses the same accessibility types defined in ANSI/IEEE C37.20.7-2007. These differ from the accessibility types in the older EEMAC G14-1 (1987) document, but roughly correspond as follows.

IEEE C37.20.7-2007 and CSA C22.2 No. 0.22 (2011)	EEMAC G14-1 (1987)
Type 1	Type A
Type 2	Type B
Type 2C	Type C

Some Canadian users request a modified type C or type 2C in which an arc in the main bus compartment of metal-clad switchgear is not allowed to propagate into the main bus compartment (of the same circuit) of an adjacent section. This is a unique requirement and is not pertinent to personnel safety, so is not supported in the ANSI/IEEE C37.20.7-2007 document.

The preferred rated arcing current is equal to the rated short-time current of the assembly and the preferred rated arcing duration is 0.5 s. Earlier standards suggested an arcing duration of 1.0 s, but a study performed by the ANSI/IEEE C37.20.7 working group determined that an arcing duration of 0.5 s was sufficient. This study considered a worst-case situation of a group of switchgear fed by a transformer with the primary of the transformer protected only by fuses (in other words, transfer tripping of the high-voltage source is not possible). The study considered the thermal withstand capabilities of transformers and the protection of the transformers, and this led to the selection of the preferred duration of 0.5 s.

Several of the members of the ANSI/IEEE C37.20.7 working group co-authored an IEEE paper on application of arc-resistant switchgear. One of the key recommendations of this paper is that arc-resistant switchgear should include some form of protection that responds to an internal failure of the switchgear and initiates tripping of all sources of power in the event of an arcing fault. A variety of protection forms may be appropriate, including differential protection, arc-detection sensors (for example, light sensitive or pressure sensitive), partial differential protection or zone-selective (reverse interlocking) protection. These forms of protection are particularly appropriate when multiple power sources are involved, a situation not covered in the selection of the preferred arcing duration of 0.5 s.

No discussion of arc-resistant switchgear is complete without a few caveats. Arc-resistant equipment is only deemed "arc-resistant" when it is in its "arc-resistant" condition. This requires that the equipment be properly installed in accordance with the manufacturer's instructions, that all doors and covers be properly secured and that any exhaust vents be free of obstructions. In particular, if a door is open to a medium-voltage compartment, the equipment is not in its "arc-resistant" condition and the level of protection to personnel may be compromised.

In addition, the concept of arc-resistant construction considers only the thermal and pressure effects of arcing and does not consider other effects of arcing that may present a hazard. Internal arcing in switchgear equipment liberates huge quantities of heat energy, as the temperature at the arc roots may approach 20,000 K, significantly hotter than the temperature of the surface of the sun. This causes extreme pressures as copper, steel and other materials are vaporized. Gases released may include toxic gases. Sound pressure levels are typically extremely high. These and other conditions must be considered in the selection of personal protective equipment.

Finally, the discussion in this issue of TechTopics is only intended as a brief summary of the ANSI/IEEE C37.20.7-2007 document. The reader is strongly encouraged to read the actual C37.20.7 guide. There is a great deal of additional discussion in the testing guide with which users should be familiar.

References:

1. ANSI/IEEE Standard C37.20.7-2007, "IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults," IEEE (<http://standards.ieee.org>)
2. EEMAC G14-1 (1987), "Procedure for Testing the Resistance of Metal-Clad Switchgear Under Conditions of Arcing Due to an Internal Fault," EEMAC (<http://www.electrofed.com>)
3. "Strategies for Mitigating the Effects of Internal Arcing Faults in Medium-Voltage Metal-Enclosed Switchgear;" Wactor, Olsen, Ball, Lemmerman, Puckett, Zawadzki; presented at 2003 IEEE PCIC conference, (PCIC-3-09) IEEE (<http://www.ieee.org>)
4. CSA C22.2 No. 0.22-2011, "Evaluation Methods for Arc-Resistance Ratings for Enclosed Electrical Equipment."

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Siemens Industry, Inc.
7000 Siemens Road
Wendell, NC 27591

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For more information, contact: +1 (800) 347-6659

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