

# TechTopics No. 60

## Use of cable for connections in medium-voltage switchgear

For many years, it has been common practice to use unshielded, insulated cable in medium-voltage metal-clad switchgear and metal-enclosed interrupter switchgear for connections to such devices as voltage transformers (VTs), control power transformers (CPTs), surge arresters, etc. Often, the cable used is applied at a higher voltage than the same cable could be used if it were shielded, e.g., 15 kV cable used in 38 kV switchgear. Occasionally, Siemens is asked if this is allowed by the standards for medium-voltage switchgear. The answer is yes, this is in full conformance with the ANSI/IEEE standards and the NEC®, as the application of the cable is not like a “normal” shielded cable application.

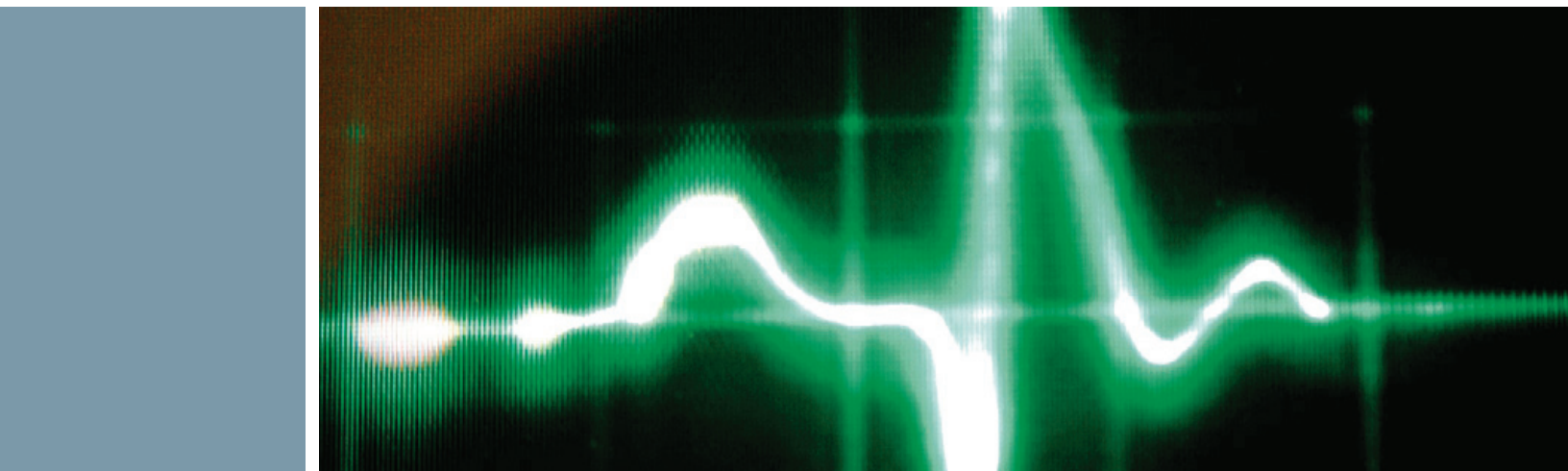
In a “normal” shielded cable application, the cable is located inside a grounded metallic shield, placing a ground plane directly adjacent to the cable insulation. For shielded cable, the cable insulation provides the entire dielectric integrity, and must be capable of handling the full dielectric levels associated with the rated system voltage. As applied in switchgear, the dielectric stress on the cable insulation is quite different.

The dielectric levels for medium-voltage switchgear are shown below.

Power cables used for distribution system wiring outside of the switchgear must be shielded. The purpose of the concentric outer shield is to make the dielectric field uniform, providing a uniform dielectric stress for the cable insulation. Such a shield is required for cables installed in permanent installations operated above 2,000 volts, in accordance with NFPA 70®-2011 NEC article 310.10(E). However, article 300 of the NEC does not apply to conductors that form an integral part of equipment, such as factory-assembled control equipment or listed utilization equipment, as indicated in NEC article 300.1(B). Hence, use of non-shielded cable as an integral part of equipment complies with the requirements of the NEC.

Our switchgear conforms to the requirements of the applicable ANSI/IEEE standards for the switchgear (C37.20.2, Standard for Metal-Clad Switchgear, or C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear). The requirements relative to insulation haven’t changed significantly from the 1969 version (then part of ANSI/IEEE C37.20). The standard continues to allow use of cable for connections in medium-voltage switchgear.

Withstand voltage	Maximum design voltage of switchgear		
	4.76 kV	8.25 kV or 15.0 kV	38.0 kV
60 Hz withstand voltage (1 minute)	19 kV	36 kV	80 kV
Lightning impulse withstand voltage (BIL)	60 kV	95 kV	150 kV



The requirements for insulation used on conductors (whether rigid or flexible) are contained in clause 6.2.1.3 of ANSI/IEEE C37.20.2-1999 (or the similar clause 6.2.7.1 of ANSI/IEEE C37.20.3-2001), which defines the test requirements for insulation used on bus bars. This particular clause is commonly referred to as the “foil test,” and simply stated, requires that tin foil (or a similar flexible conductor) be wrapped around the exterior of the insulated sample and connected to a power frequency high-potential test set. The conductor is connected to ground, and the exterior foil energized at full rated line-line voltage (4.76 kV, 8.25 kV, 15 kV or 38 kV, according to the switchgear rating) for one minute. If the insulation successfully withstands this test, it meets the requirements for use in medium-voltage switchgear.

For reference, the text of clause 6.2.1.3 of ANSI/IEEE C37.20.2-1999 is excerpted:

#### 6.2.1.3 Test for bus-bar insulation

The insulated bus-bar sample shall have a rated maximum voltage at the rated power frequency applied from the conductor to an electrode effectively covering the outer surface of the insulation but sufficiently far from the ends of the sample to be able to withstand the test voltage. The insulated bus-bar sample shall have construction that is typical of bus bars, elbows, splices, and joints as used in the manufacturer’s design. The ac test voltage shall have a value not less than the appropriate rated maximum voltage as shown in Table 1. The ac test voltage shall have a crest value greater than or equal to 1.414 times the rms value, and the wave shape shall be essentially sinusoidal. The test voltage shall be applied for 1 min.

The practical effect of the “foil test,” is to require that a certain minimum insulation level exists within the insulation itself, and the balance of the required insulation level can be obtained through use of insulating supports, air clearance or any method the manufacturer selects. To put this in perspective, consider the case of 15 kV class equipment.

For 15 kV switchgear, the rated high potential (60 Hz withstand voltage) of the complete equipment is 36 kV, and the insulation of the cable must withstand at least 15 kV (approximately 40 percent) of this level. The remaining 60 percent (or so) of the dielectric capability is provided by the insulating supports, air clearance and the like.

Siemens medium-voltage switchgear designs fully comply with these requirements. Siemens has over 40-years experience with unshielded cables used for connections to VTs, CPTs, surge arresters and similar connections, with excellent field experience.

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