UNDERSTANDING LV CABLE INSULATION

Low-Voltage Cables

ANIXTER

For cables rated 0 through 2,000 volts, the in-service voltage stress on the insulation is so low that the concept of insulation levels is largely unnecessary. For example, the operating voltage stress on a typical 600-volt cable is about 5 volts per mil of insulation thickness, i.e., each mil (0.001 inch) of insulation must withstand only 5 volts of electrical stress. On the other hand, the in-service voltage stress on a typical 15 kV cable is about 50 volts per mil or 10 times more than that for a 600-volt cable. 600-Volt rated cables have much thicker insulation per volt of applied electrical stress and are thus over insulated from a voltage stress point of view. As a result, the cable insulation thickness specified by industry standards for use in a grounded (100 percent) electrical system is also acceptable for use on an ungrounded (133 percent) electrical system.

There may be some applications that require 173 percent insulation levels for low-voltage systems such as high-resistant grounding systems. 173 percent insulation levels are not addressed by most industry standards. However, NEMA and ICEA standards such as ICEA S-95-658-1999 *Standard for Nonshielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy* recommends the use of a cable rated at least 1.73 times the phase-to-phase system voltage. For example, a 480-volt system would require the use of a cable rated at least 830 volts. Because of commercial availability, a 1 kV rated cable is typically used for this type of application in Canada and a 2 kV cable would be used in the United States.

Non-Shielded Cables Rated 0 - 2400 volts

THE OKONITE COMPANY

The NEC does not provide voltage level categories for non-shielded cables rated 0-2.4kV. The insulation thickness' as prescribed by the NEC and UL are based on mechanical requirements and are over-insulated for the voltages involved. Note that ICEA does provide these insulation levels for non-NEC applications.

Overall, insulation level for shielded medium voltage cables are based on the operating parameters of the system. The choice of 100, 133 or 173% is based on duration of the fault interrupting device. Guidelines for the appropriate level can be found in standards like:

The NEC • IEEE Red Book • ICEA • AEIC

Many medium voltage end users prefer 133% insulation level for additional security and for an additional safety factor to address the rigors of cable in installation and splicing/terminating.

Non-shielded cables are over insulated and as such do not follow the insulation level convention.

2.7.2.1.1 Limitations of High Resistance Grounded (HRG) Systems

The limitation of the system is that the capacitance current should not exceed approximately 10 A to prevent immediate shutdown. As the system voltage increases, so does the capacitance current. This limits the applications to systems of rated voltages of 4.16 kV and below.
hough immediate shutdown is prevented, the fault situation should not be prolonged; the fault should be localized and removed. There are three reasons for this:

1. The unfaulted phases have voltage rise by a factor of $\sqrt{3}$ to ground. This increases the normal insulation stresses between phase-to-ground. This may be of special concern for low-voltage cables. If the time required to de-energize the system is indefinite, 173% insulation level for the cables must be selected [11]. However, NEC does not specify 173% insulation level and for 600 V cables insulation levels correspond to 100% and 133%. Also Ref. [6] specifies that the actual operating voltage on cables should not exceed 5% during continuous operation and 10% during emergencies. This is of importance when 600 V nominal three-phase systems are used for power distributions. The dc loads served through six-pulse converter systems will have a dc voltage of 648 and 810 V, respectively, for 480 and 600 V rms ac systems.
2. Low levels of fault currents if sustained for long time may cause irreparable damage. Though the burning rate is slow, but the heat energy released over the course of time can damage cores and windings of rotating machines even for ground currents as low as 3–4 A. This has been demonstrated in test conditions [12].
3. A first ground fault left in the system increases the probability of a second ground fault in another phase. If this happens, then it amounts to a two-phase-to ground-fault with some interconnecting impedance depending upon the fault location. The potentiality of equipment damage and burnout increases.