

INSULATION LEVELS

Cable insulation is designed to withstand the voltage stresses a cable will experience over its expected lifetime. An insulation level defines various insulation thicknesses within a single voltage rating. The two most common levels are 100 percent and 133 percent. Normally, 100 percent insulation level is used on a grounded system and is sometimes also referred to as a grounded insulation thickness. Likewise, the 133 percent level is normally used on an “ungrounded” system and is referred to as an ungrounded insulation thickness. A 173 percent insulation level also exists and is normally used on an ungrounded system where further fault clearing time is needed.

INSULATION THICKNESS FOR VARIOUS LEVELS

The specified insulation thickness for each insulation level is similar among various industry standards. The thickness varies with insulation level, generally becoming thicker as the insulation level increases. Typical insulation thicknesses for many medium-voltage cables are shown in Table 1. Specific insulation thicknesses for voltage ratings up through 46 kV and various conductor sizes are given in National Electrical Manufacturers Association (NEMA), Insulated Cable Engineers Association (ICEA), Underwriters Laboratories (UL), Canadian Standards Association (CSA) and National Fire Protection Association (NFPA) publications.

Voltage Rating (kV)	Insulation Level (%)	Typical Insulation Thickness	
		mm	mils
5	100	2.29	90
	133	2.92	115
	173	3.56	140
8	100	2.92	115
	133	3.56	140
	173	4.45	175
15	100	4.45	175
	133	5.59	220
	173	6.6	260
25	100	6.6	260
	133	8.13	320
	173	10.67	420
35	100	8.76	345
	133	10.67	420
	173	14.73	580

Table 1: Insulation Thicknesses for Insulation Levels

LOW-VOLTAGE CABLES

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.

AREAS OF INSULATION LEVEL USE

The cable insulation level required for a specific application depends on the speed at which the protective relay is designed to de-energize the electrical system in case of an electrical ground fault. A ground fault is an electrical short circuit from one phase (one conductor) of the electrical system to ground. If the protective relay is set to de-energize the system in less than one minute, a cable with a 100 percent insulation level is adequate according to industry standards. If the protective relay is designed to de-energize the system within one hour, a cable with a 133 percent insulation level is required. If the protective relay is designed to de-energize the system after an indefinite period of time, a 173 percent insulation level cable is required. If desired, a cable with thicker insulation than specified in industry standards can be used for maximum system reliability.

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Anixter Inc. World Headquarters

2301 Patriot Boulevard
Glenview, Illinois 60026
224.521.8000

1.800.ANIXTER | anixter.com



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