Cable Lore

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VOLTAGE RATINGS, BIL, AND OVERVOLTAGES

Voltage Ratings

The voltage rating of a power cable is defined as the nominal phase-to-phase voltage of the equivalent three-phase circuit for which the cable is designed. The individual cables are then insulated for the phase-to-ground voltage on such a system, i.e., for 0.577 times the phase-to-phase rating. Unless otherwise indicated, it is assumed that the values quoted are RMS values at 60 Hz.

Virtually all power cables are utilized on so-called constant voltage power systems. The normal phase-to-phase and the phase-to-ground voltages of such systems are relatively stable. But they do vary somewhat with the power system loading. In recognition of this fact, cable specifications do permit continuous operation of cables at up to 5% above rated voltage, and emergency operation as high as 10% above rated voltage for 15 minutes. Such fluctuations are not an important hazard to power system equipment.

Basic Impulse Level (BIL)

However, the occasional transient steep front overvoltages that inevitably occur on all power systems, due to switching surges and lightning, are a major electrical hazard. When a power system component is designed with sufficient clearances and insulation to withstand high voltage steep front surges of certain magnitudes, the design level is known as the Basic Impulse Level (BIL). Coordination of the BIL's for various pieces of equipment in a power system leads to a system Basic Impulse Insulation Level (BIIL).

A 15 kV power cable is insulated for continuous operation at 8.66 kV conductor to ground and does not normally carry a BIL rating, but AEIC Specifications Nos. 5 and 6 require cables to withstand impulse voltages 125% of a BIL which depends on cable rating. For example, the BIL requirement for a 15 kV cable is 110 kV. A 15 kV UniShield EP cable has a BIL of about 220 kV. Cables should have a higher BIL than other system equipment. Voltage reflections occur when a voltage surge encounters the usual impedance mismatches at cable/ other equipment (such as a transformer) interfaces. These reflections, unless the cable is very long or a shorter length matched to the impulse wave train, multiply the voltage peak in the cable. Most fishermen have seen "tidal rips" and large waves follow smaller waves in a somewhat regular pattern. All these effects are wave phenomena.

Overvoltages

Some of the causes of transient overvoltages on power systems and cables are the following:

1. Lightning, either by direct strokes or by induction from nearby strokes.

2. Switching surges due to the opening or the closing of curcuits to transmission lines, cables, capacitors, motors or transformers,

3. Phase-to-ground arcing of ungrounded power systems that do not have adequate ground fault protection.

4. Resonance and ferroresonance conditions on long or lightly loaded circuits.

Obviously, very few power circuits are immune to all of the circumstances that can subject them to transient overvoltages, but the overvoltages can be moderated by the proper use of protective devices such as lightning arrestors and static wire shields.

At room temperature, a well-made cable insulated with XLPE can withstand higher ac and impulse voltages than one insulated with EP. However, XLPE insulation begins to lose this advantage as the operating temperature exceeds 90°C. Above this temperature, both its physical and electrical withstand properties are reduced. In the range of the present emergency overload temperature, 130°C, the physical properties of XLPE are inferior to those of EP insulation, and it no longer possesses any electrical advantage. Further, repeated impulses in the presence of moisture can significantly reduce the BIL level of XLPE insulation.

Since EP insulated cables have better physical and electrical properties at 130°C and better resistance to deterioration by water, EP cables will outperform XLPE insulated cables.

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