Cable Lore

ANACONDA

BY POWER CABLE ENGINEERING AND RESEARCH

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TEMPERATURE RATINGS AND OVERLOADS

The previous Cable Lores, (Nos. 41-52) explain how cable properties can be degraded by environments involving:

1. Above Grade Applications

2. Below Grade Applications

3. Nuclear Generating Stations Containments

Cable deterioration can also occur in service whenever the temperature rating of the cable is exceeded.

Temperature Ratings

The temperature ratings of power cables refer to the actual conductor temperature, not to a rise above ambient temperature as is the practice with some equipment ratings. The allowable conductor temperature is established by the ability of the nonmetallic components of the cable – insulation, polymeric part of the shielding system, and the jacket – to withstand elevated temperatures for certain periods of time.

Time enters into consideration for two reasons. First, thermal degradation is a chemical process that inescapably involves time. Second, the conduction of heat through a material is not instantaneous. It requires time to transfer heat from the cable conductor to the cable surface where it can be dissipated into the environment.

Most of the heat that is generated in a power cable is the result of power losses that occur because of current flow in the conductor. The conductor usually attains the highest temperature of any of the cable components.

It is not surprising then that power cables carry three temperature ratings (established somewhat arbitrarily on the basis of some laboratory data and field experience) and each of these ratings involves time.

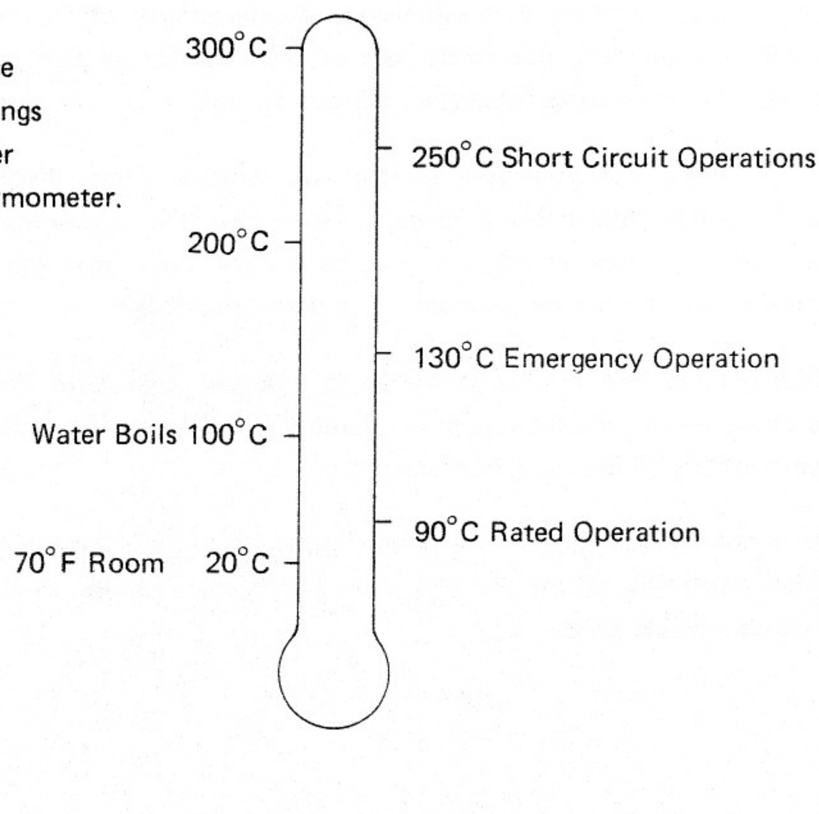
1. The *normal or service rated temperature* of a cable does not carry a specified time element, but cables are expected to operate many years at that temperature. Experience and laboratory investigations indicate that at or below this temperature, no significant temperature-dependent deterioration will occur during a reasonable service life.

2. The *emergency overload temperature* rating of rubber and plastic insulated power cables involves a time limitation of not more than 100 hours at that temperature in any consecutive twelve-month period, and not more than 500 hours at that temperature during the service life of the cable.

3. The *short-circuit temperature rating* of a cable is associated with times that are measured in fractions of a second. Power systems are usually capable of delivering many times their rated current to a system short-circuit. To minimize damage, systems are usually equipped with overcurrent protective devices that will interrupt the flow of fault current in a few cycles. For example, if the flow of fault current in a 60 Hz system is interrupted in 10 cycles, the time involved is 10/60 or 0.167 seconds. Seldom are well designed power systems permitted to carry short-circuit currents continuously for as long as one second.

Short-circuit currents are so large that they are capable of raising conductor temperatures almost instantaneously but the current exists for such a short time that there is little opportunity for the insulation to conduct the heat from the conductor during the period of the fault. Hence, it does require some time after the fault for the cable to dissipate the heat surge and regain its normal thermal state.

The relative magnitudes of these three standard temperature ratings for EP and XLP insulated power cables are indicated on the thermometer.



The 130C emergency rating of EP based insulation is justified by laboratory data showing no shrinkback of the insulation, little expansion, and no deformation at 130C and above. Experiences involving noticeable shrinkback, excessive radial expansion and considerable deformation of XLPE insulations are causing the industry to seriously question the validity of the 130C emergency rating presently ascribed to XLPE.

Overloads

Any conductor current that results in the conductor temperature exceeding its normal rated value is an overload. An overload situation can develop in several ways:

1. The conductors may be undersized for the ampere loading in the particular thermal environment.

2. The connected load or its load factor may increase more than anticipated.

3. The thermal environment may be changed after the cables are installed. For example:

   a. Directly buried or duct circuits may produce sufficient heat to dry the surrounding soil, thereby increasing the soil thermal resistivity, resulting in increased conductor temperatures at the same ampere loading.

   b. Installation of additional power cables in previously empty ducts may cause an excessive increase in duct bank temperature.

   c. Additional cables may be added to cable trays, increasing the amount of heat and limiting the circulation of cooling air.

   d. Thick fire-stops in cable trays may seriously interfere with heat dissipation from cables.

   e. Steam Lines increase ambient temperature near the cable circuits.

   f. The surface above an underground circuit may be paved.

4. Electrically paralleled cables may not share load equally because of impedance imbalance.

5. The available fault current from the power systems may be greater than that anticipated during the cable circuit design. This can occur as the result of the serving utility's effort to improve their system's voltage regulation.

6. Fuses, or relays and circuit breakers may not function properly.

In this Cable Lore, the fundamental basis for the temperature ratings of power cables has been explained and a number of circuit and environmental conditions that can result in cable overloads have been described.

Since EP has high temperature properties superior to those of XLPE – no shrinkback, little expansion, and no deformation as discussed in Cable Lores 42, 43, & 45 – we believe, EP insulated power cables will perform better under overload conditions than XLPE insulated cables. This superiority is based on the fact that the structure of EP is temperature-independent; it is a true rubber, while XLPE is a crystalline material below about 100C but a weak rubber above 100C when the crystalline regions have melted.

The effect of overvoltages will be discussed in the next Cable Lore.

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