

The temperature ratings of wire and cable products are key operating parameters. The use of wire and cable products outside their design temperature range can result in premature and often expensive failures in service. Some of the most common temperature ratings used in the wire and cable industry are discussed below.

MAXIMUM OPERATING TEMPERATURE

This is the temperature rating that most cable users think of first. It is usually defined as the maximum continuous temperature that the wire can withstand during its lifetime. It is generally limited by the thermal aging characteristics of the polymers, i.e., the plastics used to insulate and/or jacket the wire. The metallic components of the wire seldom limit the temperature rating except in high-temperature wire where oxidation of the metal begins to become a significant factor at approximately 250° C.

Most polymers age by gradually becoming brittle over time. One common measure of brittleness is referred to as elongation. This is a laboratory measurement of how much the material can stretch before it breaks. Polymers used in the wire industry typically start life with an elongation in the 300 to 700 percent range depending on polymer type. That is, some polymers can be stretched up to seven times their original length before they break. The end-of-life for polymers is often defined as the point at which the elongation declines to 50 percent because at that point even minor bending of the wire or cable can cause cracking of the insulation, the jacket or both.

Every polymer has its own unique thermal aging characteristics. However, as a rule-of-thumb, for every 10° C the operating temperature of a polymer is increased, the life is decreased by a factor of two. For example, a wire that is designed to survive 40 years at 90° C would be expected to survive only 20 years at 100° C and 10 years at 110° C. The mathematical model used to calculate the relationship between temperature and cable life is called the Arrhenius relationship^[1] after the Swedish chemist that developed it. The Arrhenius relationship coupled with field experience and laboratory aging tests are the basis for the operating temperature rating assigned to most wire and cable products.

MINIMUM COLD BEND TEMPERATURE

Most polymers become increasingly brittle as their temperatures are lowered. Depending on polymer type, they begin to crack when bent at temperatures ranging from -10° C down to approximately -80° C. The minimum cold bend rating for wire is usually defined as the lowest temperature at which it can be bent without cracking under specific laboratory conditions. There are several test methods in use by the industry to determine this

temperature. They generally involve cooling the wire to a specified temperature (-25° C is typical) and then bending the wire around a mandrel whose diameter is in the range of 4 to 8 times the wire diameter. Details of one such test method are given in Section 7.5 of UL Standard 2556.^[2]

MINIMUM INSTALLATION TEMPERATURE

This is the lowest installation temperature recommended by the cable manufacturer for a given wire or cable. This temperature is usually 10 to 20° C warmer than the laboratory cold bend temperature rating to compensate for the higher mechanical forces often encountered during installation.

MINIMUM CONTINUOUS FLEXING TEMPERATURE

The minimum continuous flexing temperature is the lowest temperature at which a wire can withstand repeated flexing throughout its lifetime without damage. This rating is especially important for applications in which the wire or cable will be flexed thousands or even millions of times while at very low temperatures. An example of such an application is the wiring for an automated material handling system located inside an ice cream storage warehouse where the ambient temperature is maintained at -30° C.

EMERGENCY OVERLOAD AND SHORT CIRCUIT TEMPERATURES

In certain situations, power cable users must operate a cable at a higher than normal electrical load (i.e., temperature) for a limited period of time. As a result, cables have been developed that can withstand such overloads. For example, many 90° C rated power cables have an emergency overload rating that permits their use at 130° C for a total of up to 500 hours during their lifetime. Generally, these cables also have a short circuit rating that is the highest temperature the cable can withstand during an electrical short circuit lasting up to about half a second. For 90° C rated power cables, the short circuit temperature rating is usually 250° C.^[3]

^[1] SAE Standard AS4851A, Relative Thermal Life and Temperature Index for Insulated Electric Wire, sae.org

^[2] UL Standard 2556, Wire and Cable Test Methods, ul.com

^[3] NEMA WC70 (ICEA S-95-658), Standard for Nonshielded Power Cables Rated 2000V or Less, icea.net

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