

## SIDEWALL PRESSURE

Whenever cable is pulled around a bend, a "sidewall pressure" develops between the conductor and the bend sidewall. The bend could be in a conduit, duct, tray, trough or trench. Sidewall pressures can occur also when cables ride over a sheave, in bends when one cable crosses another, or when a cable under tension bends around a non-yielding object.

Sidewall pressure increases with pulling tension (which is the stretching force developed between the two ends of a cable during installation) and decreases as the radius of the bend increases. If the resulting force exceeds the compression cut strength of the cable components, particularly the insulation, premature cable failure can occur due to crushed insulation, displaced or damaged shielding systems, slit or torn jackets, deformed interlocked armor, or cuts and crushing of preassembled aerial cables.

Unfortunately, the cable is usually hidden from view after installation and the damage is not easily detected. Splits in the insulation or broken metal shield components are seldom detected by dc high voltage tests. But, after penetration by moisture and application of operating voltage, the cable may fail. Further, the service failure may well destroy the evidence that damage had occurred during installation.

Pulling tensions are watched carefully to avoid overloading the pulling equipment, stretching the conductor, or developing excessive sidewall pressures. Basically, pulling tension depends upon the friction between the cable and the raceway, the extent of contact between the two, the holdback force from the supply reel or previous section of raceway, and the presence of bends. They can be calculated as described on pages 35-37 of the Anaconda Cable Installation Manual (PC7600-1 1976) and monitored using a dynamometer during cable installation.

Sidewall pressures cannot be monitored directly during cable installations. However, there are several industry guidelines which can help installers avoid excessive sidewall pressure.

The IEEE Red Book (Standard 141-76 "Recommended Practice for Electrical Power Distribution in Industrial Plants") suggests the use of the following equations to avoid excessive sidewall pressures:

Maximum Pulling Tension (pounds) allowed out of a bend =

- (a)  $450 \times \text{cable diameter (inches)} \times \text{radius of bend (feet)}$  for 1/C cable
- (b)  $225 \times \text{diameter (inches) of individual cable} \times \text{radius of bend (feet)}$  for triplexed cables
- (c)  $675 \times \text{diameter (inches) of individual cable} \times \text{radius of bend (feet)}$  for parallel cables

Anaconda and many other cable companies start with the calculated tension coming out of a bend. This procedure is based on an article in AIEE Transactions on Power Apparatus and Systems V. 72, pp. 1275-88 (1953). For example, for a single cable, if the tension (lbs) out of the bend divided by the bend radius (ft) is equal to or less than 300 lbs/ft, sidewall pressure will not be excessive. If the calculated result exceeds 300 lbs/ft, a change in the installation procedure is needed. The formulas for three conductor cradled and triangular installations are given on p. 37 of the Cable Installation Manual. In Multi-conductor cases, the problem relates to the cable which will have the severest stress, so the sidewall pressure formulas change with cable configuration.

At one time, IPCEA recommended a value of 100 pounds per foot for single conductor cable. The 1957 Underground Systems Reference Book states a safe value of 400 pounds per foot (page 3-18). A number of manufacturers, including Anaconda, then decided 300 pounds per foot was a safe value for extruded dielectric cables.

In view of the differing opinions concerning the formulas and constants, IEEE in conjunction with the Electric Power Research Institute (EPRI) and the Insulated Power Cable Engineers Association (IPCEA) is asking manufacturers to state the values they recommend so that proper guidelines can be developed.

Until this matter is resolved, Anaconda will continue to recommend 300 pounds per foot. We are also starting some experimental work on this subject and will advise you of any change.

What can be done if the calculated constant exceeds our recommended maximum of 300 pounds per foot for single conductor cables or the levels for multiple conductor installations?

1. Increase radius of the conduit bends.
2. Reduce friction during the pull by applying adequate lubricant that is compatible with the cable.
3. Select the direction and method of cable pull that will minimize the physical hazards - tension, sidewall pressure and kinking - to the cable.

Remember — long cable life requires not only a good cable, but also a sound installation.

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