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HOW MUCH IS PULLING TENSION INCREASED OUT OF A HORIZONTAL BEND?

A system designed without regard to proper planning and installation methods may be virtually impossible to install. Correct conduit or duct size, maximum pulling tension, maximum sidewall pressure, jam ratio, and minimum bending radius are all important factors that must be considered. However, the most common limitation experienced in pulling calculations is the tension coming out of a horizontal bend.

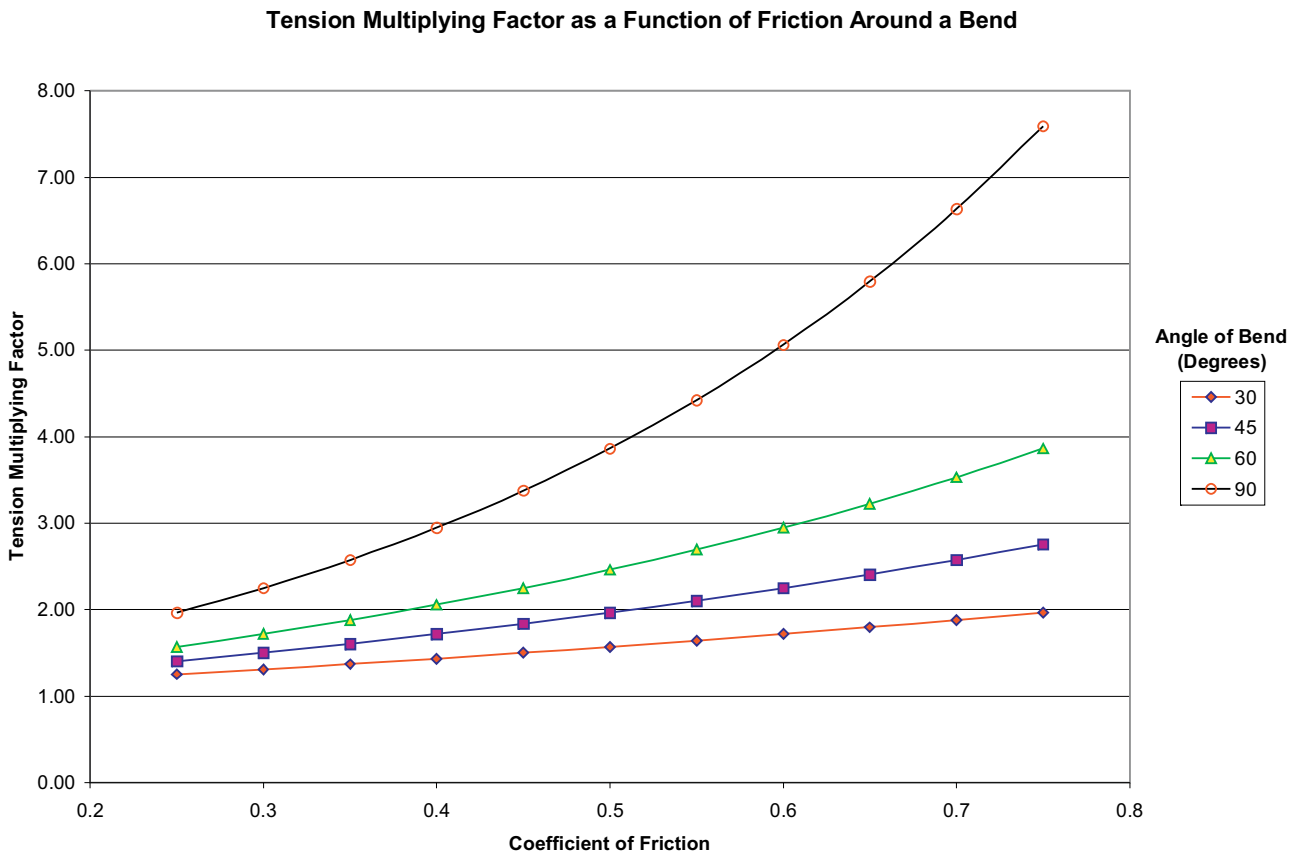
The tension out of a horizontal bend is given by the equation:

$$T_{out} = T_{in}\, e^{cfa}$$

Where T_{out} = tension out of bend
T_{in} = tension coming into bend
c = weight correction factor
f = coefficient of friction
a = angle of bend in radians

This is a simplified equation which ignores the weight of the cable. It is very accurate where the incoming tension at a bend is equal to or greater than 10 times the product of cable weight per foot times the bend radius expressed in feet.

Horizontal bends act as tension multipliers as the friction is increased exponentially due to the change in angle. To illustrate this, assume that there are 3 1/C 500 kcmil CU Okoguard Okoseal MV-105 133% 15kV cables, triangular configuration, being pulled in a 5" conduit. The weight correction factor, c, takes into account the additional frictional forces that exist between triangular arranged cables resulting in a greater pulling tension than when pulling a single cable. This constant number is based on the conduit I.D. and single conductor O.D. Next, the coefficient of friction used in this example ranged from 0.25 to 0.75 taken at 0.05 increments. Four standard horizontal bends of 30, 45, 60, and 90 degrees were then chosen to represent a typical installation scenario. Before being used in the equation, the angle units (degrees) were converted to radians. The tension multiplying factor, e^{cfa}, was calculated for each scenario and plotted.



As indicated, the greater the angle of bend, the higher the tension multiplying factor is at a certain coefficient of friction. Assume that 3 cables are being pulled around a 90° bend with a 0.4 coefficient of friction. If there was 1000 lbs. of tension coming into that bend, there would be 2950 lbs. of tension coming out of the bend.

Based on this data, the direction of pulling cable can make a very substantial difference in pulling tensions and sidewall pressures depending on the exact configuration of conduit and bends. The cable should always be pulled through horizontal bends earlier in the run rather than later. This way, the tension coming into the bend developed between the reel and the first series of bends is a lot lower than when being pulled first from a long straight section into a series of bends toward the end of the pull.

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