

Pull Force

If the construction crew foreman is not familiar with pulling cable in conduit, it is advisable to calculate the pull force that will be expected in the pull. The calculation will serve two purposes. One is that it will identify excessive pull tensions which may exceed the strength of the cable or equipment. The second is that it will identify the factors that influence the pull tension. With this information, the foreman can select the best placement of the pay off reel, where to place the winch, whether or not lubricant will be needed, etc...

As cable is pulled straight through conduit, the force required to pull the cable increases. This frictional force is due to the weight of the cable and the coefficient of friction between the cable and the conduit. The longer the length, the greater the frictional force. The coefficient of friction can be reduced if lubrication is used. The force required to pull cable through a straight conduit is simply:

$$T = \mu_k WLN$$

Where

T = Pulling Tension (pounds)

μ_k = Coefficient of Kinetic (sliding) Friction
(no dimensions)

W = Cable Weight (pounds/foot)

L = Length of the Cable (feet)

N = Number of Cables

As the cable is pulled around a bend the pull force is amplified by a factor that varies exponentially with the angle of the bend. For flexible cables, the pull force is:

$$T = T_b e^{\mu_k \alpha}$$

Where:

T_b = Back tension on the cable as it enters the bend (pounds)

α = Angle of the bend (radians)

If there are multiple cables being pulled at the same time the above tension is increased by a factor of 3 to 7 times due to a cradling effect.

Even with no back tension, however, force is required to bend the stiff cable as it enters the bend. Upon exiting the bend, force is required to straighten the stiff cable. Therefore, the bend moment of the cable must also be taken into consideration. So the above equation can be modified to:

$$T = (T_b + B_{in}) e^{\mu_k \alpha} + B_{out}$$

Where:

$B_{in} = B_{out}$ = Bending tension (pounds)

also

B_{in} = Bend Moment/Bend Radius

The bend moment of the TX10840JB cable is approximately 550 inch-pounds. So it requires about 73 pounds of tension to bend the cable around a 7.5 inch radius.

Lubrication

As mentioned before, lubrication can reduce the coefficient of friction between the cable and conduit, and cable bending tools. Most CATV cables are manufactured with a medium density polyethylene (MDPE) jacket which is tough and already has a low coefficient of friction with such materials as PVC and steel. On short pulls, where the pull force is low, it is not necessary to use lubricants.

On long straight pulls, if enough lubricant is applied and applied at the correct points, the pull forces can be cut by about 50% thus doubling the length that can be pulled. Lubricants decrease pull forces in 90 degree bends also but only by about 25%.

Actual measurements of pull force during a cable pull through 90 degree bends indicates that the coefficient of kinetic friction can be reduced from 0.36, in the case of medium density polyethylene against steel, to 0.18 by using Polywater J compound (available from American Polywater Corporation, Stillwater, MN 55082).

The selection of lubrication should take into consideration its compatibility with the cable and other components. The compound must not attack the medium density polyethylene jacket of the cable and must not attack the aluminum sheath. There have been documented cases of using a pulling compound that was compatible with the jacket but not the aluminum. The jacket was accidentally ripped off a short section of non-flooded jacketed cable during installation. The pulling compound was a caustic material that dissolved the aluminum. Electrical continuity was lost after approximately 2 weeks. The problem would have been significantly minimized if the cable were flooded, there were no sharp edges to damage the cable, and proper care was taken to pull cable. The lubricant should also not be soap based. Although the jackets of cable are resistant to soap it is interesting to note that a standard

test of polyethylene is an environmental stress crack test, American Society For Testing And Materials Standard D-1693, which uses soap mixed with water to induce jacket cracks. It may be desirable to use a lubricant that does not dry out so that it is easier to remove the cable later.

Pulling

As mentioned before, the winch operator should have good communications with everyone involved with the pull. It is his responsibility to assure that everyone has their hands clear of the pull line. During the pull, the tension should be monitored with an in line dynamometer to assure that the pull force does not exceed the maximum recommended pull force of the cable, the pull line, cable grip, winch or any of the components used for the pull. It is the responsibility of the winch operator to stop the pull if anything goes wrong.

The pull line should have sufficient strength to pull the cable under all conditions. The break strength should be roughly 2 times the highest pull force expected. The pull line should have minimum stretch as load is applied.

The pay off reel should have no back tension or breaking applied. A man should be stationed at the pay off reel to push the cable into the conduit and apply the lubricant to the cable jacket.