American Polywater's

TeleTopics

A NEWSLETTER COVERING TECHNICAL SUBJECTS OF INTEREST IN TELECOMMUNICATIONS CONSTRUCTION

ROUTE TO:

Volume 4-2

CABLE PULLING EQUATIONS

Problem:

A 4,800-ft (1450 m) duct bank runs from one campus building to another. You plan to install a fiber optic cable in an empty conduit in the bank. The run goes through a number of turns and manholes. Can you safely make the installation in a single pull, or must the cable be pulled out, figure-eighted, and then pulled back in for the rest of the run?

Problem:

You're installing shielded, twisted-pair data cable with a maximum pulling tension of 55 lbs (245 Newtons). Part of the run is into a 550-ft (165 m) conduit under a concrete factory floor. It is a straight conduit run, with a conduit stub-up at one end. Can you make the pull with less than 55 lbs (245 N) force? Which end of the run is it best to feed the cable into?

Problem:

There's an 8,300-foot (2530 meters) under bridge crossing. You want to install a "preducted" fiber optic cable (cable extruded in innerduct) into an existing FRE conduit. The recommended maximum load for the thick walled duct is 4,500 lbs (20kN). Will the run be easy, hard, or impossible? You should know before you start the pull . . .

Finding Answers

The situations above were all real field problems. While the cable types and specifics are quite different, all three do have something in common!! In all three, "Cable Pulling Theory" can answer the questions and provide a sound basis for planning the installation.

"Cable Pulling Theory" allows us to estimate pulling tension when cable is pulled into conduit. The theory is based on physical laws. In this case, the force required to move an object across a surface is equal to the force between the surfaces times the coefficient of friction.

In cable pulling, the cable becomes "the object" and the conduit "the surface." The forces depend on both gravitational weight and the "pressing" force when pulling cable around bends. The end result is a series of equations, which require specific input on cable weight; conduit length and direction; location of bends; and the coefficient of friction between cable jacket, conduit, and pulling lubricant.

Know Your Limits

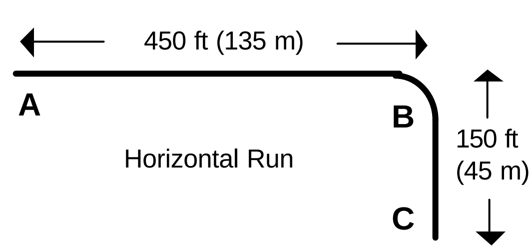
"Cable Pulling Theory" will do you no good, however, unless you know the maximum force you can put on a cable while not risking damage to it. This maximum tension varies significantly with the type, construction, and size of cable.

Lightweight coaxial and shielded data cables can have allowable tensions as low as 30 - 50 lbs (135 - 225 N). Larger outside-plant fiber optic cables with strength members are usually in the 400 to 800 lbs. (1.8 to 3.6 kN) maximum load range. Allowable tension on innerducts can vary from 500 lbs. (2.2 kN) to 5,000 lbs. (22 kN), depending on the wall thickness and reinforcing members. The maximum tension for multi-pair copper cable is determined from the number and gauge of the conductors.

All cables have tension limits, and some cables also have sidewall pressure (tension going around a bend) limits. Look for these limits on the cable's spec sheet. If you don't find anything there, consult the cable manufacturer. The cable manufacturer is just as interested in having the cable properly installed, and avoiding damage during installation, as the installer is.

What's Your Guess?

To further illustrate, which direction would you pull to get the lowest tension in the conduit diagrammed below--from A to C or C to A?



The correct answer is C to A, but why?

To answer this question, we need to look at a simplified form of the pulling equations:

Straight Conduit $T_{out} = T_{in} + LW\mu$

Conduit Bend $T_{out} = T_{in}\, e^{\mu\theta}$

Where:
T_{out} = Tension Out
T_{in} = Tension In
L = Length of Straight Run
W = Weight of Cable (per length)
μ = Coefficient of Friction
θ = Angle of Bend
e = Natural Log Base

In the first equation, we see that straight sections add the same amount to incoming tension regardless of which direction we're pulling. Any difference in tension with direction would come from the bend at B. We see from the second equation that bends multiply the incoming tension. If we start the pull at C, the tension when we get to bend B is less, so the result of multiplying it by $e^{\mu\theta}$ adds less than if we were pulling the other direction. Thus, pulling from C to A will give lower tension than from A to C. In this simple example, "Cable Pulling Theory" has answered a very practical field question, "Which direction should we pull?"

Huh?

Once you know the tension limits of the cable, or how much force you can use to pull without risking damage, you're ready for calculations using the full pulling equations, rather than the simplified versions above. Unfortunately, the full pulling equations are complex. They have numerous terms, including hyperbolic functions. Because each conduit segment builds on the one before it, working them with a calculator is cumbersome. But a PC works great!!

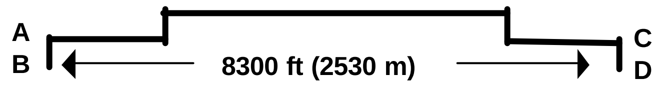
Software Solutions

American Polywater's user-friendly Pull-Planner™ 2000 for Windows™ calculates pulling tension, conduit fill, jam ratios, and sidewall pressure for a cable pull. The program allows quick changes of conduit system design, incoming reel tension, coefficient of friction, pulling direction, and cable parameters. It can even take a measured tension from an actual pull and calculate the coefficient of friction, which can then be used in calculations for similar jobs.

The Pull-Planner™ 2000 for Windows™ makes it possible to analyze complex pulls quickly and easily. You can plan operations by looking at "what if" options with various field parameters.

Saving Time and Money

One of the earlier examples involved an underbridge pull of a 1.25 inch (32 mm) high tensile duct with a 144 fiber cable preducted. The high tensile duct could be pulled with up to 4,500 lbs (20 kN). It was being installed with three empty 1-1/4" (32 mm) ducts into a 5" (127 mm) FRE conduit. A rough sketch of the underbridge conduit system is shown below:



The first set of calculations, even with the extremely low coefficient of friction possible with Polywater® J, showed tensions above the maximum on a pull from A to D.

Additional calculations, however, showed that pulling the duct in at B and out at C (avoiding the two end bends), and then back-feeding through the short vertical runs, should make the long pull possible with under 4,500 lbs.

The pull was completed successfully this way, with an actual monitored tension of 3,900 lbs (17 kN). The result? A complex installation was planned and completed safely and efficiently using the Pull-Planner™ 2000, and, of course, the low friction of Polywater® J. The money and timesavings from such an effort are obvious.

Summary

Excess tension can damage cable and/or reduce its life. A lot of cable pulls do not require the detailed analysis possible with the Pull-Planner™ 2000 Software. But, for difficult or complex pulls, the software is a powerful tool for planning safe, high quality installations. Additional information is available on our web page at

www.polywater.com/pullplan.html

or by contacting us directly.

A preview of the Pull-Planner™ 2000 for Windows™ is available on the web page at

www.polywater.com/preview.html.

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Web Site References for This Issue

All begin with: **http://www.polywater.com/**

Polywater® J: **polyj.html**
Pull-Planner™ 2000: **pullplan.html**
Software Preview: **preview.html**
TeleTopics Subscription: **newslett.html**

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