American Polywater's
TeleTopics
A NEWSLETTER COVERING TECHNICAL SUBJECTS OF INTEREST IN TELECOMMUNICATIONS CONSTRUCTION

ROUTE TO:

Volume 10

Fiber Optic Cable Pulling

Practical lengths for fiber optic cable pulls have increased significantly over the past decade. Today pulls of 3,000 to 5,000 feet at tensions well under 600 lbs. are common. Innovations in both pulling lubricants and the placement of fiber optic duct have produced most of this improvement.

In fiber pulling, bentonite clay and mineral oil-base pulling compounds have been replaced with the specially engineered, water-based lubricants, POLYWATER® F, J, and PJ. These POLYWATER® products are not only low friction, but they also coat out on polyethylene cable jacket and stay on fiber cable for long distances.

Are further improvements in fiber optic pulling possible? Can lubricants be compounded to be even slipperier? This "TeleTopics" examines this question by analyzing several new approaches in pulling lubricant technology.

Slip, Slide, or Roll?

Existing POLYWATER® Lubricants are based on water-soluble polymer materials; they feel very slippery, but are not "oily." One new technology uses *non-water soluble silicone oils* as friction-reducers in duct linings and pulling compounds. The field performance of these silicone products has been unpredictable, and good side-by-side studies of silicone and non-silicone lubricants have not been available.

A second new technology in lubrication uses "mini-rollers" (small spheres). These rollers are intended to function as "bearings" or "wheels" in a lubricant, and to literally roll underneath the cable as it is pulled. "Mini-roller" lubricants have some use in Europe, and small, plastic spheres have now been incorporated in some pulling lubricants available in the United States.

Test Methods

Lubricants are intended to *lower friction* and pulling tension. It's appropriate to first evaluate the effect on friction (slipperiness) of these new technologies.

Friction was measured by pulling an LDPE-jacketed fiber optic cable through a wound coil (540° of bend) of HDPE innerduct (smoothwall). Varying weights were put on the end of the cable (tail weight or incoming tension) and the force required to pull the cable was measured.

The effective coefficient of friction for the system can then be calculated from:

$$COF = \frac{2}{np}\,\ell n\left(\frac{T_{out}}{T_{in}}\right) \qquad \text{Equation 1}$$

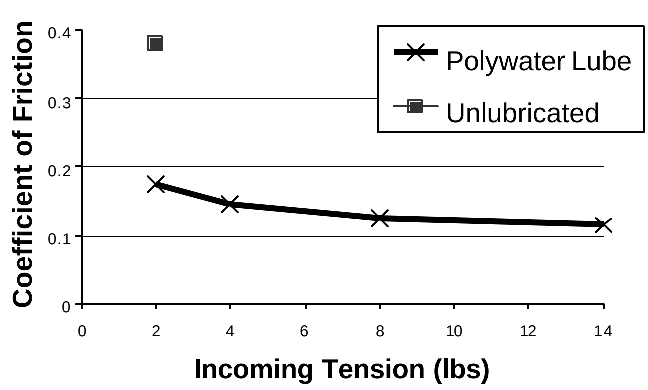
Where:	COF	=	coefficient of friction
	n	=	number of 90° bend
	T_{out}	=	measured pulling tension
	T_{in}	=	incoming tension
	ln	=	natural log (base e)

The wound duct test is a variation of a method described in BellCore specs and elsewhere. The technique uses the multiplier effect of conduit bends and an exponential friction coefficient to produce measurable tension differences in short pulls. For example, an increase in coefficient of friction of 25% can more than double pulling tension depending on the cumulative degrees of bend.

The Lube Factor

Figure 1 shows output from this test. Figure 1 plots friction coefficient versus incoming tension for unlubricated and lubricated cable.

Figure 1. Effective Coefficient of Friction With Polywater®



Lubed Cable versus Unlubed Cable

As expected, this graph shows a significant difference between lubricated and unlubricated cable. The unlubricated coefficient of friction is .38 versus the POLYWATER® Lubricant range of .11 to .17. Only one data point could be determined for the unlubricated cable because back tensions above 2 lbs. produced pulling forces above the measuring capacity of the load cell.

Figure 1 shows that the *lubricated coefficient of friction* changes (goes down) with increasing back tension. This is not the same thing as the pulling tension going down with increasing back tension. Equation (1) clarifies that the pulling tension to incoming tension ratio decreases slightly as the incoming tension increases.

A theoretical explanation for this coefficient of friction variation is beyond the scope of this article. However, this variation has been observed in a number of studies, sometimes camouflaged as a decrease in measured versus calculated pulling tension in pulls with many bends. What Figure 1 shows is that we need to view coefficient of friction as a range of potential values rather than a single, firm, established number.

Silicone

Figure 2 compares a standard water-based POLYWATER® Lubricant (no silicone) to a similar silicone-based lube (same viscosity, etc.) called POLYWATER® Plus Silicone™.

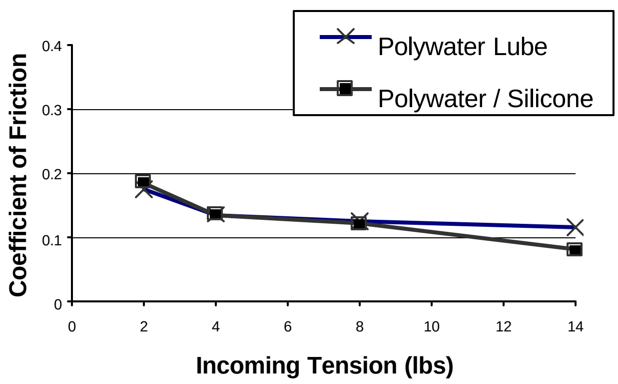


Figure 2. Effective Coefficient of Friction With Polywater® Lubed Cable versus Polywater® Plus Silicone™ Lubed Cable

The POLYWATER® Plus Silicone™ shows *slightly* lower friction coefficients at higher incoming tensions than standard POLYWATER® Lube. The difference is in the 10 to 20% range. However, the silicone-based lube shows no advantage at lower incoming tensions.

Rollers

Figure 3 compares the POLYWATER® Plus Silicone™ from Figure 2 with an identical lube with mini-rollers (average diameter of .6 mm) added.

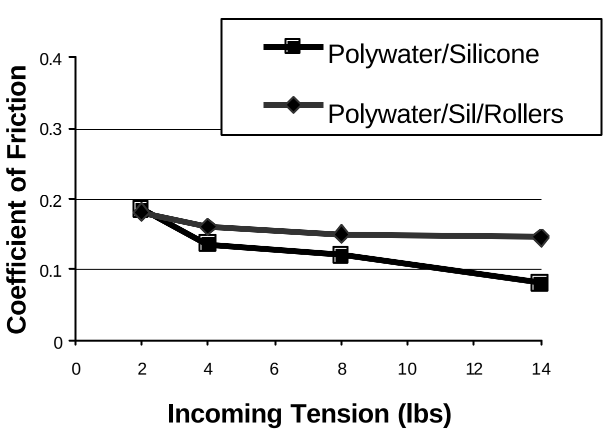


Figure 3. Effective Coefficient of Friction With Polywater® Plus Silicone™ Lubed Cable versus Polywater® Plus Silicone™ (with Mini-Rollers) Lubed Cable

The rollers show no benefit, and, in fact, raise the coefficient of friction substantially at the higher incoming tensions.

Examination of the cable pulled with the mini-rollers provided an explanation. The rollers cut into the cable jacket leaving longitudinal score marks, or the balls pressed into the jacket forming craters. The balls didn't act like rollers, they acted more like an abrasive particle.

Conclusions

The data above are restricted to a single type of cable and innerduct. However, tests on other types of cable and duct show similar results. From this we can draw some useful conclusions.

The plain POLYWATER® Lubricant shows an outstanding friction coefficient range of 0.11 to 0.17. Other less efficient lubes in this test show coefficients of 0.20 to 0.30. The silicone-based lube (POLYWATER® Plus Silicone™) shows an even lower coefficient of friction. On the other hand, the mini-rollers in the lubricant offer no apparent benefit. End users should be aware of the possible scoring and abrading of cable jacket with roller lubes.

Silicone is expensive, as are silicone-based lubes. When is the friction difference worth the added cost? From the data above, there would be very little benefit from a silicone lube in a straight pull, where the coefficient is linear and the bearing pressure low (left side of graph). However, the tension reduction with the POLYWATER® Plus Silicone™ could be quite significant in multiple bend pulls, where the coefficient is an exponent. This would include pulls where the "bending" is due to the natural undulations of innerduct contained in conduit or by displacements inherent in rough-terrain plowing.

American Polywater's silicone-based lubes (POLYWATER® Plus Silicone™) are available for testing or purchase. Please try them if you have tough pulls where you feel they may offer a cost/benefit. POLYWATER® Plus Silicone™ is also suitable for use in ducts which are already lined with silicone to reduce rope friction and cut-thru. Call our sales department at 1-800-328-9384 to arrange for a trial of the POLYWATER® Plus Silicone™ Lube.

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