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TechnicalTalk
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ROUTE TO:

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Lubricant Technology

The practical length of electrical cable pulls has increased significantly over the past 20 years. Innovations in pulling lubricants and a better understanding of the limitations of cable have both contributed to this increase

Bentonite clay, wax emulsion, and simple polymer/water pulling compounds have been replaced with high performance, multi-polymer lubricants, POLYWATER® J and PJ. Similar increases in pulling distance have been seen in the installation of fiber optic cable using specialty *liquid* lubricants like POLYWATER® F.

Are further increases in pulling distance possible? Can lubricants be made even better? This "Technical Talk" will measure the effect on friction of several new lubricant technologies.

Slip, Slide, or Roll?

Existing POLYWATER® Lubricants are based on patented technologies of *water-soluble* polymer materials. These lubes are extremely slippery, but they are not oily or based on oil. They maintain a low coefficient of friction with or without water (wet or dry).

One new technology uses *non-water soluble polymers* (silicone oils) as friction-reducers in pulling compounds. The field performance of "silicone" lubricants has been unpredictable, and good side-by-side studies to determine the benefit of "silicone" have not been available.

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

Evaluation Method

The primary function of a lubricant is to *lower friction* and tension in cable pulling. In this evaluation, friction was measured by pulling an XLPE-jacketed cable through a series of multiple bends (six 90◦ bends--helically wound) in Schedule 40 PVC conduit. Varying drag force was put on the end of the cable (tail weight or incoming tension) and the force required to pull the cable was measured.

The coefficient of friction for the cable/conduit/lubricant can then be calculated from:

$$COF = \frac{1}{3p}\ell n\left(\frac{T_{out}}{T_{in}}\right) \qquad \text{Equation (1)}$$

Where:

COF	=	coefficient of friction
T_{out}	=	measured pulling tension
T_{in}	=	incoming tension
ln	=	*natural* log (base e)

The multiple-bend duct test is a variation of a method described previously.[1] The technique uses the multiplier effect of conduit bends and an exponential friction coefficient to produce significant tension differences in short distance pulls.

The Lube Factor

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

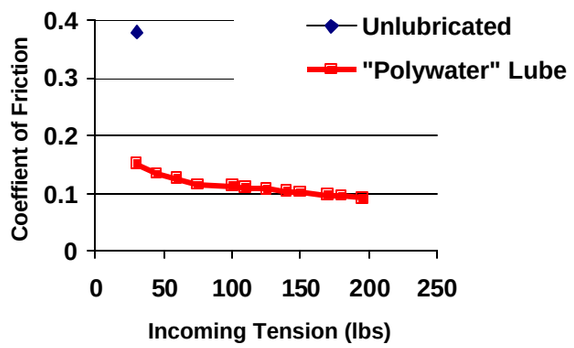

Figure 1. Effective Coefficient of Friction With "Polywater® " Lubed Cable versus Unlubed Cable

Figure 1 shows a significant difference between lubricated and unlubricated cable. The unlubricated coefficient of friction is 0.38 versus the POLYWATER® Lubricant range of 0.09 to 0.16. Only one data point could be determined for the unlubricated cable because back tensions above 30 lbs. produced forces that tore the jacket off the cable.

Figure 1 shows that the *lubricated coefficient of friction* goes down with increasing back tension. This does not mean that the pulling tension went down with increased back tension. Equation (1) clarifies that the (pulling tension/incoming tension) ratio decreased slightly as the incoming tension increased.

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 lower pulling tension than expected (calculated) in pulls with multiple bends. Figure 1 again shows that coefficient of friction is a range of values rather than a single number.

Silicone

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

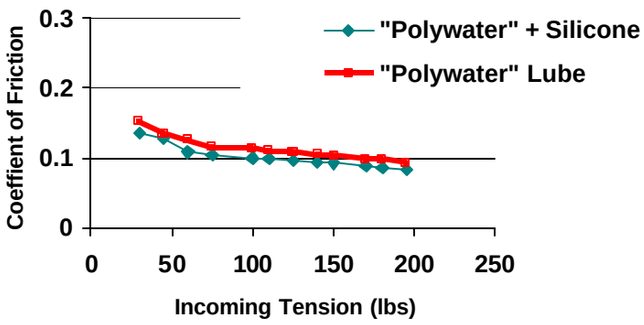

Figure 2. Effective Coefficient of Friction With "Polywater®" Lubed Cable versus "Polywater® Plus Silicone" Lubed Cable

The POLYWATER® Plus Silicone™ shows *slightly* lower friction coefficients than standard POLYWATER® Lube. The difference is in the 10 to 15% range. While small, the improvement is consistent throughout the range of incoming tensions.

Rollers

Figure 3 compares the POLYWATER® Plus Silicone™ from Figure 2 with an identical lube with mini-rollers (average diameter of 0.6 mm).

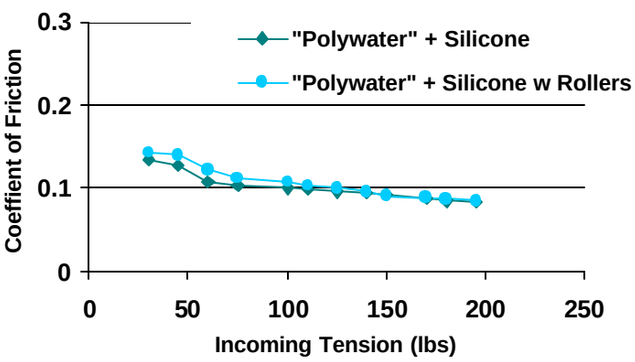

Figure 3. Effective Coefficient of Friction With "Polywater® Plus Silicone" Lubed Cable versus "Polywater® Plus Silicone (with Mini-Rollers)" Lubed Cable

The rollers show no benefit, and, in fact, increase the coefficient of friction slightly at the lower incoming tensions.

The cable pulled with the mini-rollers showed that the balls cut into the cable jacket leaving longitudinal score marks and/or pressed into the jacket forming craters. Under sidewall pressure, the balls didn't act like rollers, but embedded in the jacket instead.

Conclusions

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

The plain POLYWATER® Lubricant shows an outstanding friction coefficient range of 0.09 to 0.16. Less efficient lubes in this same test might show coefficients of 0.20 to 0.30. The POLYWATER® Plus Silicone™ shows an even lower coefficient of friction. On the other hand, the mini-rollers in the lubricant offer no apparent benefit, at least in pulling through bends. End-users should be aware of possible abrading of cable jacket with roller lubes.

Silicone is relatively expensive, as are silicone-based lubes. Is the friction difference worth the added cost? From the data shown, there would only be a minor 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 additional tension reduction with the POLYWATER® Plus Silicone™ could be significant in multiple-bend pulls, where the friction coefficient is an exponent.

Samples Available

American Polywater's silicone-based lubes (POLYWATER® Plus Silicone™) are available for testing or purchase. Try them for 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. Call our sales department at 800-328-9384 to arrange for a trial of the POLYWATER® Plus Silicone™ Lube.

(1) See paper entitled "A New Cable Pulling Friction Measurement Technique and Results." Call for copy.

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