American Polywater's

TechnicalTalk

ROUTE TO:

A PUBLICATION FOR ENGINEERS INVOLVED IN ELECTRICAL CABLE INSTALLATION

Volume 5

FIBER OPTIC INSTALLATION PROBLEM OR OPPORTUNITY?

Increasingly, electrical engineers and installers are becoming involved with fiber optic cable from a specification, design, and installation standpoint. How does the handling of fiber optic differ from electrical cable, and how can you plan and execute a high quality fiber optic installation.

This "Technical Talk" will focus on the installation of fiber optic cable in conduit, comparing it with electrical cable. The types of fiber available (single mode, multi-mode, etc.) and the various cable constructions (loose tube, tight tube, armor, etc.) are beyond the scope of this discussion. Please be aware that there are a great number of fiber cable types and constructions, and the discussion only covers general installation principles for most fiber optic cables.

First Look

From the outside, a fiber optic cable looks like any electrical multi-conductor cable. However, it is lightweight and flexible compared to metal conductor cable. Typical fiber cable OD's range from less than 1/8″ up to 3/4″, depending on the number of fibers and cable construction. The most common fiber optic cable jacket materials are polyethylene (all types), PVC, and polyurethane.

The glass fiber optics in the cable are not "fragile." They won't shatter if you drop the cable on the floor. These glass fibers are usually well protected by buffer tubes inside the cable itself. Once you've found and isolated a fiber, its most notable characteristic is its small size compared to electrical conductors. Even though the glass in the fiber is actually stronger (higher tensile strength) per unit area than a metal conductor, there is very little cross-sectional area in a fiber available for strength and support. For this reason, most fiber optic cables have other strength members intended for cable support during pulling, hanging, etc.

Pulling Strength Limitations

The placement of fiber optic cable in conduit is quite common. Conduit offers protection from crushing, ground disruption, rodents, and other environmental abuse, plus easier replacement or upgrade in the future. The *maximum* allowable pulling tension on fiber cable can vary from as low as 50 lbs. force to as much as 800 lbs., depending on the cable construction. The maximum tension for a particular cable should be available from the cable manufacturer, and is often found in the cable specs. This maximum recommended pulling tension should be noted on any drawings, installation instructions, etc. If the field installers do not know the maximum pulling tension, they cannot be expected to respect it.

Bending Radius Limitations

Probably the most common mistake of inexperienced fiber installers is to violate minimum bending radius by making tight bends in the cable. Fiber cable is often so flexible that you can wrap it around your hand to pull or yank on it. ***Don't!*** Tight bends, kinks, knots, etc., in fiber cable can cause micro-crazing or growth of flaws in the fiber, with resulting loss of performance.

Minimum bending radius in traditional fiber cable is usually in the range of 20 times cable OD, considerably higher than electrical cable. However, new fiber technologies are lowering this minimum bend radius. The specific minimum-bending radius for a particular cable should be researched in the cable manufacturer's specifications. This bending radius must be considered by the engineer when specifying conduit bends and pull box openings or sizing guide pulleys, sheaves, mid-assist capstans, etc.

Tension, Friction, Length of Pull

Fiber optic cable is often pulled for much longer distances than electrical cable. Continuous fiber pulls of over 4,000 feet are not extraordinary. These long pulls minimize the number of splices in fiber cable, which is desirable for fiber performance. The light weight of the cable makes such long pulls possible, although proper lubrication and a good conduit installation are also necessities.

Special field techniques like "mid-assist" and "figure-eighting" allow the installation of virtually limitless lengths of fiber cable without splices or breaks. Skilled installation crews routinely install uninterrupted lengths of over 20,000 feet in conduit.

The theory of pulling tension is the same for fiber optic cable as electrical. Pulling tensions can be estimated based on cable weight, conduit system design, and lubricated coefficient of friction. American Polywater's Pull-Planner™ 2000 for Windows Software can do such calculations for fiber optic installation as well as electrical.

Pulling lubricants with some unique features are required by the special nature of fiber optic pulling;

i.e., long pull lengths and lengthy pull duration. POLYWATER® F, engineered for fiber optic use, plays an important role in minimizing installation tension. POLYWATER® F Lubricant must and does maintain a low friction coefficient *throughout* long pulls ("wet" or "dry"). Lightweight fiber cable rubs on all sides of the conduit through the natural undulations of long "straight" runs. POLYWATER® F wets out and stays evenly coated on fiber cable jacket, reducing friction at all these areas of rub. Many common lubricants flow to the bottom of the cable and lose effectiveness in this type of pulling.

As with electrical cable, specific coefficients of friction depend on cable jacket type, conduit type, as well as the lubricant. With POLYWATER® F, friction coefficients observed in field fiber pulls in well-placed conduit are in the 0.10 to 0.18 range.

Duct Placement Factor

One of the types of conduit for buried fiber optic cable is the continuous (reeled) "water-pipe" type. Such continuous duct is popular because it is inexpensive and also offers enough protection to allow the use of less expensive cable constructions.

However, the natural reel memory from continuous duct can produce snaking and winding when it's placed in open trenches (later backfilled). While these "undulations" may look minor, they can result in hundreds of degrees of bend per thousand feet of pull, and vastly increased pulling tensions even with an extremely low POLYWATER® F friction coefficient.

From an engineering standpoint, this means the way the conduit is placed can *significantly* affect the practical length of a fiber pull, and thus the appropriate placement distance for pull boxes, etc. This problem is especially notable in open trench conduit placement, where rigid duct may be a better choice.

A number of specialty hard-sided (rigid) plastic ducts with multiple interior cells are manufactured today especially for fiber optic installation. Such constructions provide straighter paths of pull, and thus more predictability in fiber pulling. Traditional electrical ducts can also be used for fiber optic both above and below ground.

Experienced fiber placement crews are usually aware of the potential effect of conduit placement on pulling tensions, and have procedures to minimize the problem.

**Mid-assist, Figure-eight,
Bi-directional Pulling**

The techniques above can allow placement of unlimited, uninterrupted lengths of fiber optic cable. In "figure-eighting," enough cable for the whole run is pulled through the first section of conduit, and as the excess is pulled from the first section, it is laid out neatly in a "figure-eight" pattern (counter twists). The figure eight of cable is then "flipped" over and pulling is begun into the next section of conduit. Care must be taken to keep the cable clean in this procedure by using ground covers, etc.

Bi-directional pulling is similar in concept to figure-eighting, but the second pull is made in the opposite direction after the cable is figure-eighted from the reel (pull is started in the middle of the run). You can imagine why, as the final slack is being pulled in using the above techniques, that a large enough box opening is needed to prevent tight bending or crimping.

Mid-assist pulling involves special intermediate pullers (usually large diameter capstans or caterpillar treads) that effectively reduce tension to zero and feed the cable into the next segment of the run. For short, light pulls, manual mid-assist (hand-over-hand) can be used with a conscientious and properly coordinated field crew.

While additional details on these pulling methods are beyond the scope of this issue, designers should be aware that all three methods require appropriate access; access that is placed, with some conservatism, at maximum safe pull length distances.

As mentioned previously, the field installer must know the pulling tension limits on the cable, and should use methods to insure that this maximum is not exceeded. The options are numerous and can vary from break-away (shear pin) swivels to pullers with tension monitoring capability and automatic shutdown.

Lubrication

While short-length fiber pulls may not require lubricant, for long or complex fiber pulls lubricant is critical to making an efficient, high quality installation. Some of the requirements for a fiber optic pulling lubricant have already been covered. They are:

(1) Compatibility with polyethylene (no stress cracking) and other types of cable jacket

(2) Complete and even coating on the cable for friction reduction at all points of rub

(3) Consistent low coefficient of friction (over time)

POLYWATER® F Fiber Optic Lubricant has been proven in the installation of over half a billion feet of fiber cable. It is the lubricant of choice for specification in fiber work.

American Polywater also manufactures fiber optic lubricant applicators for use with POLYWATER® F Lubricant. If you are interested in applicator information and/or more detailed applications literature on fiber pulling, please call us toll free at *1-800-328-9384* and ask for Customer Service.

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