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Applications Engineering Note

Pulling Fiber Optic Cable in Conduit

AEN 136, Revision 2

This Applications Engineering Note (AE Note) addresses key points for planning cable pulls in conduit. Installers should consider bend radius, tension, jamming, and fill ratio before performing any conduit pull. Corning Optical Communications recommends the American Polywater® PULL-PLANNER 3000 Software program to calculate pulling tension, conduit fill, and sidewall pressure for a cable pull.

Bend Radius and Tension

When pulling fiber optic cable in conduit, observe the manufacturer's recommendations for maximum pulling tension and bend radius. Methods for limiting tension include breakaway pull swivels and hydraulic or electronic tension monitoring on winch or bull wheel type pullers. The radius of all conduit bends, cable guides, sheaves and capstans must be greater than the cable's minimum bend radius.

Additionally, fiber optic cables pulled over sharp lips and corners (e.g. manhole edges, conduit ends) conform to these features, easily violating the minimum bend radius of the cable. Equipment designed *specifically* for fiber optic cable (as opposed to electrical cable) simplifies these transitions and minimizes the likelihood of installation-caused damage. If you have any questions regarding appropriate conduit pulling equipment for your fiber optic cable installation, please contact Corning Optical Communications.

Sidewall Pressure

Pulling a cable through a conduit bend generates sidewall pressure (a crushing force) between the cable and the inside of the conduit bend. Pulling tension, the conduit radius and fill ratio all affect this sidewall pressure. Corning recommends maintaining sidewall pressures below the crush load acceptance criteria defined by ICEA-87-640 for outdoor cables, ICEA104-696 for indoor/outdoor cables, and ICEA-83-596 for indoor cables.

Jam Ratio

Pulling three cables in a conduit creates a possibility of "jamming". Corning concurs with NFPA 70: National Electric Code's®' explanation of and recommendation to prevent jamming:

> "When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. While jamming can occur when pulling four or more conductors or cables into a raceway, the probability is very low."

$$Jam\ Ratio = \frac{D}{d}$$

Where D = conduit diameter
d = outside diameter of one cable

Published: 11/10/2015. Revised: 6/26/2024.

Fill Ratio

Fill ratio is the ratio of the total cross sectional area of the cables to the cross section area of the conduit. Calculate the ratio by:

$$Fill\ Ratio = \frac{A_{cable}}{A_{conduit}} = \frac{\left(\frac{\Pi * d^2}{4}\right)}{\left(\frac{\Pi * D^2}{4}\right)} = \frac{d^2}{D^2}$$

Where A = Area
d = Outside Diameter of Cable
D = Inside Diameter of Conduit

Calculate the fill ratio for multiple cables by adding the squared cable diameters.

$$Fill\ Ratio = \frac{d_1^2 + d_2^2 + \cdots + d_n^2}{D^2}$$

Where A = Area
d_1 = Outside Diameter of 1st Cable
d_2 = Outside Diameter of 2nd Cable
d_n = Outside Diameter of the nth (last) Cable
D = Inside Diameter of Conduit

Corning and NFPA 70: National Electric Code® (NEC) both offer recommendations for fill ratio for different cable counts. Table 1 lists Corning's recommendations.

Number of Cables	Fill Ratio
1	65
2	31
Over 2	40

Table 1: Fill Ratio Values for Varying Cable Counts

Note: The Corning recommendation for one cable exceeds the NEC recommendation (53%). Corning has determined, by field testing, that one cable occupying 65% of a conduit in good condition can be installed without exceeding the recommended tension.

References

Corning Optical Communications' Recommended Procedure SRP-005-011, "*Fiber Optic Cable Placing - Duct.*"

PULL-PLANNER™ 3000 Software User's Manual, American Polywater® Corporation, 2009.

Published: 11/10/2015. Revised: 6/26/2024.