American Polywater's
Technical Talk
A Publication for Engineers Involved in Cable Installations

White Paper

Cable Installation in Duct Using "Push" or "Push/Pull"

Polywater's new Pull-Planner™ 3000 Software has a "mode" that allows a "pushing force" variable in pulling tension calculations. Pushing force is placed on a cable by a pushing machine (Figure 1) at the duct entrance, or by a pass-through pull/push machine at an intermediate point in the duct run. Pushing machines function by "grabbing" the cable jacket using driven conveyor belts or caterpillar tread devices.

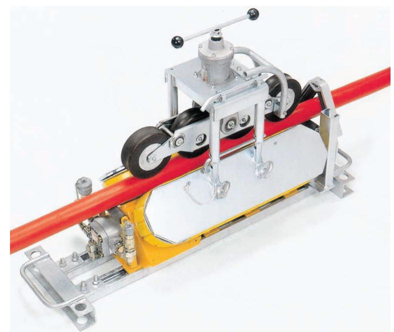


Figure 1: The Model DF-6 Cable Pushing Machine available from Sherman & Reilly.

In the Pull-Planner™ 3000, pushing is shown as a "negative" number in the predicted pulling tension. The example printout (Figure 2) highlights pushing forces in yellow.

Pull-Planner™ 3000

Pull I.D.: Example 4

Conduit Inner Diameter: 6 Inch(es) Conduit Fill: 44.5%

Total of 1Cable(s) of 1 different type being pulled.

Type #1 1 Cable(s) O.D. of 4 Inch(es) Weight of 10 lbs/ft

Total Cable Weight: 10 lbs/ft

Calculated weight correction factor: 1

Configuration: Single Cable

Jam/Clearance Analysis: Jamming Not Possible

COF = 0.15 Incoming Tension: -500 lbs

	Straight Section Angle	Angle Direct	Straight Section Length (ft)	Bend Type	Bend Direct	Bend Radius (ft)	Bend Angle	Tension (lbs)	Sidewall Pressure lbs/ft)
Seg 1	0	--	50	H	--	3	90	-312	--
Seg 2	0	--	50	H	--	3	90	-174	--
Seg 3	0	--	900	N	--	--	--	1176	--

Figure 2: Pull-Planner™ 3000 Printout

The negative tension is not meant to imply the pushing force vector is in the opposite direction from the pulling force vector, because that is not the case. However, it is convenient terminology. As long as the force is negative, the cable is being pushed, that is, the pushing force has not been fully offset by frictional resistance force. Once the pulling force turns positive, for the cable to move, it must be pulled.

We can use the Pull-Planner™ 3000 Software to make predictions using its calculation model.

Straight Run Pull

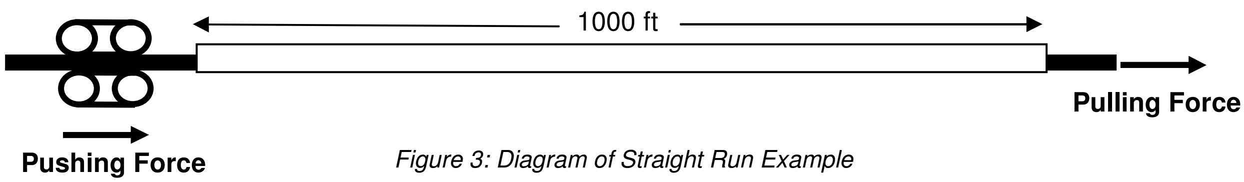


Figure 3: Diagram of Straight Run Example

In the first straight-run example (Figure 3), the conduit length is 1000 feet, the single cable being installed weighs 10 lbs/ft, and the friction coefficient is 0.4. With no pushing (incoming tension = 0), the software calculates a pulling force (tension on the cable) of 4000 lbs. This straight forward calculation we could do without the software (total weight of the cable in the duct multiplied by the friction coefficient).

The second example is like the first, but with 500 lbs of pushing force on the cable. The calculation indicates the pulling tension is reduced to 3500 lbs. On examination of the calculation detail, we find the frictional resistance force slowly negates the pushing force, which reaches zero at 125 feet. At that point, a pulling force must be exerted to move the cable farther, and the pulling force required to pull the cable the remaining 875 feet is indeed 3500 lbs. Everything is linear, so the 500 lbs of pushing force simply reduces the pulling force required by 500 lbs.

Pull with Bends

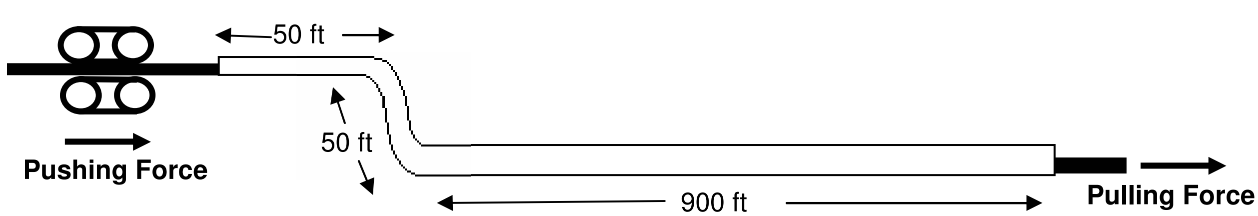


Figure 4: Diagram of a Run with Bends Example

The third example has the same 1000 foot conduit, but inserts two ninety degree horizontal bends at 50 and 100 feet as shown (Figure 4). With no pushing force, the pulling force calculated is 4680 lbs. The well-known bend multiplier effect shows more force is required for the conduit with sweeps than for the same length as a straight section.

In the fourth calculation, with 500 lbs of pushing force on the cable, the pulling force is reduced to 3907 lbs. So the pushing (500 lbs) has reduced the pulling force by 680 lbs.

The effect of the pushing force in a conduit with sweeps is complex, and the effect depends on the details. Regardless, the pulling force is lowered since the pushing force either "removes" the bend from a pulling tension contribution, or lowers the tension add-on from the bend by lowering the force coming into the bend.

Friction Reduction

The Pull-Planner™ 3000 allows easy changes in the friction coefficient variable, and indicates that lubrication is just as critical in push and push/pull as in regular pulling. The lubricant lowers the frictional resistance force whether the cable is being pushed or pulled.

The table below presents calculation results from the four examples above using a Polywater® Lubricant that can produce a friction coefficient of 0.15 or lower.

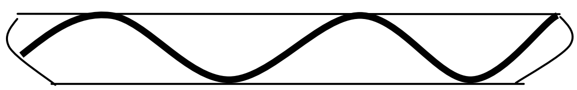
	Duct description	Pushing force	COF = 0.4	COF = 0.15
Example 1	Straight 1000 ft	0 lbs	4000 lbs	1500 lbs
Example 2	Straight 1000 ft	500 lbs	3500 lbs	1000 lbs
Example 3	Two Sweeps 1000 ft	0 lbs	4680 lbs	1567 lbs
Example 4	Two Sweeps 1000 ft	500 lbs	3907 lbs	1176 lbs

The lowest calculated tensions come from the "push" with good lubrication.

Push Only

With a shorter conduit or lighter-weight cable, we can construct a situation where the force remains "negative" for the length of the pull. This implies that no pulling force is required, and that pushing force alone will install the cable. This may or may not be true.

The limit on how far a cable can be pushed depends on the "flexibility" of the cable. Such a measure is not readily available nor is it modeled in the software calculations. Once the cable has begun to "spaghetti" (as shown in the figure), additional pushing force has very little effect, since the force just pushes the cable harder against the side of the conduit.



Both intuition and field experience indicate a stiff cable can be pushed farther than a flexible one of the same weight. For cables like small conductor building wire, instrumentation cable, or fiber optic, flexibility significantly reduces the maximum pushing length without another force being present (like a "pulling" or "blowing" force).

Medium and high voltage cable is reasonably stiff, and would seem suited for long "pushes", but in-depth studies of predicted versus actual pushing lengths have not been done.

Field Results with Distribution Cable

Some pushing is done in the field, and we can see how the experience fits with the calculations. A utility that pushes most of their primary distribution cable reports that a "push only" installation of 1000 feet with 2 sweeps is "routine". Putting cable and conduit detail for their heaviest distribution cable into the Pull-Planner™ 3000 Software indicates that it would require a friction coefficient under 0.19 to make the thousand feet.

Such a friction coefficient is well within the capability of Polywater technology. In this case, the utility crews put lubricant into the conduit before the push begins, and for a longer installation, they will stop to lubricate again part way through the installation. So, there is basic agreement between the model and this field experience.

A supplemental pulling force should minimize the cable flexibility limitation. The field experience supports this, as the installation procedures described above switch to "push/pull" for longer or more difficult installations.

Regardless of the limited correlation with the field data, "push only" calculations using the Pull-Planner™ 3000 should be used carefully with an understanding of their limitations.

Topic Related Links

Pull-Planner™ 3000 Cable Pulling Software

Polywater Home Page Link

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