COMPARISON OF HDPE CONDUIT AND FABRIC DIVIDER INSTALLED AS INNERDUCT

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Foreword

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The purpose of this technical note is to provide a practical comparison of HDPE innerduct and fabric divider technologies for conduit, and to assist specifiers, contractors and others with useful selection criteria when determining which technology to employ for fiber optic cable applications. This technical note replaces PPI Technical Report TR-44 (2008) which addressed the same topic in a different manner. TR-44 has been withdrawn.

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COMPARISON OF HDPE CONDUIT AND FABRIC DIVIDER INSTALLED AS INNERDUCT

1.0 INTRODUCTION

The purpose of this Technical Note is to provide a practical comparison of high-density polyethylene (HDPE) conduit (innerduct and micro duct), and fabric divider technologies, two options for sub-dividing installed larger conduit. For the purpose of clarity, both HDPE innerducts and micro ducts may be referred to as “HDPE conduit” when referencing both options simultaneously in this document, whereas Fabric Divider will be referenced as “Fabric Divider”. Both technologies are used to house and protect fiber optic cables for various applications.

This Technical Note will focus on comparing each technology’s installation techniques, advantages, strengths, and protection capabilities, along with cable installation considerations. It is intended to assist specifiers, contractors, and others with useful selection criteria when determining which technology to employ.

Table 1 is provided to clarify the typical size range of HDPE innerduct and micro duct technology, and to provide a general description of each.

Table 1: HDPE Conduit Type Innerducts

HDPE Conduit	Trade Sizes	Description
Standard Innerduct	½” to 2”	Trade size designation in inches, high density polyethylene (HDPE) in various wall types available in individual lengths or multiple lengths on reels.
Micro Duct	5/3.5 mm to 27/20 mm	OD/ID designation in millimeters, high density polyethylene (HDPE) in various wall types provided in individual lengths or multiple lengths on reels.

2.0 DESCRIPTIONS

High-density polyethylene (HDPE) conduit, as standard innerduct or micro duct, and fabric dividers, sometimes referred to as *fabric innerduct*, are three options for sub-dividing an installed empty or occupied conduit for current and future installation of additional fiber optic cables. HDPE conduits and fabric dividers can be installed into empty or occupied conduits. Occupied conduits are in-situ conduits, typically where one or more cables have been previously installed. When HDPE conduit or fabric divider is being installed into occupied conduits, the process is referred to as an *override*.

ASTM Standard Specification F2160 *Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)* defines “innerduct” as “a conduit installed inside a conduit”. In other words, it is one or more HDPE ducts placed within a larger HDPE conduit in order to subdivide it.

The larger HDPE conduit may house one or more pathways (i.e. innerducts) providing mechanical protection from external forces (e.g. rocks) and from the weight of the surrounding earth.

HDPE conduits and fabric dividers used as innerducts can have thinner walls than the outer ducts, since their primary function is to provide separate pathways for cables. The outer conduit provides the necessary protection in the direct-buried environment. The use of innerducts is to create pathways for current and future needs for installing fiber optic cables. Consult your supplier for wall options that may be available.

Innerducts are typically extruded separately from the installed conduit, and are fed into the installed conduit in the factory or in the field, in accordance with customer specifications. Innerducts may be produced of different colors to help identify individual pathways throughout the route. See **Figure 1** for typical HDPE installed as an innerduct configuration.

Figure 1: HDPE Innerduct within Larger HDPE Conduit

Fabric divider is an assembly of fabric channels joined together for placement inside HDPE conduit. Fabric dividers are supplied on reels and may be field-fed into the outer conduit, in accordance with customer specifications.

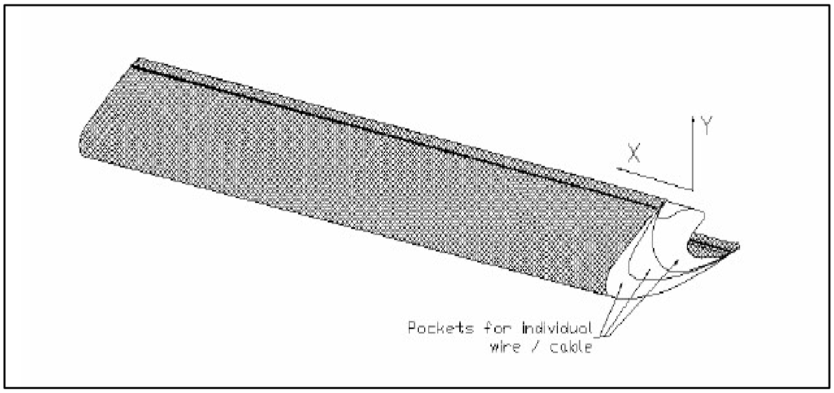

Figure 2: Illustration of Fabric Divider

Some HDPE conduits are extruded with fabric divider/s integrated into the conduit, with the fabric divider embedded in the conduit wall. Such integrated products are produced in the factory, and cannot be altered after production.

3.0 PRACTICAL COMPARISON OF HDPE CONDUIT AND FABRIC DIVIDERS

While both HDPE conduit (innerduct and micro duct) and fabric dividers add capacity to installed conduit, there are significant application differences that should be considered when selecting which option to use for a specific project. It is very important to consider both short-term and long-term objectives when selecting either HDPE innerduct, micro duct or fabric divider for creating additional pathways. See **Table 2** for a comparison of critical application considerations.

Table 2: Comparison of Critical Application Considerations

Application Considerations	HDPE Conduit	Fabric Divider
Pathway available in multiple sizes	Yes	Yes
Pathway maximum length of installation (typical)	≈ 2,500 ft. (760 m)	≈ 1,000 ft. (328 m)
Pathway requires an outer protective conduit	No	Yes
Pathway provides added mechanical cable protection	Yes	No
Pathway may be installed via pulling	Yes	Yes
Pathway may be jetted (air) into place (micro duct)	Yes	No
Cable may be pulled in	Yes	Yes
Cable may be jetted (air) into place	Yes	No

While the key objective of subdividing a larger conduit is met by using either HDPE innerduct, micro duct, or fabric divider, several additional installation factors should also be considered when making the final selection.

Each of those factors is discussed in greater detail in the following sections.

4.0 CONSIDERATIONS FOR WINCHED INSTALLATIONS

A winched installation refers to pulling individual or multiple HDPE conduits (e.g innerducts or micro ducts), or fabric divider, or cables by means of a mechanical puller into an previously installed conduit. The pulling medium can be wire rope, fabric ropes, or flat woven pull tapes. Typically, the puller is equipped with a mechanically-operated capstan and may include a wind-up for collecting and storing the pulling medium.

Installation length is a key factor when making the selection between HDPE conduit or fabric divider for use as innerducts. There are two important installation length considerations:

i. Required HDPE conduit/fabric divider installation length
ii. Planned installation lengths between splice points of the fiber optic cable

As the installation distance requirements for either the innerduct or cable increase in length, then HDPE conduit (e.g. innerduct or micro duct) becomes the better choice to improve overall installation efficiencies. This is due primarily to lower friction between the cable and HDPE conduit.

An important concern when pulling anything into a conduit that is already populated with an existing cable or cables is what will happen at locations where the pulling medium crosses the existing cable(s). This is because the pull line can abraid or “saw” into or through existing cables. Abrasion from the winch line intensifies as the pull resistance increases.

Added weight, as more material is pulled into place, combined with directional changes, are two key contributing factors leading to greater pulling resistance, causing increased tensile and sidewall loads. This accumulating resistance is often referred to as “tail load”.

Winching into an occupied conduit over an existing cable or cables is not viewed as a recommended practice, mostly because of the high probabiity of the winch line sawing into an existing cable during the winching operation.

Another key concern is that winch lines can also saw or abrade through the host conduit’s wall at bend locations. This is because changes in direction are locations where higher sidewall loads will occur. Abrasion can be substantially reduced by pushing/jetting the cable, a technology that will be discussed in more detail later.

It is undesirable to allow multiple innerducts or cables to twist during installation, because twisting adds directional changes that will contribute to greater pulling resistance of cables, resulting in higher tensile loads. Twisting of cables can also cause tortional damage to the cables. Twisting can be avoided by attaching a swivel connection (Figure 3) between the innerduct or cable and a staggered array (Figure 4) and the pulling line. See **Figures 3 & 4.**

Figure 3: Ball Bearing Swivel

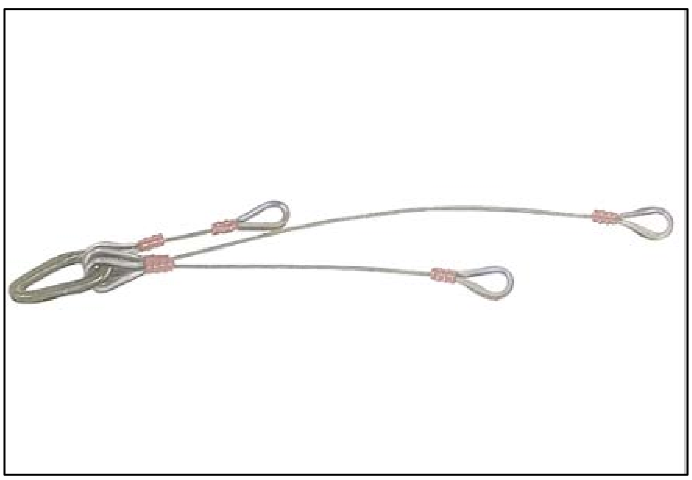

Figure 4: Staggered Pulling Harness for Pulling Multiple Cables or Innderducts

There are established tensile limitations for winchlines, cables, conduits and fabric dividers; these values are referred to as “safe working loads”. Increased resistance will result in shortening the achievable installation distances, because of the safe working load being reached more quickly. For example, traditional fiber optic cables that are designed to be pulled into underground conduits usually have a safe working load of 600-lbs tensile force.

A key goal is to try to mitigate any factors that will contribute to increased resistance when installing cables, to protect them from damage and improve installation efficiencies. Shortening of the installation distance will require adding more access structures, such as handholes or pedestals that can be used as assist/access points, potentially increasing construction and material costs.

A critical concern for fabric divider is that if it twists during installation, it could seriously jeopardize the ability to pull a cable into even one of the fabric divider's pathways, making the other pathways also unusable. This means extreme care must be taken in order to prevent twisting of the fabric divider during installation.

Industry guidelines for pulling cable recommend limiting the maximum total number of directional changes not to exceed 360 degrees within a conduit pathway. For example, a conduit pathway having four 90-degree bends might be made up of two 90-degree riser bends, one at each end, and possibly two more somewhere else in the pathway, for a total of 360 degrees. See **Figure 5** as an illustration of how pulling cable can result in friction with the conduit sidewall.

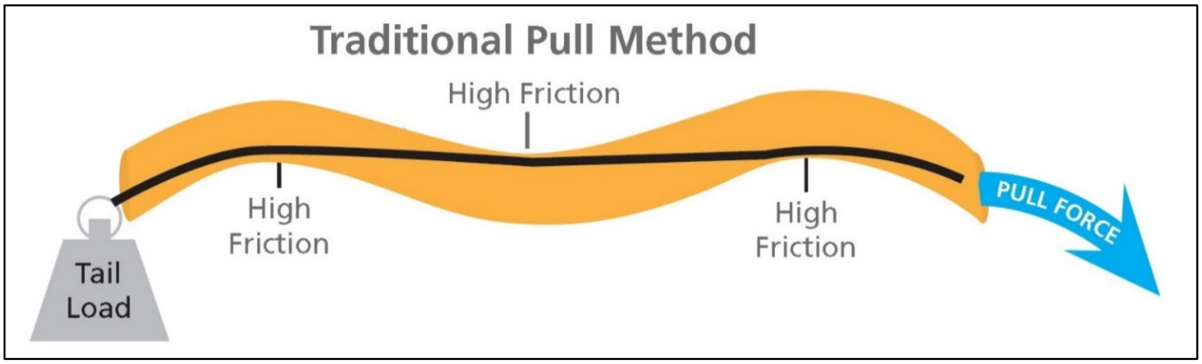

Figure 5: Traditional Pulling Method (not to scale)

4.1. <u>Rodding Installation</u>

Rodding, as a means for pulling in the HDPE conduit or fabric divider, reduces the likelihood of the pulling medium sawing through the conduit wall or existing cables. The installation is accomplished by hand-pushing a fiberglass rod into the empty or occupied conduit, and then attaching it to the material to be hand-pulled into place. Installation using a fiberglass rod is usually only effective for relatively short pulls, typically 500 feet (152 m) or less.

Fabric divider is typically supplied with individual pull lines factory-installed in each of its pathways, an added initial cost, especially when the other pathways may not be used until much later. Rodding would be an option, but only, as mentioned above, over shorter installations. Pull lines can always be added to conduit by blowing them into the conduit, a cost that can be deffered and will not be incurred until it is needed.

5.0 CONSIDERATIONS FOR JETTING INSTALLATIONS

A key advantage of installing small diameter HDPE innerducts or micro ducts is the ability to use jetting technology for installing fiber optic cables.

Jetting in ("jetting") cable is accomplished by injecting compressed air, usually from an air compressor, into a conduit. As the compressed air flows through the conduit, it helps to "jet" or carry the micro duct or cable into place. The action of air rushing over the outside of the micro duct or cable, in concert with pushing during installation, helps the micro duct or cable to be propelled into place. See **Figure 6** for an illustration of a typical Air-assisted Jetting Method.

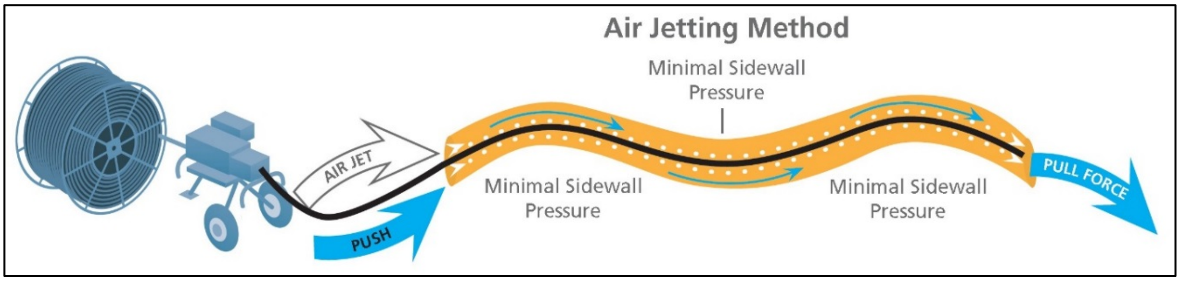

Figure 6: Typical Air-assisted Jetting Method (not to scale)

Typically, longer installation lengths can be achieved using jetting technology when compared to traditional pulling operations. This is because jetting simultaneously lowers sidewall and tail loads, reducing installation stresses on cables, two primary contributors to increased friction that can lead to cable damage.

Installing micro ducts via jetting into a conduit which is occupied by an existing cable is referred to as an *override*. The override technique can be used to create additional pathway capacity in existing occupied conduit. Override technology is discussed in more detail later.

Fewer steps are required for installations using jetting technology vs. traditional winching methods. When jetting is used, very long cable lengths of fiber can be placed, utilizing fewer set-ups and access locations. Fewer set-ups and access locations can increase installation efficiencies and potentially reduce total project material costs. This installation option is an advantage that is gained by using HDPE conduit.

In addition, a jetting system is faster to set-up than a winching operation, and can typically be done with fewer workers, increasing productivity and reducing cable installation time. This can result in additional labor cost reductions, as compared to winching cables.

Typical installation speeds vary dramatically between jetting and winching. As a comparison, winching speeds range from 50 to 75 feet/minute (15 to 23 meters/minute), while jetting installation speeds can reach over 300 feet/minute (91 meters/minute), four to six times faster.

There are various configurations of jetting equipment. Each version is designed for installing a range of diameters of micro ducts, and/or a range of micro or standard fiber cable diameters into the micro duct or innerduct, respectively. The added versatility of jetting equipment increases installation efficiencies, while potentially lowering equipment costs.

Fiber cable installation lengths exceeding 5,000 feet (1,520 m) have been achieved, when conditions are favorable, into either micro ducts or traditional nominal size ½ to 2 inch HDPE conduits.

5.1. Override Installations

Override installations permit additional fiber cables to be installed by inserting micro duct pathways within existing conduits already populated with a cable or cables. Traditionally, populated conduits that were considered to be fully utilized can now, through the use of override technology, make use of additional capacity.

Use of the override technique can reduce project costs. Both time and cost can be reduced by eliminating the need to obtain additional right-of-way approvals, thereby creating a more expedient installation alternative, as compared to the construction costs of burying additional conduit runs.

Using one or more micro ducts for an override is accomplished by jetting them over an existing cable, into the available space between the outside diameter (OD) of the existing cable and the inside diameter (ID) of the occupied conduit. **See Figure 7**.

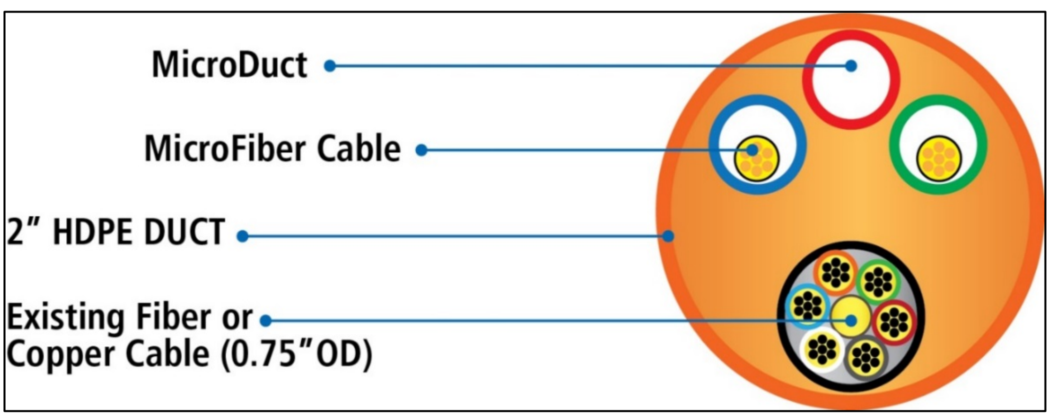

Figure 7: HDPE Outer Duct with Inner Duct and Micro Ducts

6.0 PROVIDER-TO-CUSTOMER SYSTEM DESIGN

HDPE conduits provide designers much greater design flexibility from signal souce (i.e. Provider) to the customer and for future plant expansions. This is because innerducts are not only designed to be used for subdividing larger conduits, but can also be directly buried without requiring an outer conduit, whereas fabric divider requires the protection of a larger conduit as the only way to extend a system's reach. This requirement can substantially increase the cost of expanding a system in order to make use of fabric divider in the future.

A wide range of couplers, caps and reusable plugs are available for HDPE innerducts and micro duct conduit systems for use in quickly joining and sealing both empty and occupied conduits. These products provide air-tight and water-tight connections and terminations to prevent unwanted debris, water, and chemicals from entering the conduit. Couplers also provide a sealed system that can hold and channel air flow, which is necessary in order to effectively jet cables into place. See **Figures 8a** and **8b** for examples of these accessories.

Figure 8a: Micro Duct Couplers

Figure 8b: Micro Duct Caps

No joining system exists for fabric dividers. Sealing around fabric innerducts typically requires a costly proprietary sealing system, which can be difficult to install. Such proprietary systems require special seals, suitable for the specific conduit/cable configuration, along with special installation tools and CO_2 cartridges. These sealing systems may not be reusable, and can add significantly to restoration costs.

7.0 SUMMARY

Based on the physical properties alone, it is apparent that HDPE conduit and fabric divider products differ greatly. Fabric divider does not provide the wide range of physical properties and performance capabilities inherent in HDPE conduit.

To summarize, the list of inherent advantages of HDPE conduit vs. fabric dividers:

- Traditional **HDPE conduits** provide true physical and mechanical protection for cables, and can be installed as an innerduct for dividing larger conduits
  - **Fabric divider** serves only as a divider, offering very little additional physical protection for cables

- **HDPE conduits** allow for a much broader range of applications and installation methods, as well as for the fiber cables to be installed
  - **Fabric divider** cannot be direct buried, and must have a larger conduit in order to protect it from damage

- When extending the reach of an underground system, **HDPE innerduct** can be joined to what is in place, and the next section direct-buried, without the need of adding an outer conduit for additional protection, saving time and cost
  - Adding onto an existing system requires that **fabric dividers** be installed into large diameter conduit, potentially increasing costs

- Cables can be jetted into **HDPE conduit** and innerduct over very long distances, significantly lowering cable installation costs
  - **Fabric dividers** require the cables to be pulled or winched into place, resulting in shorter installation distances; jetting is not an option

- Multiple accessories are available for **HDPE innerduct**, including couplers for joining, caps and plugs for sealing, plus split options in couplers and plugs for reentering
  - **Fabric divider** uses proprietary joining methods, and sealing is difficult, requiring proprietary materials and special training for the techniques to be used on the job site

- The ability to jet cables into existing **HDPE innerduct** eliminates the cost of having to factory or field install a pull line
  - **Fiber divider** requires pull lines to be preinstalled in the factory into each pathway, adding to its overall cost

It is important to recognize that HDPE conduit installed as an innerduct is only one type of installation method for HDPE conduit, which can also be direct-buried with requiring an external protective conduit. All of the traditional installation methods, such as open-cut (trenching), horizontal directional drilling or plowing can be used to install HDPE conduit, making it ideally suited for use as an innerduct or stand alone conduit.

8.0 CONCLUSION

Diverse installation methods combined with superior affordability makes HDPE conduit a more versitile end-to-end design solution. HDPE conduit can also be provided with cables which are factory-installed, further simplifying field installation via any of the previously mentioned installation methods.

In conclusion, HDPE innerduct provides designers and end-users the greatest flexibility when designing, installing, and protecting fiber optic cable networks for both current and future needs.