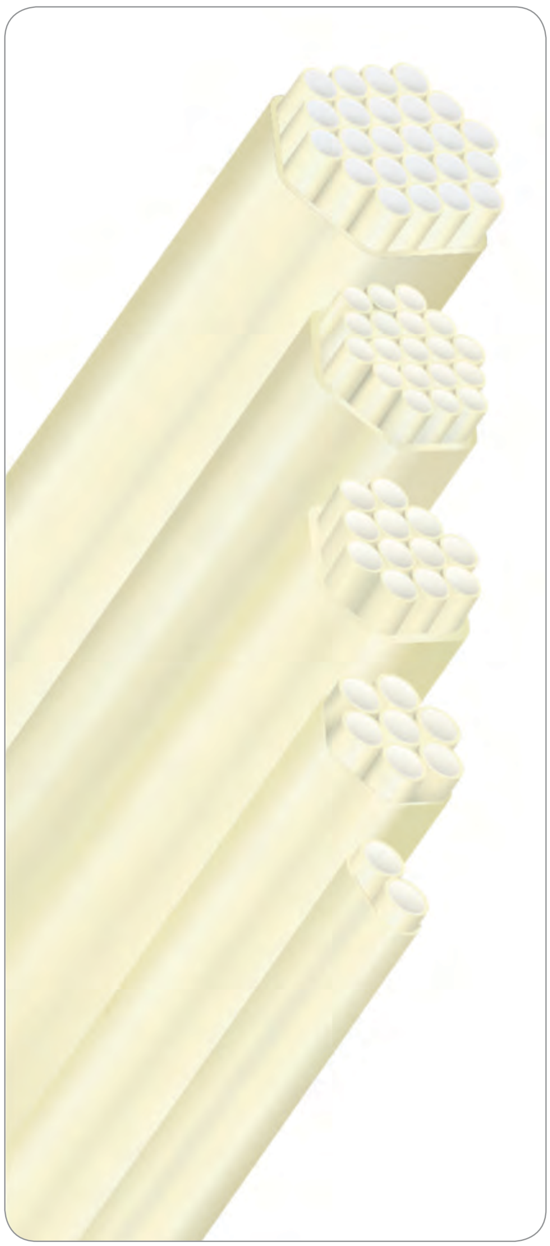
eABF® Fiber Optic Cable and MicroDuct Installation Manual



AFLglobal.com or (800) 866-7385
Duraline.com or (800) 847-7661

Table of Contents

Preface

There is a dual purpose for this manual. The first is to provide a guide for the training on the Installation and maintenance of the Dura-Line FuturePath® Enterprise System. The second and equally important purpose is to provide a reference manual.

The manual will provide:

- An overview of Jetted (blown) fiber
- Basic design criteria
- The components of a jetted fiber system
- Installation of a jetted fiber system with a focus on Dura-Line's FuturePath Enterprise System and the eABF® fiber manufactured by AFL exclusively for Dura-Line
- Connectivity associated with a blown fiber system.
- Maintenance of the Dura-Line FuturePath Enterprise System, including moves, adds and changes (MAC).

References to applicable Standards and local, state and federal codes are used in this manual. This manual is not intended to supersede these References and Standards. It remains the responsibility of the installation companies and installers being trained to be familiar with current prevailing codes and Standards. This manual is specific to Dura-Line FuturePath Enterprise and AFL's eABF fiber. Any direct or indirect references to other vendors are strictly unintended and should not be considered endorsements unless otherwise indicated.

Where indicated, this manual will refer to either Dura-Line Technical Bulletins or AFL Support Documentation for additional information of related subjects. Additional information can be obtained from the following websites:

www.duraline.com

www.aflglobal.com

Safety

Good safety practices should always be considered when placing eABF conduit and fiber optic cable. The safety issues inherent in any inside or outside plant construction project should be anticipated and appropriate precautions taken. Personal Protective Equipment (PPE) should be worn at all times during work functions that require their usage. Never look directly into the end of optical fibers, which may be connected to a laser source. Cable and conduit reels can be very heavy; so steel-toe shoes or boots are recommended.

A site survey for the purpose of planning the Dura-Line FuturePath® Enterprise System installation should include an assessment of specific risks related to safety. The survey should include planning and preparation for the unloading and staging of project materials. Discuss any local restrictions regarding work hours or any special precautions. **It is the responsibility of the Installer and/or their employers to be familiar with local, state and OSHA safety requirements.**

Safety Specific to Jetting Fiber

Specific safety requirements associated with jetting fiber are few. Jetting does require the use of high-pressure air and eye protection is recommended whenever jetting is employed. Improperly installed or defective connections may result in blowouts, which could cause injury. Always increase pressures slowly to help verify connections are secure.

Never look directly into the MicroDucts during testing.

- Never look directly into the optical fiber or optical connector.
- Use caution when working in confined spaces.
- When using or transporting nitrogen or compressed air cylinders, support in a horizontal position, unless special compartments or racks are available. Adequate blocking shall be provided to prevent cylinder movement. Regulators shall be removed or guarded before a cylinder is transported.
- Verify proper operation of compressors, as well as all pressure hoses and connectors. A 5% solution of water and dish soap may be used to test connections for leakage. Brush the solution over connections and look for bubbles. Tighten connections as appropriate should bubbles appear.
- All safety practices associated with optical fiber splicing and optical fiber connectors must be observed.
- All local safety codes, traffic management requirements and building codes must be observed.

Safety Specific to Handling Optical Fibers

Observe the standard safety requirements when handling, splicing or terminating optical fiber. Requirements that should be reinforced with each technician:

- Always wear safety glasses when handling fiber.
- Never eat or drink in areas where fiber is stripped, cleaved, or inspected.
- Be aware of the location of the fiber end at all times while handling fiber.
- Dispose of fiber ends in a labeled container used for that purpose. A tape tray may be used while work is being performed to help keep loose fiber ends under control on the work surface. Bare fibers are composed of glass and may penetrate the skin.
- Never throw or allow fiber ends to be dropped on the floor or onto work surfaces.
- Never use a straight razor blade alone to cut fibers or fiber units. The razor must be secured in a safety handle or other razor knife device and cut-resistant gloves should be worn.
- Never dispose of bare fiber in regular trash cans. Provide special containers for fiber ends.
- Use a brush to clean off work surfaces where bare fiber was handled and cleaved. Never use bare hands. Sweep the fibers on the work surface into a container used to collect fiber ends.

- Brush off the bottoms of shoes thoroughly before leaving the splicing area.
- Use only approved fiber-cleaning solution and only in a well-ventilated space.
- Avoid viewing a fiber end with direct magnification without first determining there is not an active Laser or LED source at the far end.
- Always clean hands after fiber splicing to help ensure any errant glass particles are removed.

Jetted (Blown) Fiber Cable Systems Overview

A jetted (blown) fiber installation utilizes FuturePath® bundled MicroDucts as a permanent protected pathway for valuable communications and fiber optic cabling. Enterprise Air Blown Fiber (eABF) cables are jetted into the MicroDucts using a system of compressed air (or compressed nitrogen). FuturePath is a configuration of MicroDucts surrounded by a High Density Polyethylene (HDPE) covering. FuturePath applications also include Riser, Plenum, LSHF, Armored and Aerial duct as well as standard HDPE for outside plant (OSP) installations. The comprehensive range of Dura-Line FuturePath products provides the ability to install additional eABF fiber optic cables as the network grows, all within the same duct structure. Utilizing Micro Technology, FuturePath allows maximum cost effectiveness and greatest return on investment for existing and future network builds. Current telecommunications infrastructure reaches its maximum utilization with the introduction of Micro Technology. FuturePath Enterprise can be used effectively in a number of applications, from aerial to direct buried, horizontally directionally drilled (bored), or pulled into underground conduit systems. It can be placed into rack systems, pulled into rigid steel conduit, or used as a stand-alone system in walls, ceilings, or foundations.

The concept of jetted fiber originated in the 1980s as an alternative placing method to the traditional pulling-in of fiber. There are some very important advantages in the jetted fiber technique. Fiber cable diameters can be reduced so smaller conduit can be used, minimizing space requirements. Placement distances were increased and friction-reducing linings such as Dura-Line's SILICORE® were introduced, along with advances in cable lubricants. MicroCables and MicroDucts became available originally as an override solution to nearly full conduit locations, for additional pathway creation and for adding capacity quickly and with less expense. FuturePath follows the same concept, only helps to “future proof” the network, providing additional pathways for future requirements, including moves, adds, or changes in the network.

eABF Cabling System Benefits

Using a bundled configuration of MicroDucts, FuturePath is installed in convenient lengths and joined together. Reel handling equipment is minimized, avoiding multiple reels having to be pulled simultaneously. MicroDucts can be joined using very simple “push-fit” connectors within junction boxes or splice closures. In some environments, it is very difficult to install a long, unbroken fiber optic cable. Utilizing FuturePath, installation of the MicroDuct in easy to manage sections can save substantially in time and labor.

When the eABF fiber optic cable is “jetted in” each cable is unbroken from end-to-end. This reduces the need (and cost) of joining or splicing the optical fiber. By installing the cable using a combination of air pressure and a drive wheels to propel the eABF MicroCable through the MicroDuct, the MicroCable is under very little stress. Additionally, because the fiber is installed in long, unbroken lengths, attenuation losses or reflection problems are avoided.

It is possible to remove fiber from the MicroDucts by blowing the cable out and re-installing it into other MicroDucts on other routes so long as the lengths allow. Since installing the MicroDuct (or regular fiber optic cable) is a major part of the installation cost, this allows for very low cost changes as the network evolves.

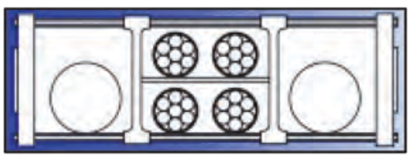
Fiber cable types and requirements are a constantly changing variable as new equipment is introduced. When that happens, jetted fiber installations will provide the flexibility to effect changes for significantly lower cost than those locations with more conventional fiber cabling.

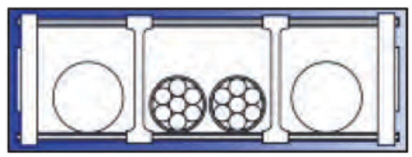
More information regarding optical fiber will be provided in a subsequent chapter.

Elements of a Jetted (Blown) Fiber System

- MicroDuct
- eABF Optical Fiber Cable
- Connectivity Equipment
- Closures/Enclosures
- Termination Connectors
- Splices
- NEMA Boxes, manholes, handholes
- Fiber Management Shelves or Patch Panels
- Jetting (blowing) Equipment

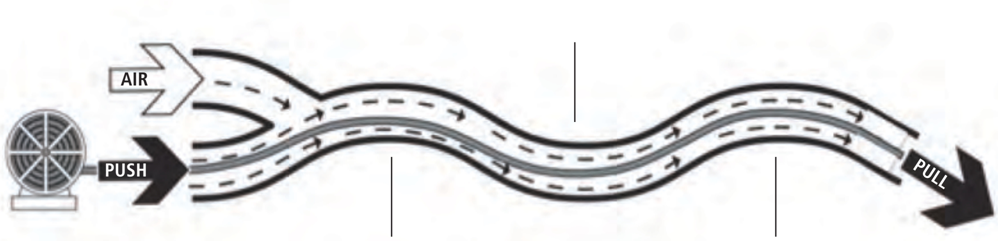
Details on these elements are more thoroughly covered in the following sections.



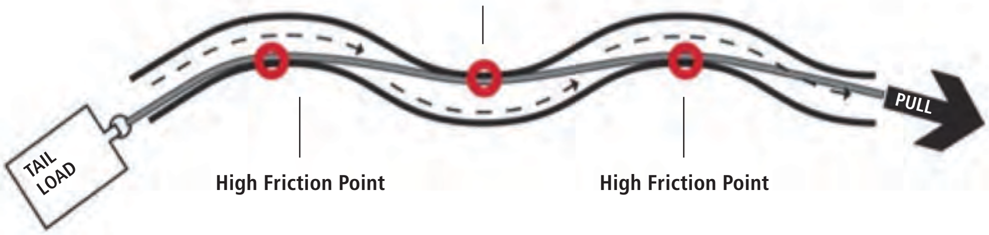


Cable distribution tray and rack space can be maximized when using FuturePath instead of traditional corrugated conduit or steel pipe. A greater number of pathways can be installed at one time and utilizing less valuable rack space than conventional conduit pathways. Additionally, the network is now "future-proofed" for expansion and addition of more fiber optic cables, which can be quickly placed into the MicroDucts using "Blown" Technology.

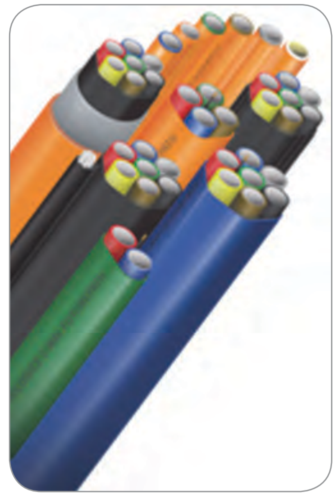
Jetting Method



Traditional Pull Method



FuturePath MicroDuct



Fiber optic pathway creation for enterprise markets is made easier with Dura-Line's FuturePath MicroDuct system and accessories. Ideal for hospitals, campuses, manufacturing facilities and government fiber optic networks, FuturePath provides a permanent protected pathway for fiber installation with the ability to add capacity to the fiber optic Network Infrastructure.

FuturePath, in conjunction with jetted eABF (blown) fiber optic cables, allows the client and designers the flexibility to build their network as needed, placing multiple pathways at one time, which allows upgrades, moves, adds and changes in a timely manner and at significant savings. With a dedicated pathway in place, additional fiber can be quickly deployed when needed, enhancing the ability to move to the latest technology with less cost, less labor and fewer disruptions.

Utilizing FuturePath quick connect couplers, the MicroDuct can be joined point-to-point, eliminating the need for splicing of fiber or use of patch panels. Placing fiber strands as needed minimizes the purchase and placement of "future-planned" large-count fiber optic cables and having to terminate dark fiber. Utilizing a bundled HDPE (High-Density Polyethylene) MicroDuct system, FuturePath gives scalability and creates a safe protective housing for a valuable fiber infrastructure.

Dura-Line's FuturePath

Dura-Line's FuturePath configurations conform to Telcordia's GR-3155-CORE-*Generic Requirements for MicroDucts for Fiber Optic Cables*. Telcordia GR-3155-CORE covers MicroDuct sizes noted below.

- 5/3.5 mm MicroDuct—Outer diameter 5 mm; Inside Diameter 3.5 mm
- 7/5.5 mm MicroDuct—Outer Diameter 7 mm; Inside Diameter 5.5 mm
- 8.5/6 mm MicroDuct—Outer Diameter 8.5 mm; Inside Diameter 6 mm
- 10/8 mm MicroDuct—Outer Diameter 10 mm; Inside Diameter 8 mm
- 12/10 mm MicroDuct—Outer Diameter 12 mm; Inside Diameter 10 mm
- 12.7/10 mm MicroDuct—Outer Diameter 12.7 mm; Inside Diameter 10 mm

While other sizes are available, the standard Enterprise MicroDuct sizes used in the Dura-Line Enterprise FuturePath system are:

- 5 /3.5 mm MicroDuct
- 8.5/6 mm MicroDuct
- 12.7/10 mm MicroDuct

The FuturePath MicroDuct sizes are designed to provide maximum price/performance and the ability to supplement and extend existing installations by other vendors. **See Table 1 for FuturePath Configurations and Specifications.**

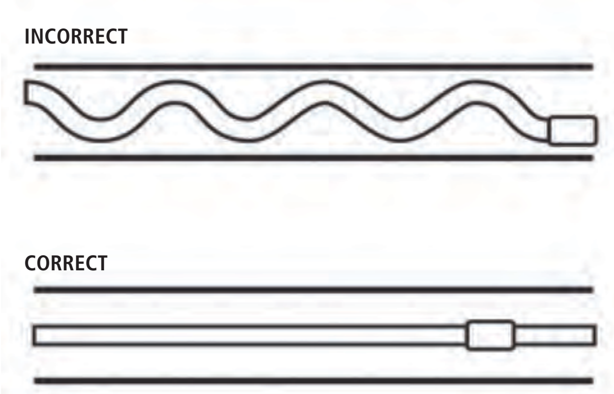
Specifications for MicroDuct and FuturePath

The specification for Dura-Line MicroDuct and FuturePath establishes the minimum material and performance requirements. A number of MicroDucts can be jetted (blown) into an outer duct. The individual MicroDuct then provides a dedicated path for a single cable. FuturePath is the latest technology in the Dura-Line MicroDuct product line. MicroDucts are placed together (based on the customers installation requirements) and a polythene sheath is extruded over the entire bundle. FuturePath can be jetted (blown) in, pulled in, buried or placed aerially.

Table 1—Basic FuturePath Configurations and Specifications

MICRODUCT SIZE	NUMBER OF MICRODUCTS	OUTSIDE DIAMETER (INCHES)	MDPE OVER SHEATH WALL THICKNESS (INCHES)	TOTAL WEIGHT LBS/FT	SAFE WORKING PULL STRENGTH (LBS)	MIN. BEND RADIUS (INCHES)
12.7/10 mm	7	1.64	0.070	0.380	1,962 LBS	25
12.7/10 mm	4	1.35	0.070	0.249	1,700 LBS	20
12.7/10 mm	3	1.22	0.070	0.201	971 LBS	18
12.7/10 mm	2	1.100	0.060	0.127	754 LBS	9
12.7/10 mm	1	0.500	N/A	0.033	223 LBS	9
8.5/6 mm	24	2.13	0.060	0.614	2,500 LBS	53
8.5/6 mm	19	1.80	0.060	0.501	2,100 LBS	45
8.5/6 mm	12	1.48	0.060	0.341	1,400 LBS	37
8.5/6 mm	7	1.13	0.060	0.221	900 LBS	28
8.5/6 mm	4	0.93	0.060	0.145	600 LBS	23
8.5/6 mm	3	0.85	0.060	0.118	400 LBS	21
8.5/6 mm	2	0.77	0.050	0.081	300 LBS	11
8.5/6 mm	1	0.335	N/A	0.019	115 LBS	4
10/6 mm (HDPE) with 20 AWG Locate Wire and Oversheath	1	0.394 0.489 (LOCATABLE)	0.015 (LOC)	0.033 0.042 (LOC)	300 LBS	6
5/3.5 mm	24	1.266	0.040	0.238	1,214 LBS	19
5/3.5 mm	19	1.069	0.040	0.195	995 LBS	16
5/3.5 mm	12	0.88	0.040	0.134	685 LBS	13
5/3.5 mm	7	0.675	0.040	0.088	447 LBS	10
5/3.5 mm	4	0.56	0.040	0.059	300 LBS	7
5/3.5 mm	3	0.51	0.040	0.046	244 LBS	8
5/3.5 mm	2	0.46	0.030	0.031	157 LBS	4
5/3.5 mm	1	0.197	N/A	0.007	50 LBS	4

When designing a Network using FuturePath, dimensional limitations should be considered, including minimum bend radii for the product being installed. While individual MicroDucts have a relatively tight bend radius, maintaining large sweeping bends will increase jetting distances and limiting the number and severity of bends will help the installer when it comes time to place the eABF cable.



As in all conduit installations, bends and degree of turns are cumulative; that is, they all add up to increased pulling or jetting friction when placing cable. Keeping runs as straight as possible will aid in placing the pathway as well as the cable within it. Minimize elevation changes and when possible, jet cable from a higher to lower elevation, taking advantage of the effects of gravity.

Pathway Considerations

Where the pathway will be placed and what size cable will be required make up the determining factors as to what product is selected when designing an eABF solution. These are some of the factors to consider: if the pathway will need to be riser or plenum rated, will it be placed outside in conduit or direct buried, or will it be continually exposed to sunlight, requiring a UV protection. What size cable requirements will also help determine what diameter MicroDuct is needed.

Project Checklist for MicroDuct Selections

- **Riser**—For many inside locations, a riser rating is all that is required. Check with the project director to help ensure a higher rating is not a requirement. Riser pathways are typically of a pale yellow color and will have "Riser or Durathane" printed and UL-94, V-2 printed upon the product.
- **Plenum**—If the pathway is to be placed into an air-handling space, then a plenum product may be required. Plenum has the designation "FireJacket or Plenum," is colored a bright white and has a UL-94 designation of V-0.
- **UV Rated**—Riser or Plenum products are useful for indoors where there is not constant direct sunlight. Riser products can be made with a UV-resistant oversheath should that be required where the pathway transitions between indoor and outdoor locations. Plenum cannot be made in a UV version. Standard OSP (orange sheath) FuturePath has enough UV protection to safeguard the product for up to two years in outside storage in sunlight. For extreme conditions or constant sunlight exposure, request a UV-resistant oversheath for 20+ years of protection from exposure to sunlight.
- **Cable Size**—Dura-Line recommends fill ratios of MicroDuct inside diameters to be at least 20% larger than the diameter (O.D.) of the cable being installed. 50%-75% fill ratio is generally considered ideal. It is important to leave enough room for sufficient airflow around the cable to maximize jetting potential. For example, an eABF cable with an O.D. of 4.1 mm would work well in a MicroDuct of 8.5 mm x 6 mm. A MicroCore fiber optic cable with a diameter of 7.1 mm, for instance, would be best placed into a 12.7 mm x 10 mm MicroDuct. The following product sheets provide information on the FuturePath HDPE, Riser and Plenum pathways.

ENTERPRISE HDPE FUTUREPATH – 12.7mm/10mm (9.8mm)

MICRODUCT SPECIFICATIONS:	
OD	12.7mm ± 0.10 (0.500" ± 0.004")
Wall Min.	1.30mm (0.051")
Wall Max.	1.40mm (0.055")
ID Min.	9.80mm (0.386")

FIBER:
Fiber Count: 24, 36, 48, 72, 96, & 144 strand MicroCable SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:
1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:
MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

SPECIFICATIONS:
All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios

	2-Way	3-Way	4-Way	7-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.60/1.10 15.3/28.0	1.08/1.14 27.4/29.1	1.14/1.35 29.1/34.3	1.51/1.64 38.4/41.8
Outside Diameter (inches) Outside Diameter (mm)	1.10 28.0	1.22 31.0	1.35 34.3	1.64 41.8
Weight/Foot				
Over-Sheath Thickness	0.050"	0.070"	0.070"	0.070"
HDPE Over-Sheath Color MicroDuct Color	Orange Natural	Orange Natural	Orange Natural	Orange Natural
HDPE Locate Wire	20 ga.	20 ga.	20 ga.	20 ga.
Ripcords	1	2	2	2
Length:	PART #	PART #	PART #	PART #
1,000 ft	4-160136-1000	4-160137-1000	4-160138-1000	4-160139-1000
4,000 ft	4-160136-4000	4-160137-4000	4-160138-4000	4-160139-4000
6,000 ft	4-160136-6000	4-160137-6000	4-160138-6000	4-160139-6000

dura·line www.duraline.com 800-847-7661

ENTERPRISE HDPE FUTUREPATH – 8.5mm/6mm

MICRODUCT SPECIFICATIONS:	
OD	8.5mm ± 0.10 (0.335" ± 0.004")
Wall Min.	1.14mm (0.045")
Wall Max.	1.24mm (0.049")
ID Min.	5.92mm (0.233")

FIBER:
Fiber Count: 2, 6, 12, Fiber Unit 24, 48 strand MicroCables
SM, MM – OM-1, OM-2, OM-3, OM-4

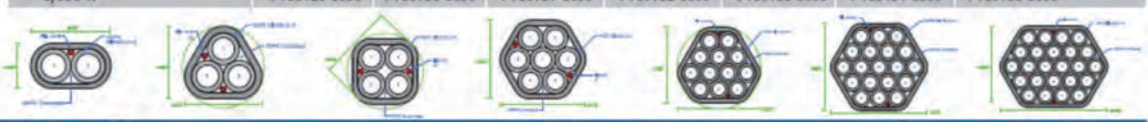
SHIPPING LENGTH – FEET PER REEL:
1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:
MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

SPECIFICATIONS:
All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios

	2-Way	3-Way	4-Way	7-Way	12-Way	19-Way	24-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.44/0.77 11.2/19.7	0.75/0.79 19.0/20.2	0.79/0.93 20.2/23.7	1.04/1.13 26.4/28.7	1.33/1.46 33.8/37.2	1.62/1.80 41.1/45.7	1.62/2.13 41.1/54.2
Outside Diameter (inches) Outside Diameter (mm)	0.77 19.7	0.85 21.5	0.93 23.7	1.13 28.7	1.48 37.7	1.80 45.7	2.13 54.2
Weight/Foot							
Over-Sheath Thickness	0.050"	0.060"	0.060"	0.060"	0.060"	0.060"	0.060"
HDPE Over-Sheath Color MicroDuct Color	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural
HDPE Locate Wire	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.
Ripcords	1	2	2	2	2	2	2
Length:	PART #	PART #	PART #	PART #	PART #	PART #	PART #
1,000 ft	4-160129-1000	4-160130-1000	4-160131-1000	4-160132-1000	4-160133-1000	4-160134-1000	4-160135-1000
4,000 ft	4-160129-4000	4-160130-4000	4-160131-4000	4-160132-4000	4-160133-4000	4-160134-4000	4-160135-4000
6,000 ft	4-160129-6000	4-160130-6000	4-160131-6000	4-160132-6000	4-160133-6000	4-160134-6000	4-160135-6000



dura·line www.duraline.com 800-847-7661

ENTERPRISE HDPE FUTUREPATH – 5mm/3.5mm

MICRODUCT SPECIFICATIONS:	
OD	5mm ± 0.10 (0.197" ± 0.004")
Wall Min.	0.66mm (0.026")
Wall Max.	0.76mm (0.030")
ID Min.	3.38mm (0.133")

FIBER:

Fiber Count: 2, 6, & 12 Fiber Unit
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:

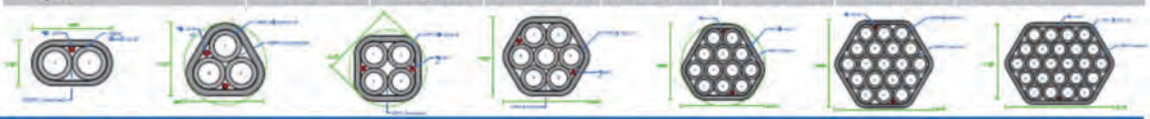
1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:		
MINIMUM TEMPERATURE:	-40°F	(-40°C)
MAXIMUM TEMPERATURE:	+180°F	(+82°C)

SPECIFICATIONS:	
All Conduits produced to:	GR-3155-CORE
All Fiber Optic Cable produced to:	GR-409-CORE

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios

	2-Way	3-Way	4-Way	7-Way	12-Way	19-Way	24-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.26/0.46 6.6/11.6	0.45/0.48 11.5/12.1	0.48/0.56 12.1/14.2	0.62/0.68 15.8/17.1	0.79/0.87 20.1/22.1	0.96/1.07 24.5/27.2	0.96/1.27 24.5/32.2
Outside Diameter (inches) Outside Diameter (mm)	0.46 11.6	0.51 12.9	0.56 14.2	0.68 17.1	0.88 22.4	1.07 27.2	1.27 32.2
Weight/Foot							
Over-Sheath Thickness	0.030"	0.040"	0.040"	0.040"	0.040"	0.040"	0.040"
HDPE Over-Sheath Color MicroDuct Color	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural	Orange Natural
HDPE Locate Wire	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.	20 ga.
Ripcords	1	2	2	2	2	2	2
Length:	PART #	PART #	PART #	PART #	PART #	PART #	PART #
1,000 ft	4-160121-1000	4-160122-1000	4-160123-1000	4-160124-1000	4-160125-1000	4-160126-1000	4-160127-1000
4,000 ft	4-160121-4000	4-160122-4000	4-160123-4000	4-160124-4000	4-160125-4000	4-160126-4000	4-160127-4000
6,000 ft	4-160121-6000	4-160122-6000	4-160123-6000	4-160124-6000	4-160125-6000	4-160126-6000	4-160127-6000



dura·line www.duraline.com 800-847-7661

ENTERPRISE RISER FUTUREPATH – 12.7mm/10mm (9.8mm)

MICRODUCT SPECIFICATIONS:	
OD	12.7mm ± 0.10 (0.500" ± 0.004")
Wall Min.	1.30mm (0.051")
Wall Max.	1.40mm (0.055")
ID Min.	9.80mm (0.386")

FIBER:

Fiber Count: 24, 36, 48, 72, 96, & 144 strand MicroCable
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:

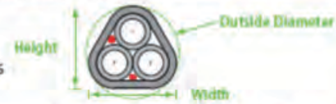
1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:		
MINIMUM TEMPERATURE:	-40°F	(-40°C)
MAXIMUM TEMPERATURE:	+180°F	(+82°C)

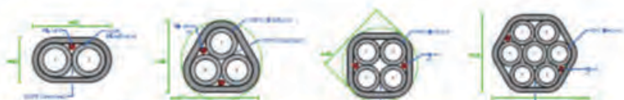
SPECIFICATIONS:	
All Conduits produced to:	GR-3155-CORE
All Fiber Optic Cable produced to:	GR-409-CORE
ETL & CSA Listing UL 2024 Riser	

Outside Dimensions: Height x Width

Outside Diameter: Used to Calculate Fill Ratios



	2-Way	3-Way	4-Way	7-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.60/1.10 15.3/28.0	1.08/1.14 27.4/29.1	1.14/1.35 29.1/34.3	1.51/1.64 38.4/41.8
Outside Diameter (inches) Outside Diameter (mm)	1.10 28.0	1.22 31.0	1.35 34.3	1.64 41.8
Weight/Foot	0.127	0.201	0.249	0.380
Over-Sheath Thickness	0.050"	0.070"	0.070"	0.070"
HDPE Over-Sheath Color MicroDuct Color	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow
Ripcords	1	2	2	2
Length:	PART #	PART #	PART #	PART #
1,000 ft	4-160115-1000	4-160116-1000	4-160117-1000	4-160118-1000
4,000 ft	4-160115-4000	4-160116-4000	4-160117-4000	4-160118-4000
6,000 ft	4-160115-6000	4-160116-6000	4-160117-6000	4-160118-6000



dura·line www.duraline.com 800-847-7661

ENTERPRISE RISER FUTUREPATH – 8.5mm/6mm

MICRODUCT SPECIFICATIONS:	
OD	8.5mm ± 0.10 (0.335" ± 0.004")
Wall Min.	1.14mm (0.045")
Wall Max.	1.24mm (0.049")
ID Min.	5.92mm (0.233")

FIBER:

Fiber Count: 2, 6, 12, Fiber Unit 24, 48 strand MicroCables
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:

1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:

MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

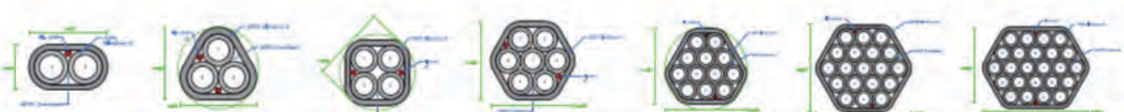
SPECIFICATIONS:

All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE
ETL & CSA Listing UL 2024 Riser

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios

*Black & Orange Oversheath available in some configuration, Min's applys

	2-Way	3-Way	4-Way	7-Way	12-Way	19-Way	24-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.44/0.77 11.2/19.7	0.75/0.79 19.0/20.2	0.79/0.93 20.2/23.7	1.04/1.13 26.4/28.7	1.33/1.46 33.8/37.2	1.62/1.80 41.1/45.7	1.62/2.13 41.1/54.2
Outside Diameter (inches) Outside Diameter (mm)	0.77 19.7	0.85 21.5	0.93 23.7	1.13 28.7	1.48 37.7	1.80 45.7	2.13 54.2
Weight/Foot	0.081	0.118	0.145	0.221	0.341	0.501	0.614
Over-Sheath Thickness	0.050"	0.060"	0.060"	0.060"	0.060"	0.060"	0.060"
HDPE Over-Sheath Color* MicroDuct Color	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow* Light Yellow	Light Yellow* Light Yellow	Light Yellow Light Yellow	Light Yellow* Light Yellow	Light Yellow Light Yellow
Ripcords	1	2	2	2	2	2	2
Length:	PART #	PART #	PART #	PART #	PART #	PART #	PART #
1,000 ft	4-160108-1000	4-160109-1000	4-160110-1000	4-160111-1000	4-160112-1000	4-160113-1000	4-160114-1000
4,000 ft	4-160108-4000	4-160109-4000	4-160110-4000	4-160111-4000	4-160112-4000	4-160113-4000	4-160114-4000
6,000 ft	4-160108-6000	4-160109-6000	4-160110-6000	4-160111-6000	4-160112-6000	4-160113-6000	4-160114-6000



dura·line www.duraline.com 800-847-7661

ENTERPRISE RISER FUTUREPATH – 5mm/3.5mm

MICRODUCT SPECIFICATIONS:

OD	5mm ± 0.10 (0.197" ± 0.004")
Wall Min.	0.66mm (0.026")
Wall Max.	0.76mm (0.030")
ID Min.	3.38mm (0.133")

FIBER:

Fiber Count: 2, 6, & 12 Fiber Unit
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:

1,000', 4,000', 6,000'
Custom Lengths Available

HDPE TEMPERATURE SPECS:

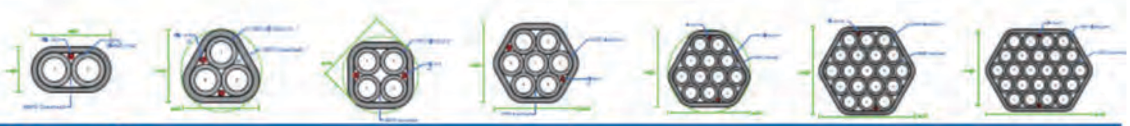
MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

SPECIFICATIONS:

All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE
ETL & CSA Listing UL 2024 Riser

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios

	2-Way	3-Way	4-Way	7-Way	12-Way	19-Way	24-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.26/0.46 6.6/11.6	0.45/0.48 11.5/12.1	0.48/0.56 12.1/14.2	0.62/0.68 15.8/17.1	0.79/0.87 20.1/22.1	0.96/1.07 24.5/27.2	0.96/1.27 24.5/32.2
Outside Diameter (inches) Outside Diameter (mm)	0.46 11.6	0.51 12.9	0.56 14.2	0.68 17.1	0.88 22.4	1.07 27.2	1.27 32.2
Weight/Foot	0.029	0.046	0.057	0.084	0.131	0.190	0.232
Over-Sheath Thickness	0.030"	0.040"	0.040"	0.040"	0.040"	0.040"	0.040"
HDPE Over-Sheath Color MicroDuct Color	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow	Light Yellow Light Yellow
Ripcords	1	2	2	2	2	2	2
Length:	PART #	PART #	PART #	PART #	PART #	PART #	PART #
1,000 ft	4-160100-1000	4-160101-1000	4-160102-1000	4-160103-1000	4-160104–1000	4-160105-1000	4-160107-1000
4,000 ft	4-160100-4000	4-160101-4000	4-160102-4000	4-160103-4000	4-160104–4000	4-160105-4000	4-160107-4000
6,000 ft	4-160100-6000	4-160101-6000	4-160102-6000	4-160103-6000	4-160104–6000	4-160105-6000	4-160107-6000



dura·line www.duraline.com 800-847-7661

ENTERPRISE PLENUM FUTUREPATH – 12.7mm/10mm (9.8mm)

MICRODUCT SPECIFICATIONS:

OD	12.7mm ± 0.10 (0.500" ± 0.004")
Wall Min.	1.30mm (0.051")
Wall Max.	1.40mm (0.055")
ID Min.	9.80mm (0.386")

FIBER:

Fiber Count: 24, 36, 48, 72, 96, & 144 strand MicroCable
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:

1,000', 4,000', 6,000'
Custom Lengths Available

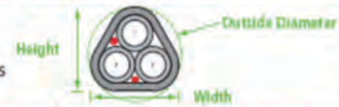
HDPE TEMPERATURE SPECS:

MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

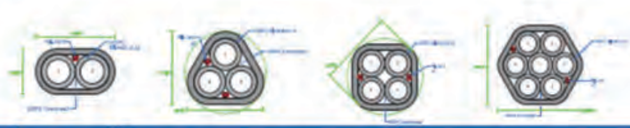
SPECIFICATIONS:

All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE
ETL & CSA Listing UL-2024 Plenum UL-94-V0

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios



	2-Way	3-Way	4-Way	7-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.60/1.10 15.3/28.0	1.08/1.14 27.4/29.1	1.14/1.35 29.1/34.3	1.51/1.64 38.4/41.8
Outside Diameter (inches) Outside Diameter (mm)	1.10 28.0	1.22 31.0	1.35 34.3	1.64 41.8
Weight/Foot				
Over-Sheath Thickness	0.050"	0.070"	0.070"	0.070"
HDPE Over-Sheath Color MicroDuct Color	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White
Ripcords	1	2	2	2
Length:	PART #	PART #	PART #	PART #
1,000 ft	5-160190-1000	5-160191-1000	5-160192-1000	5-160193-1000



dura·line www.duraline.com 800-847-7661

ENTERPRISE PLENUM FUTUREPATH – 8.5mm/6mm

MICRODUCT SPECIFICATIONS:	
OD	8.5mm ± 0.10 (0.335" ± 0.004")
Wall Min.	1.14mm (0.045")
Wall Max.	1.24mm (0.049")
ID Min.	5.92mm (0.233")

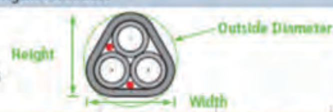
FIBER:
Fiber Count: 2, 6, 12, Fiber Unit 24, 48 strand MicroCables
SM, MM – OM-1, OM-2, OM-3, OM-4

SHIPPING LENGTH – FEET PER REEL:
1,000', 4,000', 6,000'
Custom Lengths Available

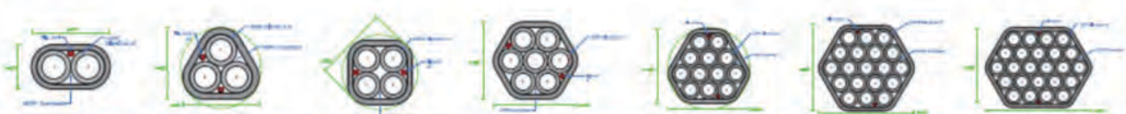
HDPE TEMPERATURE SPECS:
MINIMUM TEMPERATURE: -40°F (-40°C)
MAXIMUM TEMPERATURE: +180°F (+82°C)

SPECIFICATIONS:
All Conduits produced to: GR-3155-CORE
All Fiber Optic Cable produced to: GR-409-CORE
ETL & CSA Listing UL-2024 Plenum UL-94-V0

Outside Dimensions: Height x Width
Outside Diameter: Used to Calculate Fill Ratios



	2-Way	3-Way	4-Way	7-Way	12-Way	19-Way	24-Way
Outside Dimensions HxW (inches) Outside Dimensions HxW (mm)	0.44/0.77 11.2/19.7	0.75/0.79 19.0/20.2	0.79/0.93 20.2/23.7	1.04/1.13 26.4/28.7	1.33/1.46 33.8/37.2	1.62/1.80 41.1/45.7	1.62/2.13 41.1/54.2
Outside Diameter (inches) Outside Diameter (mm)	0.77 19.7	0.85 21.5	0.93 23.7	1.13 28.7	1.48 37.7	1.80 45.7	2.13 54.2
Weight/Foot							
Over-Sheath Thickness	0.050"	0.060"	0.060"	0.060"	0.060"	0.060"	0.060"
HDPE Over-Sheath Color MicroDuct Color	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White	Opaque White Opaque White
Ripcords	1	2	2	2	2	2	2
Length:	PART #	PART #	PART #	PART #	PART #	PART #	PART #
1,000 ft	5-160183-1000	5-160184-1000	5-160185-1000	5-160186-1000	5-160187-1000	5-160188-1000	5-160189-1000



dura·line www.duraline.com 800-847-7661

Planning a FuturePath Enterprise Installation—Site Survey and Preparation

A Dura-Line FuturePath Enterprise installation may come in several forms. It could be a single tenant in a building, a complete building for a single tenant or a campus including multiple buildings. All projects will be unique but all will adhere to basic installation concepts and practices.

Following basic installation concepts and developing a methodology is the best possible way to be sure satisfactory results are obtained. One example of a proven methodology is as follows:

- Locate an acceptable location to stage and store your equipment and materials. It should be a secure and protected area. An area protected from the weather may be required.
- Arrange for delivery of the material to the staging area.
- Inventory materials against the design documents and bills of lading.
- Address missing or damaged material immediately. Avoid removing protective wraps until ready to place the material.
- It is recommended to perform an acceptance test of the fiber before using. The test will provide a valid baseline for the records and for warranty purposes. Testing prior to placement will identify potential problems and aid in rectifying them more quickly and then after everything is connectorized and spliced.
- Verify a pathway if shipping damage is suspected. Pressure or BB testing procedures are available for testing while the FuturePath is still on the reel.

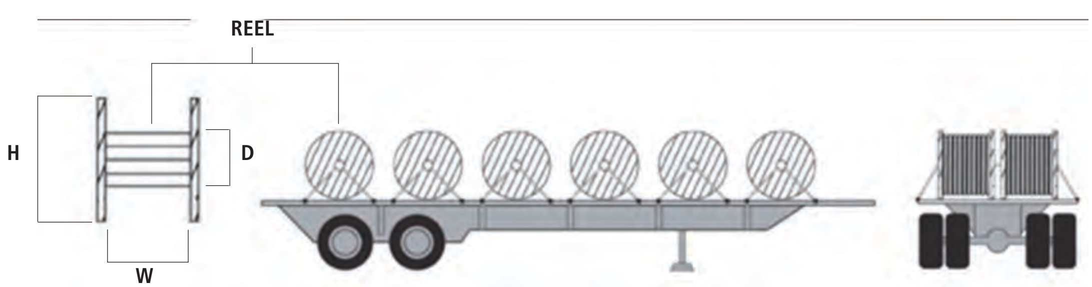
- Make sure working areas are suitable and ready to use.
- Decide on the jetting sequence in order to minimize set up and tear down time.
- Secure jetting equipment as necessary to facilitate jetting.
- Perform the required pressure and continuity tests on the MicroDucts after installation. Document the testing results.
- Verify all mounting locations that are being jetted through or into are installed and accessible.
- Prepare MicroDucts for jetting (blowing) fiber. Couple tubes as appropriate for maximum jetting distances.
- Jet all fiber making sure to mark and record the footage markers at the beginning and end of each run. Place all labels prior to jetting or pulling fiber into place.
- Secure and dress the MicroDuct as required. Dressing or organizing the MicroDuct helps eliminate braiding or bending, which could hinder placement of the fiber optic cable.
- Terminate connectorized or splice all fiber making sure that adequate labeling is completed from end-to-end.
- Record all runs and any other miscellaneous data that may be required as benchmarks for future system expansion as well as maintenance and repairs. Submit as-built drawings to the project designer for updating.

Receiving FuturePath

Upon receipt of a shipment of FuturePath, it is important to inspect the FuturePath and the reel for shipping damage.

When using a forklift for unloading FuturePath from the truck, lift the reel from the side placing the forks under the reel flanges. **DO NOT** lift the reels with the forks under the FuturePath. When using a boom truck to unload MicroDucts, place a properly rated spindle through the reel arbor hole and then attach a chain to the spindle. **DO NOT** wrap the chain around the MicroDuct flange to lift the reel. **DO NOT** ship or store reels on their sides, as this will allow coils to overlap and create problems during installation during payout.

Lift reels by flanges to avoid damaging FuturePath.



Truckload reels are shipped on flatbed trucks and secured with chains.

When using a boom truck to unload MicroDucts, place a properly rated spindle through the reel arbor hole, then attach a chain or rated sling to the spindle. Use an appropriately rated spreader bar so the chain or sling does not distort or bend the reel flanges.
DO NOT wrap the chain around the MicroDuct flange to lift the reel.

FuturePath Reel Markings

Contain the following:

- A complete product description
- Customer "Bill to" and "Ship to" address
- FuturePath length and sequential print start and end footage
- Dura-Line's reel number and Q.A. information

The Building Project

There are three basic components of the building or high-rise project:

- The building entrance
- The vertical or riser cabling
- The horizontal cabling
- The components used to interconnect the above three

Centralized Optical Fiber Cabling Building Entrance

The Building Distribution System per ANSI/TIA/EIA-568

A centralized optical cabling system is the most common, cost-effective design for most projects. A centralized optical cabling system minimizes connectorization and splicing while allowing maximum utilization of expensive electronics. This approach is much more cost-effective than the traditional method of distributing the electronics to the individual floors.

The building entrance facility can be a source of reduced costs and performance improvements when the Dura-Line FuturePath Enterprise system is used. The use of bundled MicroDucts in the entrance facility allows for future growth with spare ducts and the ability to remove and reuse the fiber optic cable. A major advantage is gained by coupling MicroDuct for outside and inside plant than jetting fiber from end-to-end.

Pathway connections are extended to the main cross-connect by utilizing either pull-through cables, an interconnect location, or a splice in the telecommunications room. Use of an interconnection between the horizontal and backbone cabling provides the greatest flexibility, ease of manageability and can easily be migrated to a cross-connect.

Centralized cabling systems shall be located within the same building of the work areas being served. All move and change activity can be performed at the main cross connect location.

Horizontal links can be added and removed in the telecommunications room depending upon the project design.

When using the pull-through method, the cable is to have a continuous sheath from the work area through the telecommunications room to the centralized cross-connect. A single telecommunications room can serve multiple floors.

When storing slack, provisions shall be made to ensure bend radius limitations are not violated (typically 20X the diameter of the cable). Cable slack can be stored within an enclosure or on the wall of the telecommunications room. Protective enclosures shall be used when storing slack fibers. Bend radius in slack storage is minimized by virtue of the fact all eABF fiber is bend-insensitive.

When planning the wall-mount or rack-mount layout, provisions should be made to allow future growth. Plan cable routes and equipment mounting to minimize space usage within the equipment or telecom space.

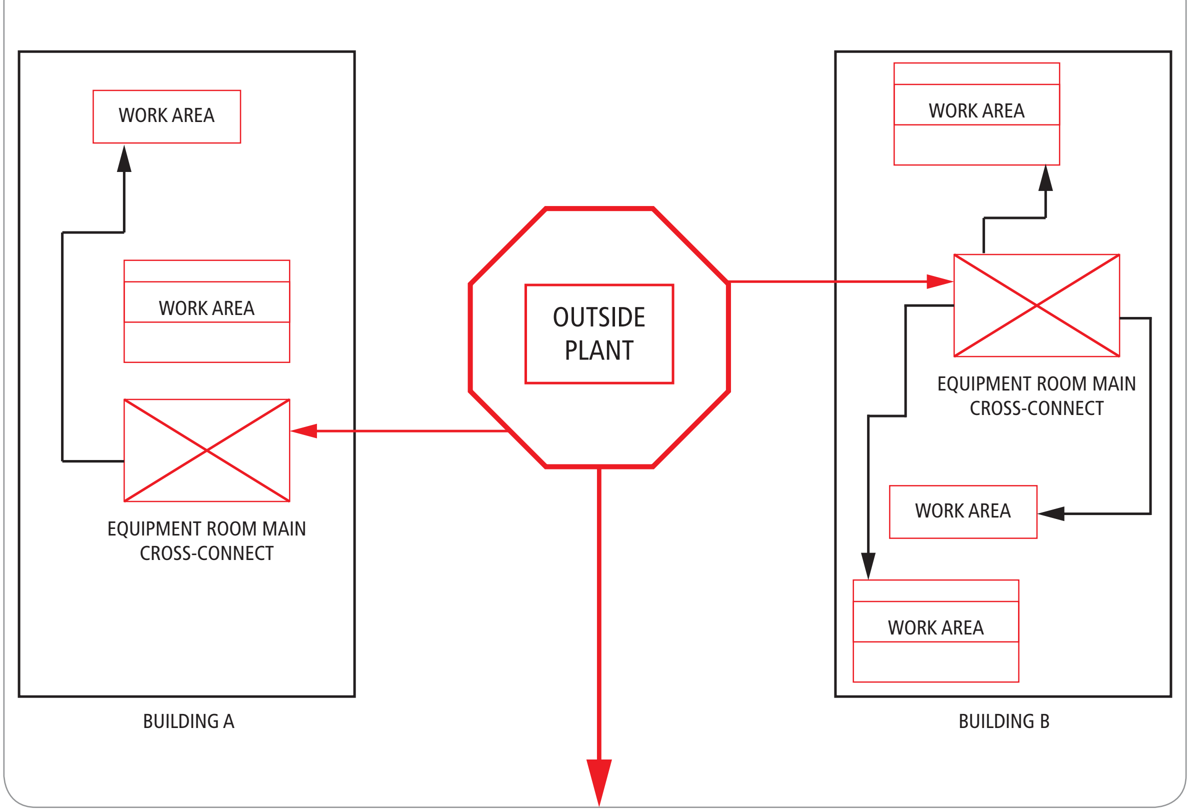
When sizing backbone cabling, provisions should be made for future horizontal links thereby minimizing the need for additional backbone cables. The backbone fiber count should be capable of supporting present and future networking technologies. The use of FuturePath MicroDuct with spare pathways offers a future-proof solution. If it should become necessary to increase fiber counts beyond existing capacities or change fiber types, fiber can be removed from the MicroDuct and possibly reused elsewhere in the network in order to re-occupy existing MicroDucts to increase capacity or install new fiber types.

Labeling of the centralized cabling system shall follow the requirements as specified in TIA/EIA-606.

The Campus Installation

The Primary difference between a high rise and a campus application is the Outside Plant (OSP) element connecting all of the buildings to create a complete connecting infrastructure.

TYPICAL eABF CAMPUS DIAGRAM



FuturePath in the OSP is configuration of MicroDucts surrounded by a Medium Density Polyethylene (MDPE) covering, similar to Enterprise FuturePath. FuturePath applications provide the ability to install additional fiber optic cables as the network grows, all within the same duct structure. Utilizing Micro Technology, FuturePath allows maximum cost effectiveness and greatest return on investment for existing and future network builds. Current telecommunications infrastructure reaches its maximum utilization with the introduction of Micro Technology. OSP FuturePath can be placed in a number of applications, from aerial to direct buried, horizontally directionally drilled (bored), or pulled into underground conduit systems. Due to the many variables encountered when placing outside plant products, this manual serves as a general guideline only.

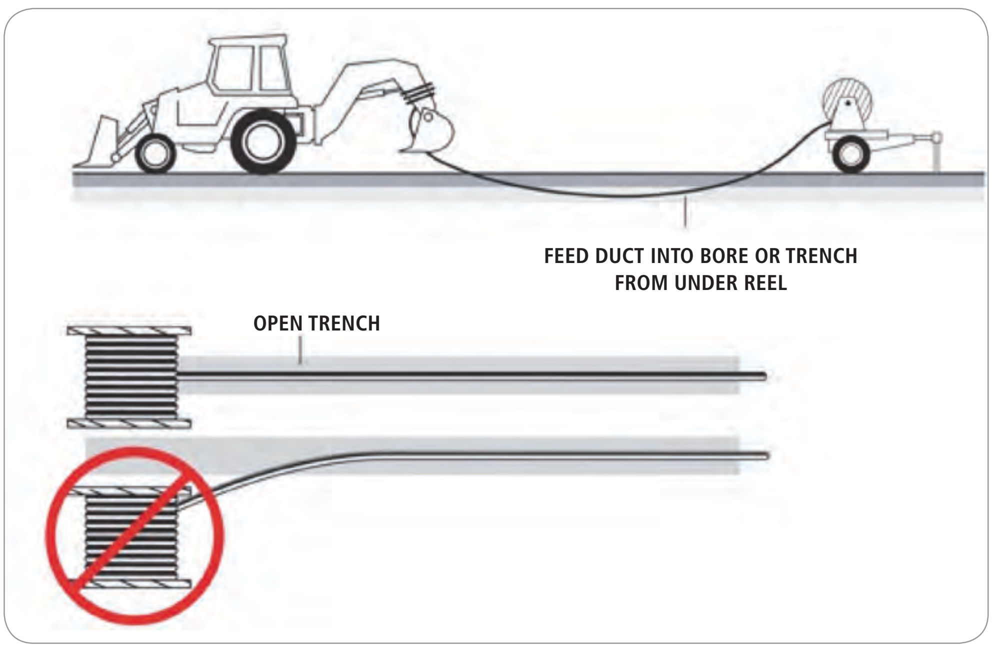
The manual pertains to all configurations of FuturePath, but is not specific to any particular version. OSP FuturePath is generally a configuration of 2, 3, 4, 5, or 7 MicroDucts with a protective oversheath, although OSP versions up to 24-count are available in MicroDuct diameters of 8.5 mm and below.

The FuturePath oversheath is designed so it can be pulled into a conduit (duct), placed in aerial applications or buried directly into the ground by plowing, open trench or horizontal directional drilling (boring). The interior of each MicroDuct is **co-extruded with SILICORE®** to provide a permanent low friction boundary layer between the wall of the duct and the cable being placed. The MicroDucts greater than 5 mm O.D. are also manufactured with a ribbed interior to reduce friction further

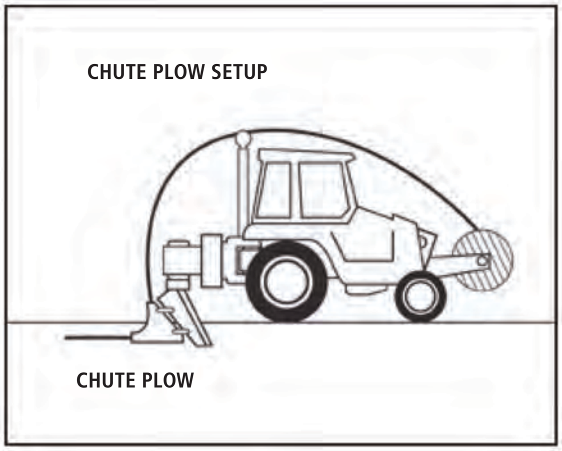
Loading the Reel Carrier

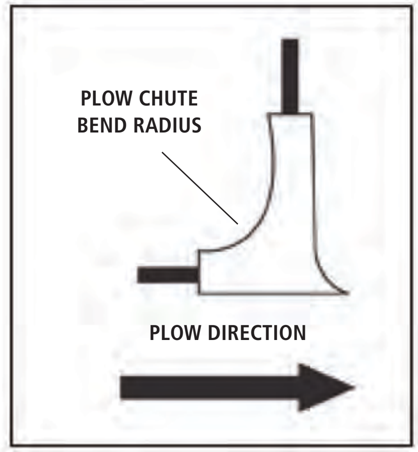
Load the reels of FuturePath onto the reel carrier to avoid reverse bending the FuturePath. Reverse bending occurs when the duct bends in a direction opposite from which it was wound on the reel. Depending on which method you use to place the FuturePath, follow these general guidelines:

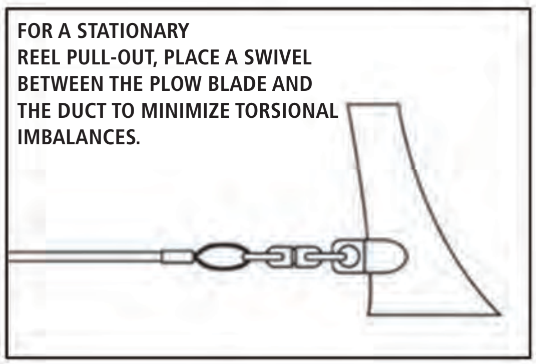
- Placed in Existing Conduit—Payout the FuturePath from over the top of the reel through a sheave or feed tube.
- Horizontal Directional Drilled (Bored)—Payout the FuturePath from below the reel into the bore tunnel.
- Aerial Placement—Payout the FuturePath from over the top of the reel.
- Whenever placing FuturePath, use spacers or reel stops to keep the reel centered on the reel carrier shaft. Center the reel so the FuturePath will feed directly toward the centerline of the placement site.



- Open Trench Construction—Payout the FuturePath from below the reel.
- Plowing—Payout the FuturePath from over the top of the reel into the chute.

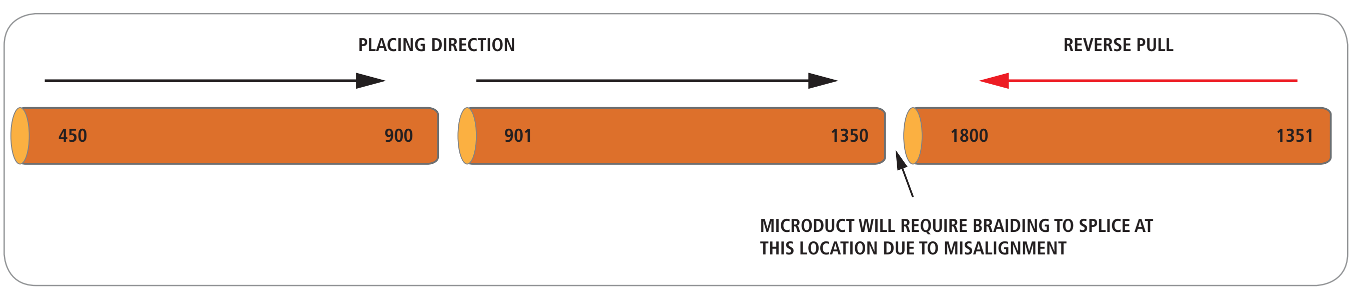






FuturePath—Installation and Handling

All FuturePath and MicroDucts are numbered sequentially. When installing the FuturePath into a trench, conduit or cable tray, it is necessary to make sure that the MicroDuct is installed or ***pulled in one direction***, otherwise the same numbered MicroDucts will not line up, they will be crossed, creating splicing issues, congestion and may even affect blowing performance. To help ensure the FuturePath is being installed in the correct direction, follow the footage marker on the outer jacket and install from smaller footage number to larger or vice-versa. Make sure the same sequence is followed through-out the entire run.

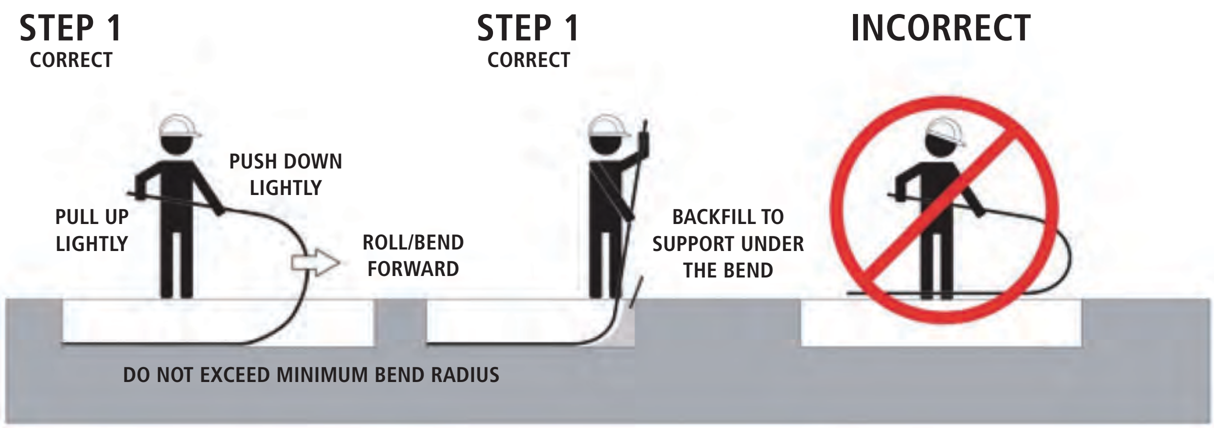


Bending FuturePath

At pedestals and pads, bend FuturePath into the shape needed to feed it into a pedestal or pad. It is not necessary to use a heat source or additional tools even in sub-freezing weather.

Feed FuturePath into a pedestal or pad using a technique called "form bending." Use this technique to form bends as small as the FuturePath minimum bend radius. By using this technique, the FuturePath can be leveraged to form the bend without kinking.

Bend the FuturePath back over itself. Roll the FuturePath into a horizontal "U." While forming the bend, monitor the FuturePath shape in the bend area. If the FuturePath becomes oval in shape, the minimum bend radius has been exceeded.

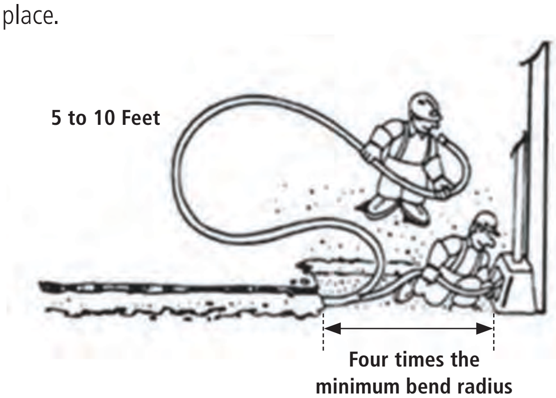


Bring the FuturePath into the pedestal or pad location. Keep the end of the FuturePath in a vertical orientation and tape or cap the end during restoration to the area around the pedestal or pad.

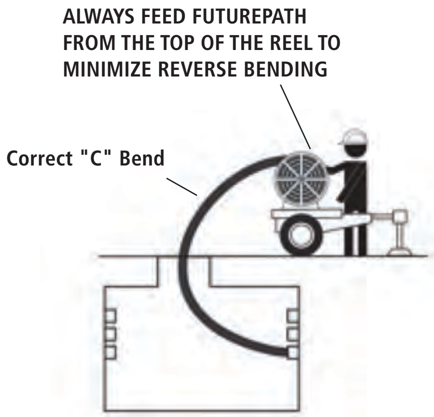
Leave enough FuturePath to complete a splice, termination or branch splice. Over-pull the duct to compensate for any stretching that may occur during placement. Cut and remove any excess FuturePath.

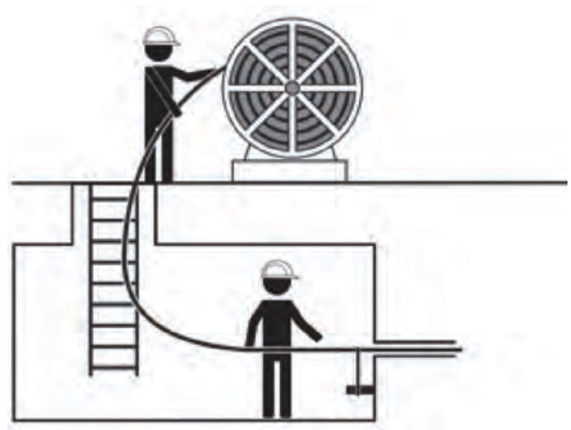
At risers, bores and tight spaces, the trench length should be four times the minimum bend radius to form a loop.

Make a loop in the FuturePath 5 ft. to 10 ft. from where you are working. Pull the FuturePath end back to make the loop. Use the slack loop to guide the FuturePath into place.



When feeding FuturePath into a vault or manhole, allow the FuturePath to follow its natural bend as it leaves the reel to avoid "reverse bending" as it enters the conduit system. Ensure that the FuturePath is protected from sharp corners as it is pulled in.

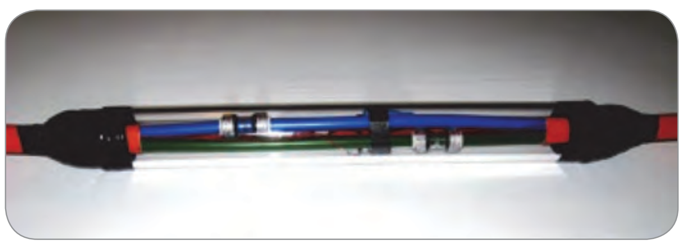




Joining, In-span Tap or Repairing FuturePath

Dura-Line can provide methods and material for preparing and splicing or joining two OSP FuturePath ends together and placing a mechanical protection sleeve over the completed splice. The methods described in these Technical Bulletins also apply when repairing FuturePath. The figure below shows what a completed FuturePath splice looks like. The actual splice sleeve is of a solid color and not clear as in the model below. Dura-Line has Technical Bulletins available which describe the recommended procedures for splicing (joining) FuturePath.

Splice protection sleeve kits are available and designed for the various OSP FuturePath configurations.



Straight Splice Protection Sleeve Kits

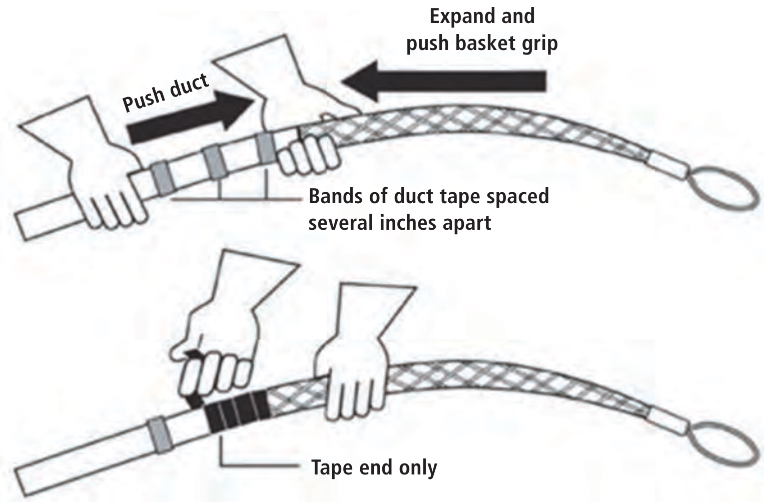
In-span Tap on FuturePath

In many cases of installing FuturePath MicroDuct in the outside plant, it will be necessary to install a lateral run or make an in-span tap. When that becomes necessary, the methods of preparing FuturePath for an in-span tap or branch splice will require placing a protection sleeve over the completed splice. The same methods can also apply when repairing FuturePath.

The severity of the damage to the FuturePath will determine the repair procedure. If the FuturePath only is damaged the process will require repair to the oversheath and MicroDucts only. If the fiber optic cable is damaged, then a splice will be required to repair the fiber optic cable. It is recommended to bury splices in a hand hole, manhole or vault so the splice can be accessed easily if needed in the future. It is also recommended that whenever fiber optic cable is placed into conduit, that slack loops are placed in the fiber optic cable along the route so it can be pulled back to the damaged location should a repair become necessary. This will eliminate two splices and aid in rapid restoration of service.

Attaching a Pulling Device to FuturePath

Technical Bulletin DCEB-04003 "Preparing FuturePath for Pulling Grip Installation" outlines the method of preparing FuturePath for placing a pulling grip.

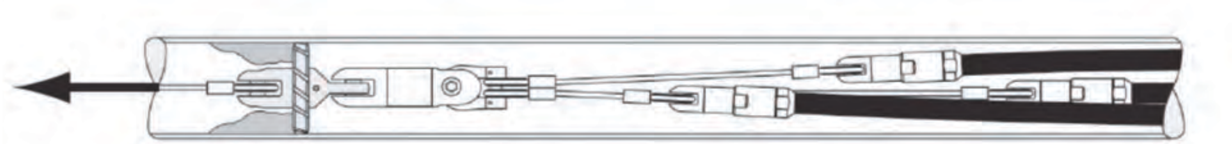


Pulling grips should be of proper size to fit the circumference of the duct (Table 2 on the following page).

Table 2

FUTUREPATH VERSION	CABLE DIAMETER O.D. (INCHES)	PULLING STRENGTH (LBS)	PULLING GRIP LENGTH (INCHES)	DURA-LINE PART NO.
24-Way 8.5 mm	2.00-2.50	11,200	34	1-908928
19-Way 8.5 mm	2.00-2.50	11,200	34	1-908928
12-Way 8.5 mm	1.00-1.50	7,840	24	1-908926
7-Way 8.5 mm	1.00-1.50	7,840	24	1-908926
4-Way 8.5 mm	0.75-1.0	5,600	20	1-908925
3-Way 8.5 mm	0.75-1.0	5,600	20	1-908925
2-Way 8.5 mm	0.75-1.0	5,600	20	1-908925
7-Way 12.7 mm	1.50-2.00	11,200	29	1-908927
4-Way 12.7 mm	1.00-1.50	7,840	24	1-908926
3-Way 12.7 mm	0.75-1.0	5,600	20	1-908925
2-Way 12.7 mm	0.75-1.0	5,600	20	1-908925
7-Way 16 mm	2.00-2.50	11,200	34	1-908928
7-Way 18 mm	2.00-2.50	11,200	34	1-908928
Pull-back Swivel	1-1/2" Diameter	5,400-9,000 lbs	Wt. 1.7 lbs	1-903841

When pulling FuturePath from the reel, employ a pulling harness or grip with swivels to eliminate unnecessary twisting or spiraling during placement operations.



Pulling harness with swivels

Tensile Expansion and Thermal Expansion/Contraction of MicroDucts and FuturePath

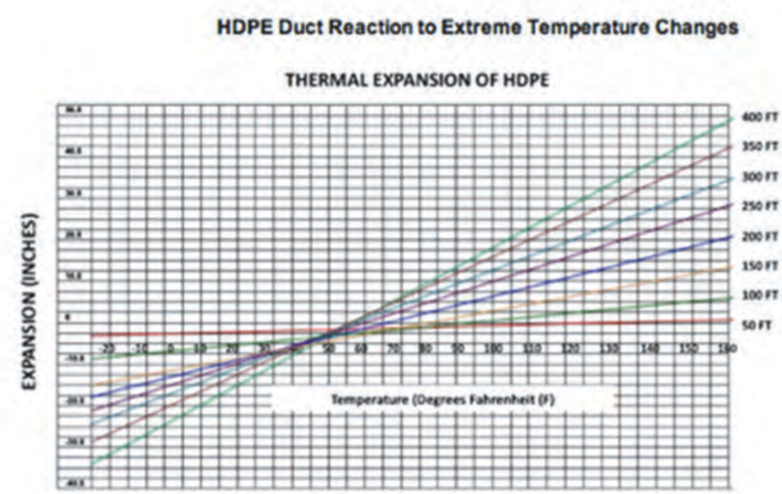
Tensile Expansion

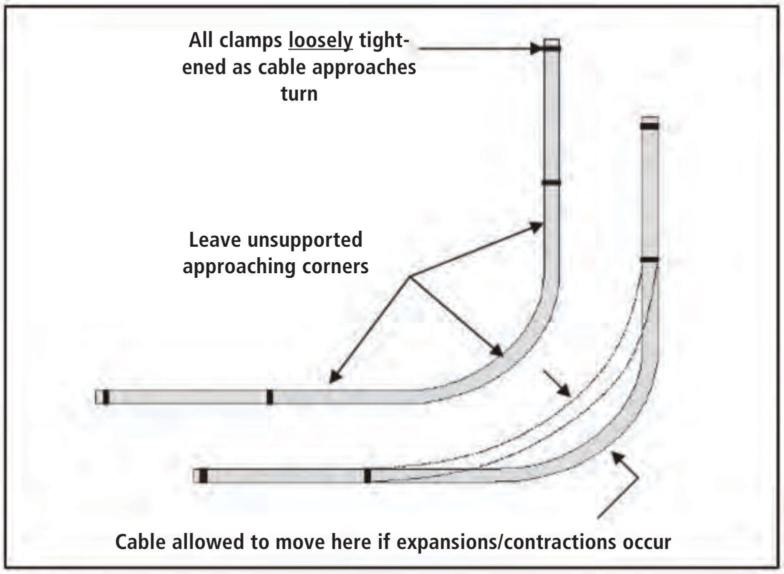
When pulling the FuturePath into a conduit or when being back-pulled during a directional bore, the product may stretch. It is important to know the maximum pulling tension before the installation begins and not to exceed those pulling limits. All FuturePath products have this information on the product cut sheets. Additional slack should be pulled in the FuturePath, as it will stretch up to 1.5%, depending upon the difficulty of the pull. Therefore, it is recommended that the FuturePath be "over-pulled" to allow for this temporary stretching. For example: a pull of 800 ft. would need to have an excess of 800 ft. X .015 = 12 ft. additional product to compensate for any shrinking or settling that may occur after the FuturePath relaxes.

Thermal Expansion

FuturePath can also expand or contract due to temperature change. It is recommended to pull slack and allow the product to set-up or relax, between 12-24 hours before dressing or terminating the FuturePath into a closure or NEMA-Rated box. HDPE thermal expansion is demonstrated in Table 3.

Table 3





Always label both ends of the FuturePath during the installation.

Always maintain the minimum bend radius of the FuturePath. A good rule of thumb is 20X the outside diameter of the product. Always install the largest bend or sweep possible, as jetting performance will be directly affected when tight bends are employed.

When securing a bend in a building, always secure the FuturePath before and after the bend. This will help ensure the minimum bend radius is maintained and allow for movement during expansion or contraction due to temperature variations.

When transitioning from (OSP) to a (ISP) MicroDuct or FuturePath, it may be necessary to use gas block connectors with all MicroDucts that have fiber installed and use end caps on all unused MicroDucts. It is also important to seal the interstices or voids between the MicroDucts to prevent any water or gases entering the building. Technical Bulletin DCEB-08008 provides further detail on sealing FuturePath voids.

Direct Buried Installation

Safety Precautions

Before starting any trenching operation, all personnel should be thoroughly familiar with the operating systems' safety practices governing, but not limited to the following:

- Wear appropriate safety equipment. Guard and protect work areas.
- Locate and resolve route conflicts in easements with other utilities or buried locator services before digging.
- Perform work in accordance with applicable national, state or local codes and standards.
- Prior to working with FuturePath, seal the ends to prevent debris from entering. If a cable-pulling grip (e.g. Kellem Grip or Chinese Fingers) is used, duct tape or a heat shrink cap may be used to seal the end of the FuturePath before installing the pulling grip.

Sealing the End of FuturePath Prior to Installing a Pulling Grip

Trench Preparation

When opening a trench, it is important to know that every direction or elevation change will have a negative impact on cable placing resistance. A properly prepared trench will result in lower cable placement resistance.

Reduce the severity of a bend whenever you need to make a change in depth or when forced to veer around barriers and obstructions. Where a rapid change in grade exists, use backfill to make the change gradually.

Undercut intersections or corners of the trench lines. The undercut must provide for the minimum bend radius of the FuturePath being placed.

Keep the trench bottom as straight and level as possible.

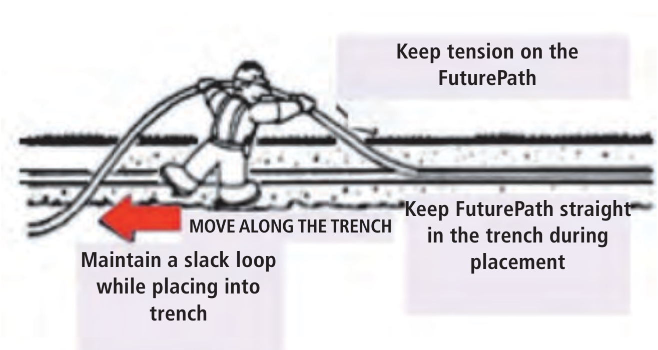
Installing FuturePath in a Trench

The moving trailer method is most efficiently used when the path of the FuturePath does not contain road bores, utility lateral crossings and other obstructions that require the FuturePath to be pulled through or placed under.

Secure the end of the FuturePath at the desired location. Then move the reel trailer slowly along the top of the trench paying out the FuturePath directly into the trench. Pay out the FuturePath from the bottom of the reel and avoid over spinning the reel.

The stationary trailer method is most efficiently used when the path of the FuturePath contains road bores, utility lateral crossing and other obstructions that require the FuturePath to be pulled through or placed under.

Pull out the FuturePath next to the trench line. Place the FuturePath as you walk along the trench line. Keep it as straight as possible.

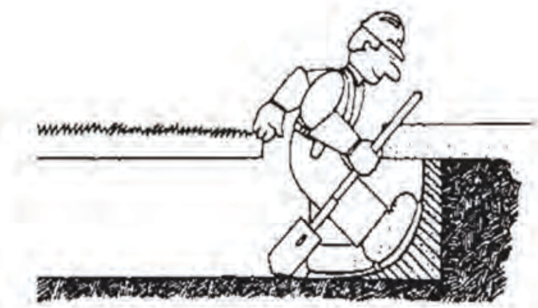


When encountering an obstruction, bores or utility crossing, pull the FuturePath beyond the obstruction until you have enough slack to maneuver the FuturePath through or under the obstruction. Continue pulling the FuturePath along the trench line.

When working in areas with a shallow water table, the trench may fill with water before restoration is completed. As the FuturePath is buoyant, take the following steps before FuturePath placement. Water should be pumped out of the trench before placing the FuturePath. Plan to restrain the FuturePath in the trench after placement to prevent flotation. Returning the spoils to a flooded trench will not force the FuturePath to remain in place on the trench bottom. Duct organizers may be useful for restraining multiple FuturePath in a trench. For a single FuturePath, it may be more practical to use sand bags or wire stakes for restraint.

Trench Restoration

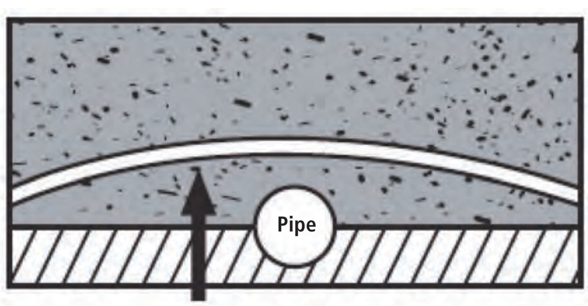
Restoration begins by returning some of the spoils under all sweeps to vertical. To accomplish this support, compact the soil under and behind the bend. When returning soil, use soil with rocks no larger than 1-½ inches to the region around the FuturePath.



Compact the backfill to support the FuturePath

Radius Corners

Back fill the trench in a manner that will provide proper compaction. The FuturePath gains crush resistance and support from the soil when properly compacted. Failure to compact the material in the trench will allow it to continue settling for several weeks or months. This can result in safety hazards and return trips to refill the trench. Where obstacles are encountered during trenching, add soil so as to support the FuturePath and help avoid unnecessary pressure against the oversheath in one location.



Backfill to support duct

Return the spoils in layers, covering the FuturePath with soil that is free of large rocks. Continue to add the layers of soil removed from the trench. All effort should be made to compact the soil during restoration. Do not return backfill that contains rocks larger than 1-½ inches to the region around the FuturePath.

Plowed Installation

The purpose of this section is not to offer instruction on plowing but rather to cover specific details of using FuturePath in plowing operations.

Never allow a completed FuturePath splice to travel through a moving plow chute. Where splicing occurs, place into trench or pit and continue plow deployment without putting undue stress on FuturePath couplers and splice. Restrain the trailing end of the FuturePath until about 50 feet of plowed conduit is in place.

Plowing is the preferred installation method for long continuous runs, primarily in rural areas. The major distinction between plowing and trenching is that trenching removes the soil from the trench, whereas plowing only displaces soil while laying in the FuturePath.

Micro-Trenching Applications

This section addresses how HDPE (High Density Polyethylene) duct should be placed and protected using shallow (under 18 inches depth) saw or slot cut trenches, along with some recommended restoral processes. It is important to determine during the planning stages the route, depth and restoral method to be used. Governing agencies and municipalities may stipulate certain materials or design criteria, which should be agreed upon prior to the start of any work.

Design guidelines may stipulate curb cuts, cross road cuts, centerline cuts, sidewalk or alley cuts, or any combination of these procedures. Each of these obstacles presents individual considerations. The transition between pavement and the curb or gutter is a good choice, providing there are no known future plans to break up the curb for roadway changes. The use of existing surface joints or transitions is recommended as reducing aesthetic impact. These transitions may also be easier to resurface or restore, possibly allowing a choice of two resurfacing materials.

HDPE can be affected by extreme heat and may deform if subjected to heat in a concentrated form over a long enough period. This document will outline recommended precautions to be taken when hot asphalt/concrete mixture is used, as well as addressing alternative fill types and methods.

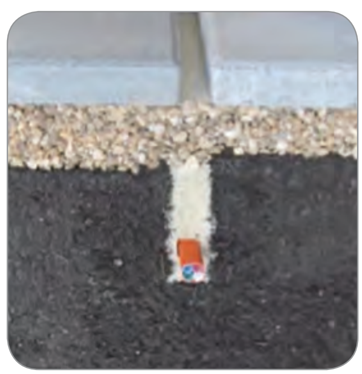
Dura-Line's HDPE duct conforms to the guidelines set forth in ASTM 2160 and as such retains a VICAT softening index that is 240°F. This means that the plastic begins to turn soft at this temperature. Exposure to temperatures in excess of this can cause the duct to deform, especially if under pressure due to being buried or continued traffic pressure. Traditional HDPE installations are typically placed from 24 to 48 inches below ground and are not influenced by the application of heated asphalt due to the insulating properties of the backfill soil or concrete encasement. As shallow trenches become more commonplace, this raises the possibility of HDPE encountering heated asphalt, leading to the risk of damage to the duct.

Dura-Line manufactures a variety of MicroDuct solutions, which are excellent for saw cut and Micro-Trenching applications.

FuturePath Flex

2-Way FuturePath

Locatable pinpoint MicroDuct

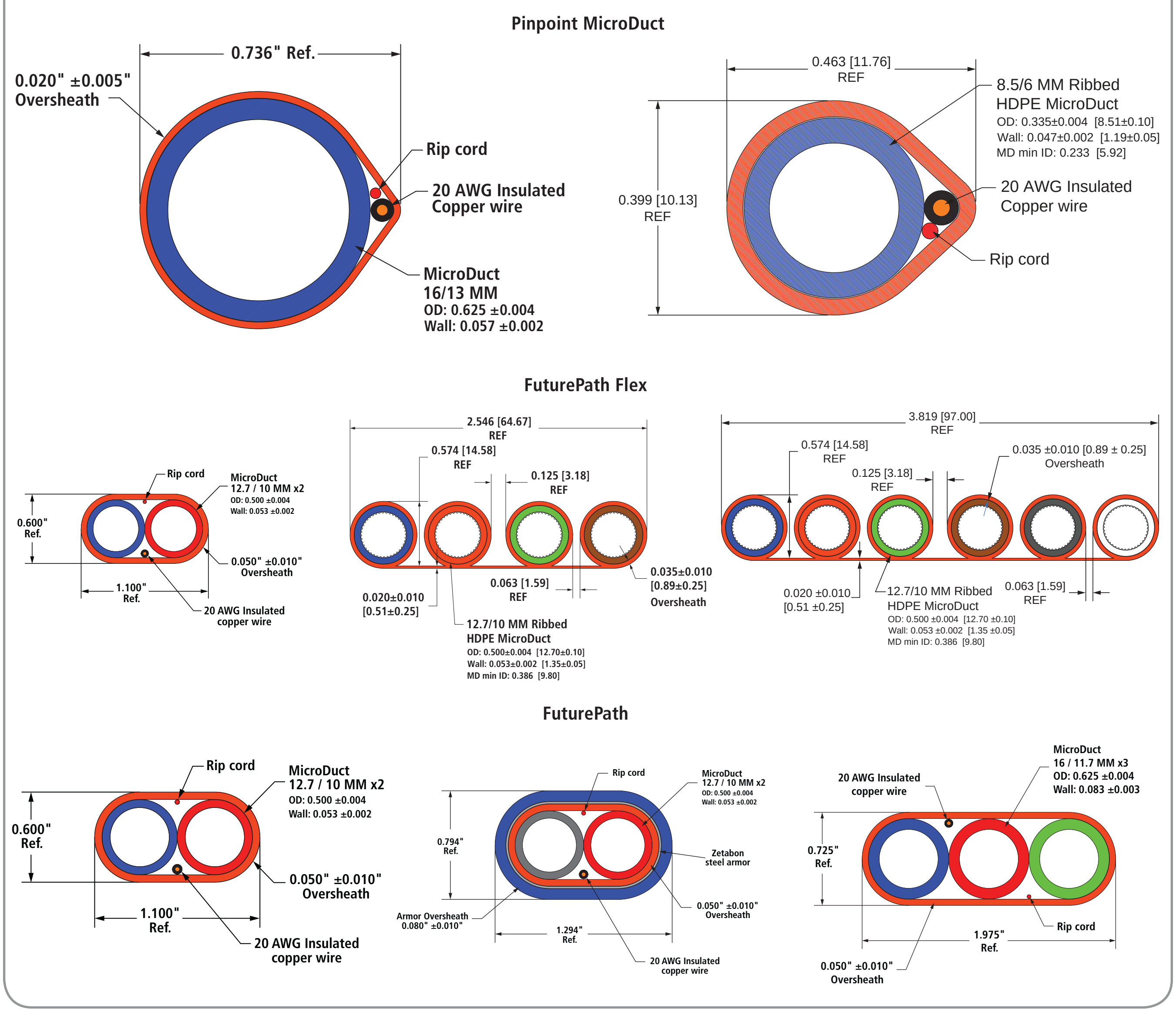


4-Way FuturePath

Recommended Procedures/Guidelines for Micro-Trenching

When placing duct close to the surface and in proximity of an asphalt application, it is advisable to shield the duct from the hot asphalt mixture. Since the temperatures of the restoral material may affect the duct, there is a need to insulate the duct from the heat during the cooling phase of the asphalt.

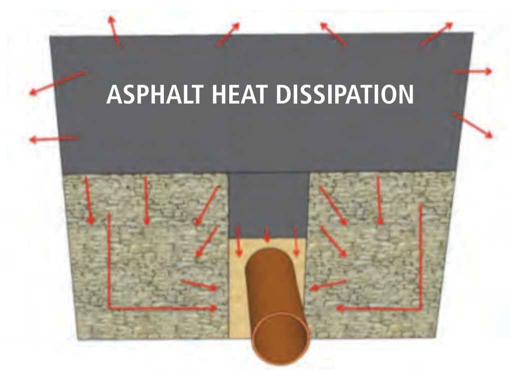
Typical Pinpoint, FuturePath Flex and FuturePath Designs



In order to properly insulate the duct, it must be understood how asphalt will cool once it is applied and compacted. The heat from the asphalt will migrate toward the cooler earth surrounding it. While some heat is lost to the air surface, unless it is windy and cold, the asphalt tends to heat the air above it quickly; and once the air heats, the heat energy from the asphalt mix will not lose much more heat to the air. This includes summer applications where the ambient air temperatures will not support much cooling. There are 10 factors that affect the cooling rate of the asphalt mix and those variables are:

1. Densities of pavement layers
2. Thermal conductivity values
3. Specific heat values
4. Ambient temperatures
5. Wind speeds
6. Convection coefficients
7. Incident solar radiation
8. Coefficients of emission and absorption of solar radiation for the pavement surface
9. Time and depth increments
10. Initial pavement temperature profiles

While the heat from the asphalt is lost in two directions, the cooling is primarily from the bottom of the mix into the base soil. That is important, as it will help determine the placement of the duct in order to gain sufficient insulating properties from the covering soil. For pavers, it is generally more desirable to apply the asphalt in warmer temperatures, as that allows more time to "work" the material. Since the heat will transfer primarily into the surrounding soil, the beginning temperature of the soil is a factor. Probably of greatest aspect to cooling rate are the thickness of the layers being installed and the amount of time for cooling. Subsequent layers of asphalt will be cooled in part by the absorption of heat from the primary layer and thus less heat will be transferred to the base material soil. Road contractors often prefer thicker layers, as this allows more time for compaction, as thicker layers will retain the heat longer. For instance, if the ambient temperature is 40°F and a three-inch layer of asphalt mixture is placed at 250°F, it will take 19 minutes for the layer to reach the working cutoff temperature of 175°F. If the same conditions exist, a one-inch layer will cool to the cutoff temperature in only 3 minutes. The following diagram shows most of the heat dissipation transferring to the surrounding soil layer as compared to the surface in contact with the air.



Heat transfer to surrounding materials and air spaces, minimum asphalt compaction temperature is about 175°F

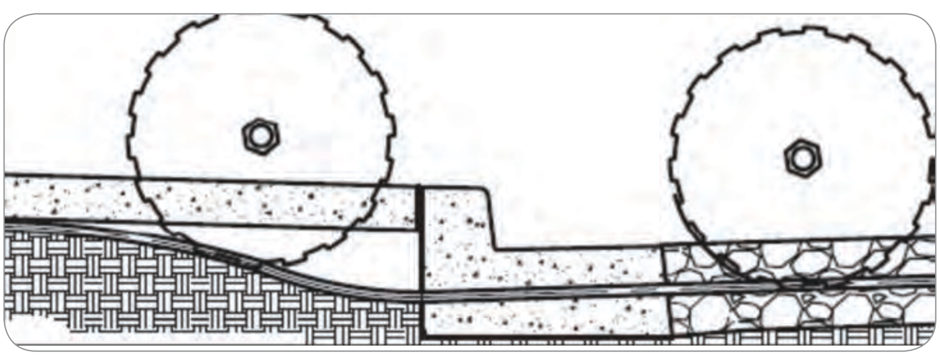
As in all HDPE duct installations, the proposed pathway of the excavation should be carefully determined, avoiding other utilities and obstacles that would require cutting the duct. While couplers exist, which are airtight and water tight and designed for quick installation, any splice has a potential to weaken the duct structure and is time consuming to construct. Continuous, straight pathways are always preferred when possible.

When placing the duct into a saw cut or Micro-Trench, follow the placement with a shovel handle or similar item to fully push the duct to the bottom of the trench. This will allow the maximum amount of cover possible for the trench depth. If the soil is very rocky, it is recommended to spread a one-inch layer of clean sand into the trench prior to placing the duct. This will help prevent large or sharp rocks from deforming the duct over time. When making turns with the saw cut, make several gradual cuts and if possible under cut the corners so the MicroDuct bend radius is not exceeded and so it transitions around corners in a natural bend.

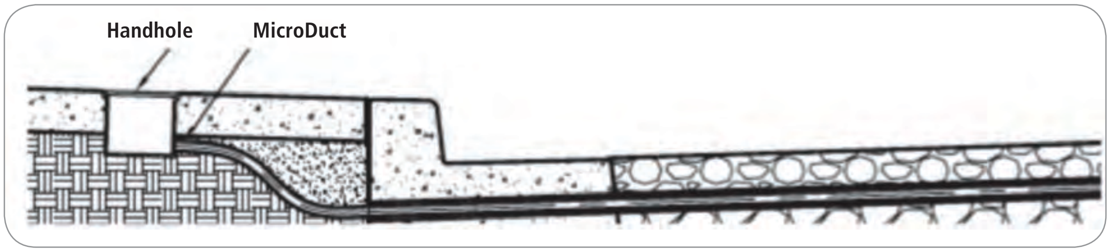
Conduit can be unrolled and deployed from the reel in two ways: using a stationary reel method or travelling reel method. If the route has several obstacles that prevent the duct from being placed directly to the bottom of the trench, then a stationary reel trailer can be placed at one end of the trench and the duct pulled along the trench path, placing the end below or around obstacles as they are encountered. If few obstacles exist, the moving reel method is generally easier and the reel carrier can travel along the route, while workers place the duct to the bottom of the trench. For trench deployments, it is best for the duct to leave the bottom of the reel instead of over the top to avoid reverse bending.

Once the cut has been cleaned of debris, place the MicroDuct product into the bottom of the cut. It may be necessary to use a blunt, narrow tool or board to push the FuturePath to the bottom.

Cutting the curb or gutter may perform a transition from the roadway to the right-of-way, but it is best to tunnel under them. Avoid cutting the curb completely, as this will help maintain the structural integrity of the curb construction. Once through the curb, raise the saw blade and continue cutting creating a gradual rise to the right-of-way.



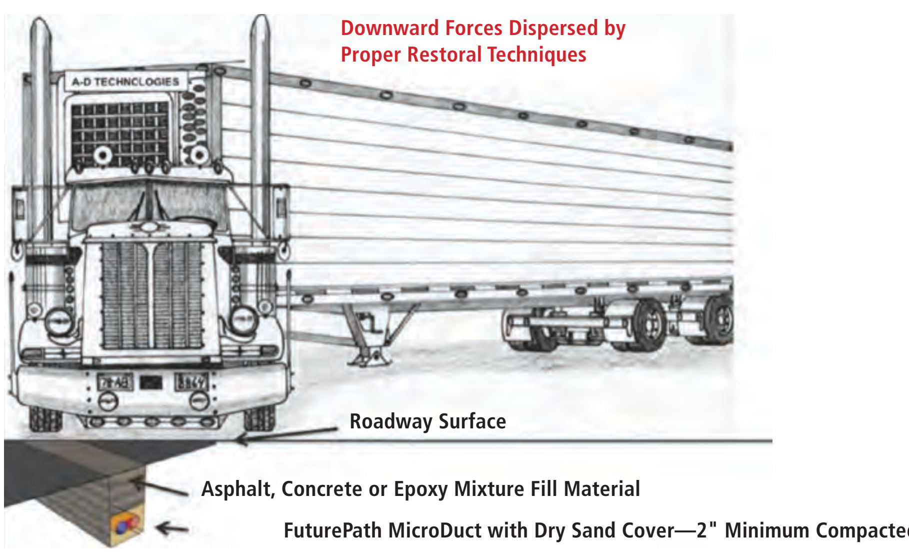
After the transition is complete, the conduit may be stubbed into a handhole or above ground closure.



Recommended Procedures/Guidelines for Trench Restoration

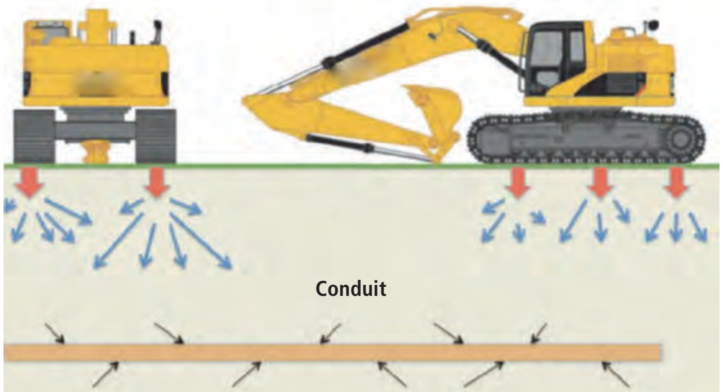
Restoration, by definition, is the process of returning something to as near original condition as possible. This process can be important for trench restoration for several reasons. The first is safety. Poorly backfilled or compacted excavations soon show signs of settling, which can be hazardous to humans and livestock. Poorly restored trenches that are subject to heavy traffic volume do not last long and may cause potholes in the restored surface. Inadequate fill or compaction will generally fail to bond properly with the original adjoining surface, allowing water penetration into the soil below. It is desirable to keep the soil below a trafficked surface as stable as possible and moisture penetration can change the soil viscosity, causing movement of the soil, which may affect the restoration over time. Severely cold climates may be subject to frost heave, where moist soils push upward when subjected to freezing temperatures. The water in the soil will expand, taking the soil with it. Bits of soil are separated in the process, affecting even properly compacted soils. It is thus critical to create the best bond possible between the restoration material and the original surface, to avoid water penetration into the trench location.

When HDPE duct is buried at depth, proper compaction of the backfilled material can increase the strength of the duct as pressure is applied equally around the wall of the conduit. Unequal pressures can cause the duct to deform over time, such as the applied pressure from a large rock. Voids in the soil will cause the duct to try to occupy that space (the path of least resistance). This has the result of allowing an unequal pressure upon the duct, potentially causing deformation. If backfill is tamped correctly and added as layers of 2-3 inches at a time, soil compaction of 85%-90% of the original density is possible. As heavy loads are exerted in the area of the trench, the backfill material lends support to the duct, dispersing the weight around the circumference of the conduit, which has extremely high crush resistance when affected in this manner.



Downward pressure is also transferred to the interior wall of the trench, resulting in reduced pressure variations the deeper the duct is placed. A 4,000-pound vehicle may exert 1,000 pounds of downward pressure per wheel, but that is generally disbursed over an area of 4" x 6" (the contact area of the tire with the road surface), which would result in a downward pressure of only 42 lbs. per in^2. Any additional depth that can be managed will reduce this pressure even more as some of the load is transferred to the trench walls. Heavy construction equipment has similar load bearing requirements and large tires and tracks help distribute the vehicle weight.

Downward Forces Dissipates Quickly as Soil Transfers Load to Surroundings



Pressure dissipates quickly when heavy loads are transferred to soil, but soil type and moisture content have a factor in how much load is disbursed onto the duct wall. To maintain a near-constant pressure upon the duct, it is necessary to limit movement of the surrounding soil. Soil adhesion results from capillary pressure and viscous resistance of moisture at the interface of the duct. Moist soil will be more easily displaced than dry soil, which during pressure variations can cause unequal loading upon the exterior duct wall. This can reduce the ability of the duct and supporting backfill to accept extreme loads. It is therefore critical to backfill with a soil having low moisture content and place a sealing layer of surface restoral material quickly in order to keep water from penetrating the fill material. If soil does become saturated, allow enough time for drying to occur prior to sealing. Examples of good bonding materials are concrete, hot rolled asphalt and epoxy mixtures which all provide water-resistant bonding to the original surface material. Cold asphalt patching material does not usually provide an adequate bond, especially if exposed to traffic or extreme weather, but may work for lightly trafficked locations.

Hot asphalt is generally applied between 210°F and 300°F. Temperatures below 175°F make the asphalt unsuitable for proper application and compaction. At temperatures above this value, aggregate particles can be manipulated by the compactor into the heated asphalt, reducing the air in the mixture and increasing its overall lifespan. Since the asphalt begins to cool once loaded upon a truck, the shipment has time to cool prior to arriving at the jobsite. Time is therefore critical for applying the mixture and compacting it into place. If the mixture is allowed to fall below this average temperature, it will become too stiff to increase its density by compaction methods. Due to the elevated heat requirements when installing the asphalt mixture, there are some recommended procedures providing increased protection of the HDPE duct and help maintain the reusable pathway for which it was designed.

R-values are familiar to many as a rating of the insulating properties of a material, such as foam or fiberglass insulation. The higher the number, the better the insulation. K-values are related to the heat conductivity of a material. The lower the number, the less likely the material is to transfer heat to other adjacent material. The actual K-value of a material is a measure of the amount of heat, in BTUs per hour, that will be transmitted through one square foot of material that is one inch thick to change the temperature one degree F from one side of the material to another. Common K-values are shown on the following page.

Table 4—Material K-Value

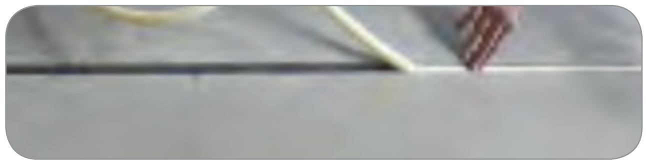
MATERIAL	K-VALUE
Common Brick	5.0
Cement Mortar	5.0
Ventilated Air Space	0.7
Sand	1.7
Concrete Block (Empty Core)	1.0

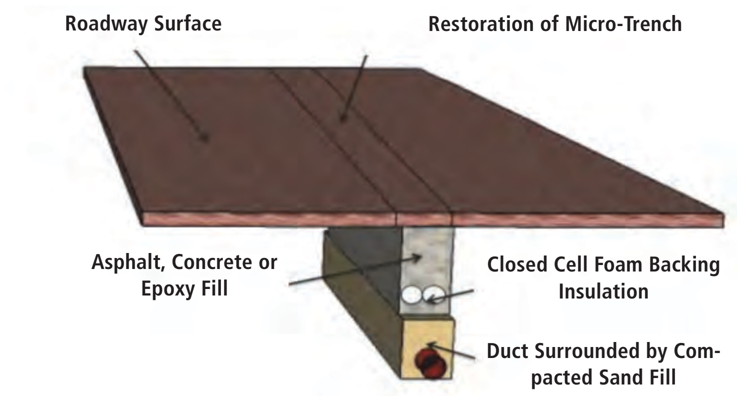
Sand has a relatively low level of heat transference and is preferable as a backfill material, especially in the case of a shallow trench procedure, where the depth of the fill material is limited.

As noted, it is important to limit heat transfer from hot asphalt to the HDPE. Another procedure to limit heat transfer is to insulate the duct with material such as closed cell foam. Open cell material can absorb and trap moisture, which can cause similar problems as the moist soil previously mentioned.

Foam-backing material (shown below) can be used to provide heat insulation to HDPE placed in shallow trenches where backfill material space is limited. This material is primarily used for insulating around windows. It is chemically inert and compatible with hot and cold fill materials. Once the duct has been placed, it is possible to backfill with a layer of dry sand, followed by the closed cell, low-density polyethylene foam-backing material. This is available in varying diameters and should be sized for the trench width or slightly wider. If necessary, two or more lengths can be placed into the trench to provide improved insulation. Another layer of backfill can then be added and tamped prior to resurfacing.

Foam backer rod also provides a breaker between the material being placed and the sealant material. Should resurfacing of the roadway become necessary, the backer rod can provide an "early warning" of sorts that contact with the duct is immanent. The type of sealant used, plus environmental and temperature requirements governs the type of backer rod used. For hot asphalt or similar sealant methods, the backer rod should be of the type to withstand high temperature applications (available in 400°F to 500°F versions). It should be compatible with rubber-asphalt and coal tar rubber compounds. The backer rod may be inserted into the cut after the conduit has been placed and covered by 1-2 inches of clean, tamped sand and pushed by hand or some other blunt, narrow tool to the top of the sand, completely covering the length of the duct. Avoid any gaps where hot fill can make contact with the HDPE duct.





Other methods of surface restoral may be preferred in lieu of asphalt fill. Concrete slurry or epoxy mixtures are used when performance or aesthetic requirements preclude the use of hot asphalt. These include bonding agents that adhere to the original surfacing material, limiting water migration into the area of the trench. Depending upon the installation, trench depths may be reduced, as the insulating requirements when using hot asphalt are no longer required. Consideration should still be given as to load requirements and weight distribution in the area of the trench. Whichever restoration material is selected, it should meet the necessary engineering requirements as determined in the planning stages. The American Society for Testing and Materials (ASTM) International has developed standards for fill and construction materials, which are helpful in determining what product(s) to use when restoring a surfaced excavation.

Table 5—Epoxy-type fillers should conform to the following ASTM guidelines:

ASTM TEST METHOD	PROPERTIES
ASTM C-822	Material bonding and masonry standards
ASTM C-666	Rapid freeze/thaw characteristics
ASTM C-78	Flexural properties
ASTM C-109	Compressive strength
ASTM C-157	Length change factors
ASTM C-1107	Product flow rate
ASTM C-191	Setting time
CRD C-621 (U.S. Army Core of Engineers Standards)	Grout shrink factors

Final restoration should be done using compatible materials that allow for the near seamless aesthetic appearance of the original layer. Traffic durability and performance should not be compromised due to the result of the restoration. Complete the restoration in accordance with local codes and procedures.



With proper planning and utilizing sound construction techniques, Micro-Trench applications can provide a quick installation for HDPE conduit and MicroDucts, creating minimal disturbances to existing utilities, commerce and inhabitants, all while reducing costs to deploy. Dura-Line's MicroDuct products are designed to be robust and provide very capable pathways when combined with saw cuts or Micro-Trenching procedures.

FuturePath can be spliced in smaller vaults when directional changes are not taking place. The airtight and watertight couplers are sufficient so no additional closure is needed for splicing. The vault provides mechanical protection

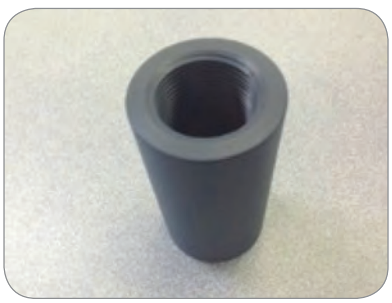


Splicing FuturePath MicroDucts in Manholes, Handholes or Direct-buried Applications

FuturePath may require splicing or joining when reels lengths need to be joined together, where downgrades occur, or where field conditions require cutting the FuturePath, or wherever access points are needed. FuturePath may be spliced in wall mount cabinets or closures designed for buried or underground conditions. Where necessary, ladder rack or tray mounted closures may be used as well and should be made of fire-retardant material when used indoors. The following procedures describe how to use a commercially available underground or buried splice closure for joining lengths of FuturePath, or for branching off additional sections of FuturePath when the job design calls for splitting off in alternate directions.

The 3M 2-type 505-closure is shown in the photos below. It is available in a fire-retardant version for use inside buildings. The closure is available in various lengths and diameters and can be configured to accept up to 6 FuturePath bundles or even single MicroDucts. Should directional changes be needed within the closure body itself, such as a full 180-degree bend, the closure must be of a diameter, which will allow this without compromising the bend radius of the MicroDucts. For this application, order a "D" or "E" body closure, which will accommodate full 180-degree bends within the confines of the closure. When couplings are installed on a full 180-degree bend, ensure the couplings are placed in the straight sections of the MicroDuct and not in the bends themselves. Strand and Manhole mounting brackets are available from 3M.

For a more ruggedized direct bury splice closure, Preformed Line Products (PLP) offers their Armadillo Stainless steel closure. The endplates can be drilled in the field to accept the size FuturePath used, or ordered factory prepared from PLP. Adapters are available to join to the DETA FuturePath Terminators for placing into the PLP Armadillo.



In order to minimize space requirements and to limit expense, utilize smaller diameter closures and try to avoid the need to change directions within a closure. Even with larger diameter closures, a tight 180-degree turn may affect the ability to jet maximum distances.

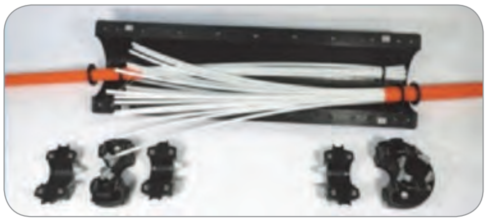
Installation Recommendations of a 3M 2-Type 505 Closure for Joining FuturePath MicroDucts in Direct-bury or Manhole/Handhole Applications

- Torque all bolts to 250 inch-pounds. Torque wrench recommended.
- Follow manufacturer's 2-type endplate and cover installation instructions. Documents 78-8140-1011-8-A (endplate) and 78-8140-1009-2-B (cover).
- When installing endplates onto non-symmetrical FuturePath configurations (2-Way and 24-Way), fill voids on sides of FuturePath adding sealing tape as necessary to build up outside as round as possible.
- Where routing of MicroDucts include severe directional changes (180°), utilize larger diameter closures, such as "D" or "E" body (9-1/2" or 12" diameter) to accept MicroDuct bending radii.
- Place MicroDuct couplers in straight section of MicroDuct avoiding placing and splicing in bends.

FuturePath MicroDuct Splice Using a 3M 2-Type 505 Closure

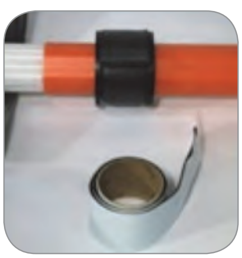
- Endplates are available in single, 2-Way or 3-Way openings.
- Washer cutter is required for cutting correct size opening in sealing washers. Sealing washers are labeled and pre-scored to aid in sizing. They can be split for fitting onto FuturePath.

Steps



1. Remove oversheath and expose MicroDucts
2. Cut sealing washers to fit FuturePath O.D.

3. Place the 1-1/2" x 1/8" sealing taper between washers leaving about 2 inches of FuturePath inside the endplate. The sheath retention clamps will contact the oversheath at this location.



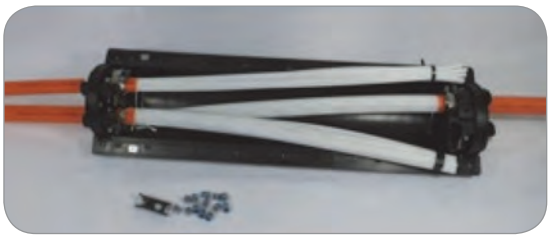

4. Place the 1-1/2" x 1/8" sealing tape level with the outside edge of the washers and place the endplate with the sheath retention clamps facing the inside of the closure body.



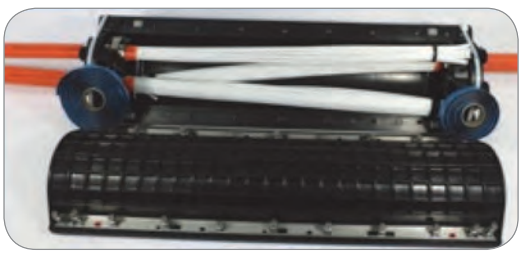
5. Cut the 3/4" x 3/8" thick sealing cord to fit the grooves of the endplate sections. This same size sealing cord fits into the grooves of the endplate for sealing when the closure cover is installed.

6. Using a 1/2" socket, tighten the endplate bolts securely.


7. Secure the steel clamps around the gripping teeth, tightening by hand until teeth make contact with oversheath.

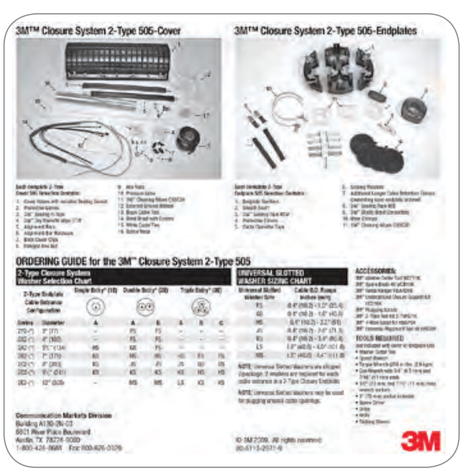


8. Secure endplates into slots on back of closure prior to coupling the MicroDucts. **NOTE:** front half of closure has the bolts installed.



9. Sealing 3/8"round sealing cord and endplate tape (shown) are used for sealing the closure and is placed in the appropriate grooves. See 3M installation manual (included with closure) for details on this procedure.

10. Place clear inside cover over MicroDuct Splice. Cap any unused MicroDuct to keep out dirt and debris. When a 180-degree routing is needed within the closure, utilize the "D" or "E" size closure in order to maintain bend radius of MicroDuct. Shown here is "B" size closure. Avoid placing couplers in bends. Place couplers in straight sections only.



Supporting Riser MicroDucts in High Rise MDU and MBU Buildings

The method and hardware used to place and support riser MicroDucts in multistory buildings is usually determined by the type of riser openings between floors or space (indoors or outdoors) allocated for communication equipment. This information should be determined at meetings with the owner or his agent before any work is started.

Dura-Line recommends Cable Grips be used at every fourth floor with an intermediate support at every two floors or 24 feet with split cable grips. Or the riser MicroDuct can be fastened directly to the building walls by placing equally spaced cable ties at intervals of 24 inches. If the MicroDuct is fastened to the walls intermediate cable supports split cable grips will not be required.

Existing conditions or type of wall construction will determine which type of hardware is best suited for securing the split grips and cable ties to the walls Always start fastening the riser MicroDucts at the top of the MicroDuct run. Continue until the entire length of the riser MicroDucts is securely fastened.


Single


Double


Universal

Install the split cable grip on the riser MicroDucts at every fourth floor so the weight of the MicroDucts is distributed equally on each split grip support. Split grips are supplied with a single eye or double eye. Lewis Manufacturing Company (www.lewismanufacturingco.com) makes a wide range of offset eye support grips.

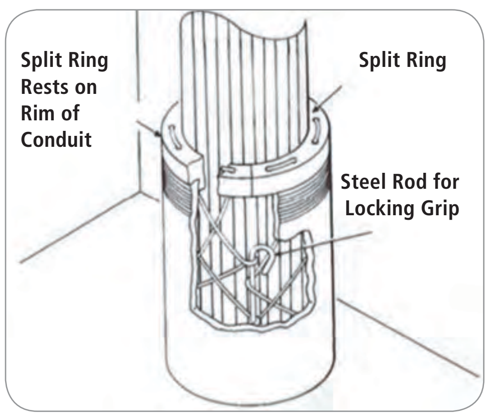
To place the split cable grip, proceed as follows:

A. Obtain the proper size split cable grip for the number of MicroDucts being supported.
B. Raise the MicroDucts above the terminating point and hold them at that point. If there are between 10 and 24 ducts, place two cable ties around the MicroDucts. If there are more than 24 ducts, divide the number and make two bundles. Place one above and one below the area where the split grip will be placed. This will aid in placing the split grip. Wrap the split-cable grip around the MicroDucts and thread the rod through the preformed loops with a corkscrew motion, using the curved end of the rod to engage the loops.
C. The action required is a steady and simultaneous push and twist. The fingers of the left hand are used to bring the loops together just ahead of the hook on the end of the rod.
D. Continue inserting the rod through the loops until all of the loops have been threaded.

E. Lower the MicroDucts to obtain a constriction or holding action around the MicroDucts.

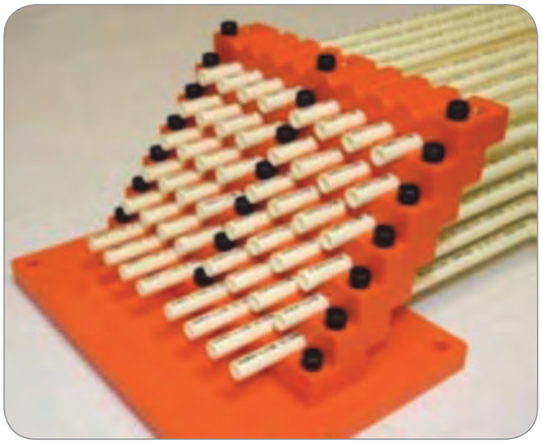
F. When the MicroDucts have been properly supported at each location, the ducts can then be released from the pulling device.
NOTE: be sure the structure that is used to support the MicroDuct hardware is structurally sound and will withstand the rigors of time.

If the MicroDucts are placed in a conduit, a split ring type cable grip is available. The split ring grip is designed to be supported by the rim of the conduit. Ensure the conduit is cut level to support the ring.



MicroDuct Mounting Bracket

The MicroDuct organizer is designed for use where 8 or more MicroDucts are terminated. Depending on your specific project application, you can choose from a 8.5 mm or the 12.7 mm MicroDuct Mounting Bracket. Technical Bulletin: DCEB-07003 covers the description, installation and ordering information for this Bracket.



Dura-Line "FuturePath" Oversheath Jacket Removal

When stripping off the outer jacket or oversheath, first mark where it is desired to stop the MicroDuct exposure. At that location, use a rotational cutter to “score” a circle around the FuturePath. It is very important not to set the blade too deep as this will cause damage to the MicroDucts beneath the outer jacket. A razor or sheath knife may also be used to score the oversheath. Once the outer jacket has been scored, it is possible to “snap” open the score mark and leave a clean cut. FuturePath has two pull strings installed during manufacturing. At this point, the installer would pull on the strings toward the score mark. The outer jacket will peel off of the MicroDucts and the MicroDucts will then be exposed for coupling or routing. The FuturePath sheath-slitting tool is an alternative way to perform the longitudinal cut safely. See the tools section for ordering information on this item.

General Information

FuturePath is a Dura-Line product, which offers the reduced profile and ease of use of MicroDucts for fiber optic cable pathways in a variety of bundled configurations. FuturePath is available in numerous sizes of MicroDucts and various numbers of MicroDucts, all as a singular size under a protective oversheath, or combinations of different size MicroDucts to suit the users’ individual applications.

The FuturePath design allows installation and splicing without specialized tools or equipment.

Recommendations

FuturePath over-sheath jacket is designed for easy removal by the field technician. Ripcords on opposing sides are installed at time of manufacture to aid in the process. These pull cords travel the entire length of the product allowing unlimited lengths of jacket to be removed quickly. These guidelines accommodate all MicroDuct sizes. Recommended tools are listed below.

1. Duct Cutter
2. Utility Knife
3. MicroDuct Straight Cutter
4. Duct Slitting Tool
5. Electricians Scissors
6. Gloves
7. Safety Glasses
8. Permanent Marking Pen
9. Needle Nose Pliers
10. Tape Measure

To expose the MicroDucts beneath the FuturePath oversheath when there is not an installed cable, mark the jacket at least 22” from the end. Longer lengths of MicroDuct may need to be exposed for access and splicing. At this marked location, use a utility or sheath knife to gently score the oversheath, completely encircling the oversheath layer. Do not penetrate the oversheath with the blade, so that damage to the MicroDucts is avoided. This cut will be referred to as a “ring cut.” A layer of vinyl electrical tape encircling the FuturePath can help as a guide for completing the ring cut.

Inspect the ends of the FuturePath to locate the ripcords. If the ripcords are recessed within the outer jacket, use a utility knife and longitudinally slit the oversheath 3” from the end. Peel the jacket exposing the ripcords. If the knife has cut into a MicroDuct within 3-4” of the end, that is not a concern as the damaged end will be trimmed off.

Grip a ripcord around the tip of the needle-nose pliers and roll the ripcord around the tip several times. This will prevent the ripcord from slipping out. Steadily pull the ripcord alongside the jacket creating a slit. **Caution: do not pull the needle nose pliers toward the body or head to avoid injury. Pull ripcord to where jacket was “ring cut” earlier.**

Repeat process for the other ripcord. **NOTE:** Heavy-wall FuturePath jackets (optional) may require a small nick at the end of the jacket to get started. The jacket slitter tool (part number 1-909040) is useful for this function.

Peel the outer jacket back and trim flush. Use caution, as to avoid damage to the MicroDucts. A layer of vinyl tape may be applied at the point where the oversheath has been trimmed to cover any rough edges at the ring cut.

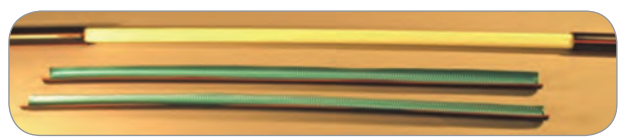
Before proceeding further examine the MicroDucts to ensure that no damage has occurred in the preparation process. Flex the MicroDucts and observe for any errant cuts where the ring cut was performed.

Window Cut

A window cut is a “mid-span” technique designed to expose the MicroDucts without cutting through the entire bundle. There may be occasional need to perform a mid-entry access and one or more of the MicroDucts be occupied with fiber optic cable that has previously been installed. Additional steps are required when using armored FuturePath. The additional steps are shown below. First, collect the tools required for the procedure. To begin, make marks on the outer jacket, not to exceed the width of the closure or NEMA box that will protect the cut and straight connectors. The installer would perform (3) rotational or ring cuts on the outer armored jacket using the large circular conduit cutter, part number 1-900414. The first two ring cuts are performed on the outer marks and the third is cut 1” inside of one of these cuts.

This third rotational cut is designed to help gain access for the longitudinal stripper, part number 1-900418. It is necessary to make a small cut with a razor knife or chipping knife and with the aid of a small flat head screwdriver, remove the 1" section. Then use the longitudinal slitter to cut to the far end rotational or ring cut.

The armor may then be pried off with a screwdriver at this point; but for easy access, use the longitudinal slitter to perform a cut 180-degrees away from the other side of the FuturePath. The remainder of the armor sheath will then just fall away, exposing the FuturePath sheath below.



Accessing the individual MicroDucts below the FuturePath oversheath can be done by performing ring cuts just inside the armored layer, only scoring the outside of the oversheath so there is no damage to the MicroDucts within. Using the FuturePath Slitter Tool, part number 1-909040, make slits 180-degrees apart on the oversheath. Using a tearing motion, tear the oversheath at each ring cut, completely removing the oversheath and exposing the MicroDucts for access and splicing.

Table 6—Bend Radius and Pulling Tensions of FuturePath

MICRODUCT SIZE (MM)	NO. OF MICRODUCTS	TOTAL WEIGHT (LBS/FT)	BEND RADIUS (IN)		PULL STRENGTH		HDPE	LSHF	RISER
			STATIC	DYNAMIC	75%	100%			
12.7/10	2	0.127	9	15	500	714			✓
12.7/10	2	0.141	9	15	500	697		✓	
12.7/10	2	0.122	9	15	600	917	✓		
12.7/10	3	0.201	18	31	800	1130			✓
12.7/10	3	0.223	18	31	800	1103		✓	
12.7/10	3	0.193	18	31	1000	1445	✓		
12.7/10	3	0.173	9	15	900	1307	✓		
12.7/10	4	0.249	20	34	1000	1399			✓
12.7/10	4	0.277	20	34	1000	1370		✓	
12.7/10	4	0.240	20	34	1300	1807	✓		
12.7/10	7	0.380	25	41	1600	2136			✓
12.7/10	7	0.422	25	41	1500	2087		✓	
12.7/10	7	0.362	25	41	2000	2763	✓		
8.5/6	2	0.081	7	11	300	455			✓
8.5/6	2	0.088	7	11	300	435		✓	
8.5/6	2	0.077	7	11	400	574	✓		
8.5/6	3	0.118	13	21	400	663			✓
8.5/6	3	0.139	13	21	500	688		✓	
8.5/6	3	0.112	13	21	600	837	✓		
8.5/6	4	0.145	14	23	600	815			✓
8.5/6	4	0.145	14	23	500	717		✓	
8.5/6	4	0.138	14	23	700	1038	✓		
8.5/6	7	0.221	17	28	900	1242			✓
8.5/6	7	0.242	17	28	800	1197		✓	
8.5/6	7	0.209	17	28	1100	1594	✓		
8.5/6	12	0.341	22	37	1400	1917			✓
8.5/6	12	0.376	22	37	1300	1860		✓	
8.5/6	12	0.323	22	37	1800	2489	✓		
8.5/6	19	0.501	27	45	2100	2816			✓
8.5/6	19	0.533	27	45	2000	2735		✓	
8.5/6	19	0.474	27	45	2700	3684	✓		
8.5/6	24	0.614	32	53	2500	3451			✓
8.5/6	24	0.677	32	53	2500	3349		✓	
8.5/6	24	0.582	32	53	3400	4539	✓		

Table 6—Bend Radius and Pulling Tensions of FuturePath (cont.)

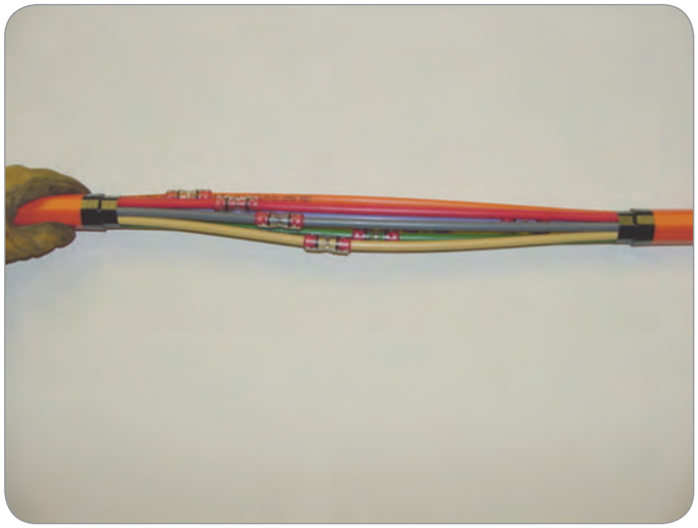
MICRODUCT SIZE (MM)	NO. OF MICRODUCTS	TOTAL WEIGHT (LBS/FT)	BEND RADIUS (IN)		PULL STRENGTH		HDPE	LSHF	RISER
			STATIC	DYNAMIC	75%	100%			
5/3.5	2	0.029	4	7	100	163			✓
5/3.5	2	0.030	4	7	100	148		✓	
5/3.5	2	0.026	4	7	100	194	✓		
5/3.5	3	0.046	8	13	100	259			✓
5/3.5	3	0.047	8	13	100	232		✓	
5/3.5	3	0.042	8	13	200	312	✓		
5/3.5	4	0.057	8	14	200	320			✓
5/3.5	4	0.058	8	14	200	287		✓	
5/3.5	4	0.051	8	14	200	382	✓		
5/3.5	7	0.084	10	17	200	472			✓
5/3.5	7	0.087	10	17	300	430		✓	
5/3.5	7	0.075	10	17	400	570	✓		
5/3.5	12	0.131	13	22	500	736			✓
5/3.5	12	0.133	13	22	400	658		✓	
5/3.5	12	0.116	13	22	600	891	✓		
5/3.5	19	0.190	16	26	800	1068			✓
5/3.5	19	0.288	16	26	1000	1425		✓	
5/3.5	19	0.167	16	26	900	1297	✓		
5/3.5	24	0.232	19	32	900	1304			✓
5/3.5	24	0.236	19	32	800	1167		✓	
5/3.5	24	0.202	19	32	1100	1577	✓		

Coupling MicroDucts

When joining two MicroDucts together with a straight coupler, it is important to make sure that the ends have been cut squarely with MicroDuct straight cutters. It is equally important to make sure that the MicroDucts have been seated into the connector stops and the collets have been locked. This will prevent MicroDuct slippage when the pressure test is preformed and allow the fiber to pass seamlessly.

It is possible to join two different size MicroDucts with a reducer coupler. Note that it is not recommended to jet from a larger size O.D. to a smaller OD, unless the I.D. of the MicroDuct is the same. Jetting from a larger MicroDuct into a smaller size can result in back pressure, which can hinder jetting performance.

Begin the coupling process by selecting one of the MicroDucts and using a MicroDuct cutting tool. For larger bundles, begin selection at the rear of the bundle, or furthest from the position of the person splicing. Cut one MicroDuct a few inches from where the sheath ends and select the appropriate MicroDuct from the other side and cut it where the end of the previously cut MicroDuct meet. **MicroDuct couplings should be placed in a staggered configuration, to help keep the splice bundle as small as possible.** Couple the two ends together with an approved connector. Continue with the remaining MicroDucts in the same manner while staggering the couplers across the sheath opening.



Note: Ensure the MicroDuct end is inserted fully into the coupler to avoid coupler failure and make sure the collet is properly locked.

Correct

Incorrect

Every attempt should be done to place FuturePath in the same direction, so that like colored or numbered MicroDucts match up within the splice bundle. While this may not always be possible due to field conditions, FuturePath that does not line up can still be spliced, matching colors or numbers, while taking care to minimize "braiding" or adding unnecessary bends within the splice.

Once the MicroDucts are either coupled or capped, install either a protective closure or FuturePath protection sleeve over the splice area. FuturePath splice kits are available for most sizes and configurations of OSP FuturePath, which includes protective sleeves, all tapes, couplers and locate wire splice connectors.

MicroDuct Coupler and End Cap Performance Specifications

Push-Fit Couplers make splicing MicroDuct fast and easy. The scope of this section is to describe the performance specifications of the MicroDuct straight splice coupler and end cap assemblies.

The Straight Splice Couplers and End Caps have the necessary sealing assemblage to operate safely at blowing pressures of 10-bar (1000 kilopascals or roughly 10 atmospheres) and protect the inner cavity against significant ingress of mud, sand and debris. "Standard" sea level pressure is considered to be 1.01325 BAR or 14.7 psi. The maximum operating internal pressure for the couplers and end caps shall be considered about 150 psi at sea level. This pressure is reduced in direct proportion to decreases in the atmospheric pressure.

The couplers can be disconnected and reconnected up to ten (10) times while maintaining the same high performance specifications required for air blown installation systems.

The connector body is constructed with a center stop to ensure the MicroDuct is properly inserted. Collets (outer release rings) are integral to the coupler and provide easy removal of the MicroDuct. Captive O-rings provide the seal. The Quick Burst rating for the MicroDuct straight splice connector and end caps are 25 BAR (363 psi). All couplers exceed this rating. The figures that follow show the coupler and end caps for MicroDuct.

FuturePath and MicroDuct Installation Recommendations

To make a splice with the Dura-Line Push-Fit MicroDuct Coupler or to install an End Cap, use either the Straight Cutter or the Round Cutter and cut the MicroDuct at 90 degrees. Repeat the cut on the second MicroDuct, if coupler is used. Make sure the MicroDuct end(s) are clean and firmly push the MicroDuct(s) into the coupler or end cap. An uneven or ragged end cut may compromise the performance of the coupler or end cap. A slight twist may help insert the duct into the coupler. The collet tool can be used to help depress the collet for release and removal of the coupler. It can also be used to spread or separate the collet from the body of the coupler, prior to inserting the MicroDuct fully into the center stop. This helps avoid gapping within the coupler when high-pressure air is applied. Gapping can cause the cable being jetted to become lodged inside the coupler, especially if the coupler is placed in a MicroDuct bend or if the fiber optic cable tips are not used on the lead end of the cable.

Straight Cutter
Performs 90-degree cut on MicroDuct
(Part No. 1-907163)

Round Cutter
Scores MicroDuct occupied with cable to
perform 90-degree cut (Part No. 1-907162)

Once the MicroDuct end(s) have been pushed into the coupler or end cap, visually examine the clear "inspection window" to ensure the MicroDuct(s) have passed through the O-ring seal. This will ensure that the duct has reached the center stop.

Remove coupler by pressing in on release rings (collets) and
simultaneously pulling MicroDuct from the coupler.

To remove the coupler or end cap, simply push the outer ring (collet) at the end of the coupler toward the center while simultaneously pulling the MicroDuct out of the coupler.

Both the Straight Splice Coupler and End Cap can be installed and removed up to 10 times while still maintaining the same performance rating.

The connectors and end caps shall meet all performance requirements as designed. They are intended and manufactured so there is no residual stress that could adversely affect performance over the lifetime of the product. Transition Couplers are available for some connections to dissimilar sized MicroDucts or for connection to legacy installations of other companies.

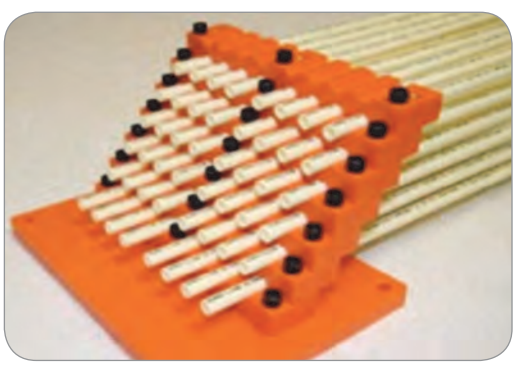
8.5 mm x 8 mm Transition Coupler (Part No. 1-907162)

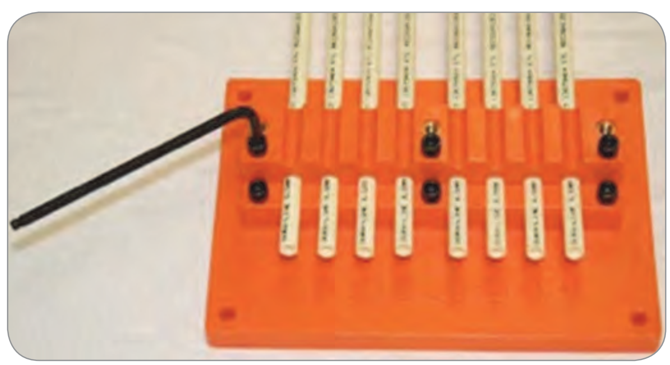
Collet Locking Tool

The design of the MicroDuct coupler allows for easy removal by pushing in on the release collets and simultaneously pulling the MicroDuct out of the coupler. This design will allow the collet to push outward from the body of the coupler when high-pressure air is introduced into the system. This slight movement outward forms a small gap on either side of the coupler center stop. This gap, especially if the coupler is placed within a bend of the MicroDuct, may become a hindrance to placing the fiber optic cable should the lead edge of the cable become snared in this gap. To limit the possibility of this occurring, use the collet-locking tool, Dura-Line part number 1-909053, to spread the collets and fully push the MicroDuct toward the center stop of the coupler.

MicroDuct Organizer

The MicroDuct organizer is designed for use where eight (8) or more MicroDucts are terminated. It requires a minimum amount of space to mount and is modular so it is possible to order only the number of organizer brackets needed. The mounting plate includes one bracket.

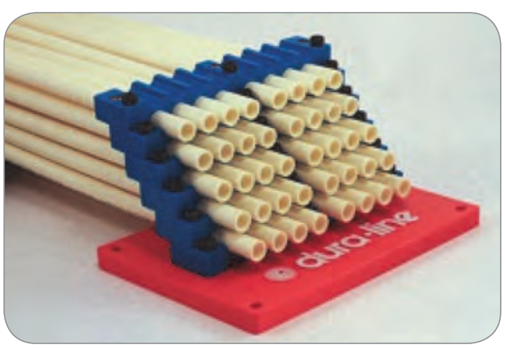




Additional brackets can be added simply by attaching to the existing brackets. Each bracket is designed to hold eight (8) MicroDucts.

Insert the MicroDuct into a round cutter and cut the MicroDuct at the mark ***being careful not to cut the fiber optic cable or pull line.*** Remove the excess duct. Next place another bracket over the MicroDucts and attach it with the three, 3/16-inch Allen-head screws provided with the organizer. Using a 3/16" Allen wrench, tighten the screws, starting with the center screw, until the bracket is tight against the bottom bracket.

Continue adding MicroDucts and brackets until all MicroDucts have been secured in the organizer.



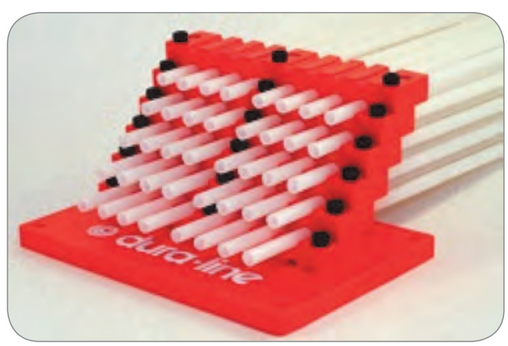
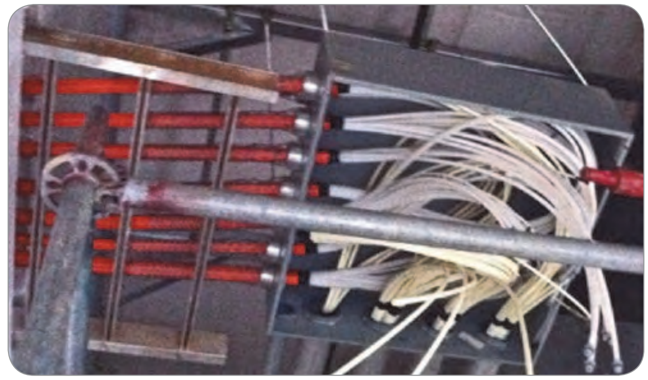


Table 7

DURA-LINE PART NO.	DESCRIPTION	PART INCLUDES
1-907171	8.5 mm MicroDuct Mounting Bracket	One Bracket Holds 8 MicroDucts
1-907172	12.7 mm MicroDuct Mounting Bracket	One Bracket Holds 8 MicroDucts
1-907173	8.5 mm MicroDuct Mounting Plate (Orange)	One 8.5 Bracket with 3 Screws
1-907174	12.7 mm MicroDuct Mounting Plate (Blue)	One 12.7 Bracket with 3 Screws

Vault and Cabinet Entry Positions

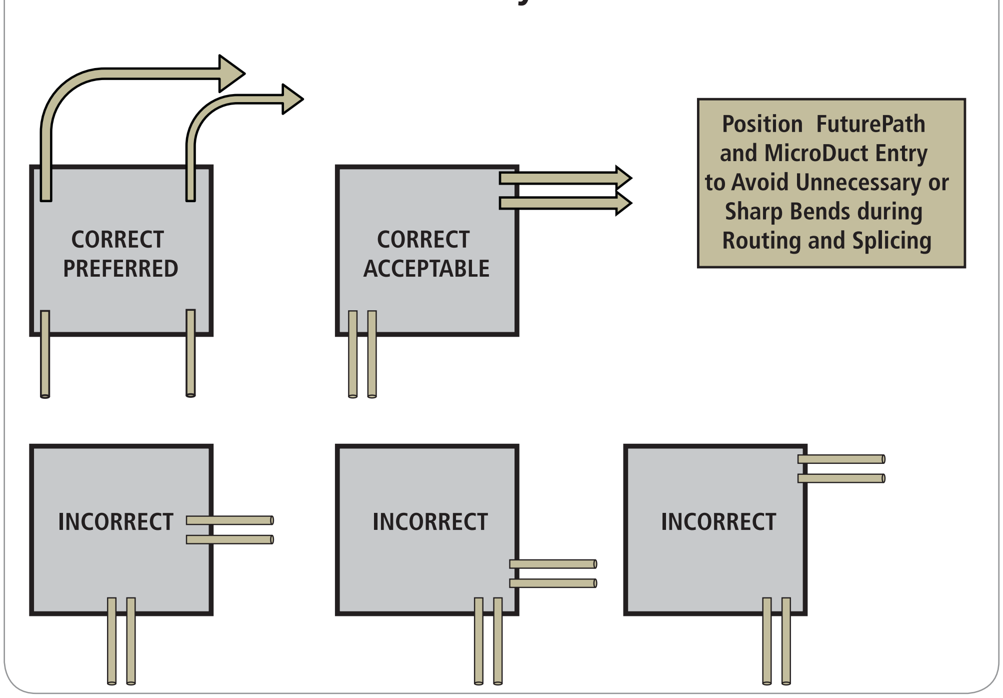


When entering a vault or cabinet with FuturePath or MicroDucts, select a position for entry, which will facilitate routing and splicing of the loose MicroDucts. Whenever possible, make directional changes before entering the vault or cabinet, so MicroDucts are adjacent or facing each other to ease splicing. Avoid tight bends and maintain sweeping bends whenever possible. When terminating into cabinets, it is recommended to use a DETA or ETA FuturePath Termination, which is specifically sized to the variation of FuturePath used. Each connector has a steel ring nut for securing to the inside wall of the cabinet; and in the case of the DETA and external security nut which gives a measure of pullout and keeps the FuturePath from moving inside the cabinet. The ETA Termination may be fitted with an appropriately sized heat shrink sleeve to increase pullout and water tightness, if desired.

Cabinets with multiple FuturePath should be sized for the number of MicroDucts they will contain. Avoid overfilling or under sizing a cabinet. Cabinets should be rated for the application and location requirements.

The following drawing shows some suggested entry locations for cabinet routing, as well as some less preferred or incorrect locations for bringing FuturePath to a cabinet or vault. FuturePath should be labeled as per the engineering drawings to help identify routes within the network design. Unspliced MicroDucts should be capped or plugged so their interior remains free of dirt and debris.

Preferred Vault and Cabinet Entry Positions




When placing in a tray or ladder rack, care should be given to securing the FuturePath, especially at bends. Cable ties may be used if they are of a heavy-duty design, such as a Thomas and Betts Deltec® strap or Belden Diamond® strap. These straps are rated at about 400 lbs. tensile strength. Securing the FuturePath at least every 4 feet in straight sections and at the beginning and end of a bend is recommended.



When FuturePath is placed into a vault, it is best to enter the vault with the ends facing each other to facilitate splicing of the MicroDucts. If this is not possible, then a "jumper loop" may be added to form a large diameter loop to aid in jetting of the fiber optic cable.

FuturePath Enclosure Connectors—Outside Plant (OSP)

The outside plant connectors for connections to OSP NEMA-type cabinets are listed below. The connectors have a metal lock ring for securing the FuturePath into the cabinet wall. The plastic lock nut compresses the urethane grommet around the FuturePath to provide pullout strength. The grommets are sized for each configuration of FuturePath. To install, loosen the plastic lock nut and slide onto the FuturePath. After securing the pathway into the cabinet, secure the locknut by hand and wrench tighten one full turn for extra security.

Table 8—FuturePath OSP Connector Configurations

CONFIGURATION	PART NO.	CONNECTOR IMAGE
FUTUREPATH—5 mm / 3.5 mm		
Single MicroDuct	1-908786	
2-Way	1-908787	
3-Way	1-908788	
4-Way	1-908789	
7-Way	1-908790	
12-Way	1-908791	
19-Way	1-908792	
24-Way	1-908793	
25-Way	1-908794	
FUTUREPATH—8.5 mm / 6 mm		
Single MicroDuct	1-908795	
2-Way	1-908796	
3-Way	1-908797	
4-Way	1-908798	
7-Way	1-908799	
12-Way	1-908800	
19-Way	1-908801	
24-Way	1-908802	
FUTUREPATH—12.7 mm / 10 mm (9.8 mm)		
Single MicroDuct	1-908803	
2-Way	1-908804	
3-Way	1-908805	
4-Way	1-908806	
7-Way	1-908807	

FuturePath Enclosure Connectors—Inside Plant (ISP)

The inside plant connectors for connections to interior-rated NEMA-type cabinets are listed below. The connectors have a metal lock ring for securing the FuturePath into the cabinet wall. The grommets are sized for each configuration of FuturePath. To install, slide onto the FuturePath. After securing the pathway into the cabinet by tightening the metal lock ring, a heat-shrink sleeve may be added for moisture/dust resistance. Be sure to add the heat shrink sleeve material prior to sliding the connector onto the FuturePath.

Table 9—FuturePath ISP Connector Configurations

CONFIGURATION	MAX. OUTSIDE DIAMETER	PART NO.	CONNECTOR IMAGE
FUTUREPATH—5 mm / 3.5 mm			
Single MicroDuct	5 mm	1-908867	
2-Way	0.46"	1-908868	
3-Way	0.51"	1-908869	
4-Way	0.56"	1-908870	
7-Way	0.68"	1-908871	
12-Way	0.88"	1-908872	
19-Way	1.07"	1-908873	
24-Way	1.27"	1-908874	
25-Way	1.27"	1-908875	
FUTUREPATH—8.5 mm / 6 mm			
Single MicroDuct	8.5 mm	1-908876	Photo not available
2-Way	0.77"	1-908877	
3-Way	0.85"	1-908878	
4-Way	0.93"	1-908879	
7-Way	1.13"	1-908880	
12-Way	1.48"	1-908881	
19-Way	1.80"	1-908882	
24-Way	2.13"	1-908883	
FUTUREPATH—12.7 mm / 10 mm (9.8 mm)			
Single MicroDuct	0.50"	1-908884	Photo not available
2-Way	1.10"	1-908885	
3-Way	1.22"	1-908886	
4-Way	1.35"	1-908887	
7-Way	1.64"	1-908888	

DETA-Type Connector

ETA-Type Connector

DETA-UV-Type Connector

Quality of MicroDucts and FuturePath

Dura-Line is independently audited and certified to ISO 9001 specifications and has a quality plan in place for its HDPE MicroDucts concerning testing of the various product configurations, whether it is a single MicroDuct or FuturePath in a 24-Way version. Nevertheless, some customers may choose to perform their own tests upon MicroDucts, either upon receipt of a shipment or post installation and prior to acceptance of a third-party installer. This information will provide recommendations of testing procedures that can be performed upon the individual MicroDucts as well as any locate wire continuity testing in FuturePath configurations.

MicroDuct and FuturePath are designed to be flexible, lightweight, durable, easy to install and are available multiple configurations. Unless otherwise specified, all MicroDucts are smooth on the outside, micro-ribbed on the inside and contain a permanent co-extruded layer of SILICORE®, which is a super slick low-friction layer which greatly reduces the coefficient of friction over standard HDPE conduits.

The quality of MicroDuct and FuturePath shall allow jetting (blowing) and replacement of cables over a life of at least 15 years after the installation.

The MicroDuct and FuturePath shall be free from holes, blisters, inclusions, cracks, or other imperfections, which would affect the performance or serviceability. The MicroDuct and FuturePath shall be homogenous throughout and the bores free from dimensional non-conformities as much as possible within the manufacturing process.

Conformance Continuity Test

Factory testing of MicroDucts is performed using BBs on empty MicroDucts (CIC, or Cable in Conduit, manufacturing process does not allow for BB testing). Generally, two BB tests are performed. The first is during the extrusion process, when a BB which measures up to 80% of the inside diameter is used to test the MicroDuct for non-conformities. The maximum fill ration recommended for the placement of cables in MicroDucts is 80%. The second BB test is performed after MicroDuct has been placed onto the reel. In this test, a BB with a diameter of 60% of the MicroDuct Diameter is blown from the outside end to the inside end using high-pressure air. Due to HDPE ovalization potential during reeling of MicroDucts, the smaller diameter BB is used. The MicroDuct and FuturePath should recover its circular shape upon removal of a transverse compression load, such as is present during the placing of the product upon shipping reels. MicroDucts are tested to comply with Bellcore GR-356-CORE for crush and compression recovery. FuturePath and MicroDucts will recover to their original round orientation soon after removal from a reel and after installation into larger conduit, direct bury, plow, aerial, or horizontal directional drill applications.

Fill ratio can be easily calculated by taking the cable diameter intended to be placed into the duct and divide by the inside diameter of the conduit.

$$\frac{\textbf{7.1 mm Cable Diameter}}{\textbf{10 mm MicroDuct ID}} = \textbf{Fill Ratio Percentage} = \textbf{71\%}$$

Additional factory testing includes a sustained pressure test upon the MicroDucts and a continuity or "end-to-end" test on the locate wire if included in the FuturePath version ordered.

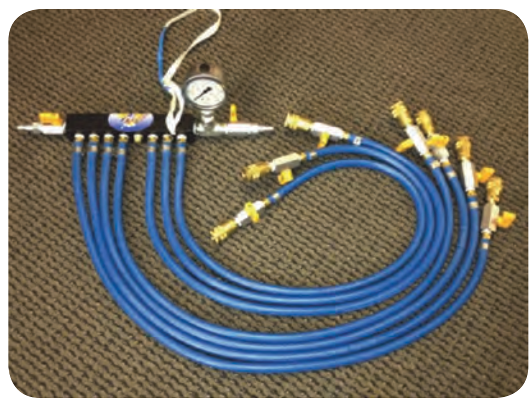
Sustained Pressure Test

During the oversheath removal of FuturePath, it is possible to damage the MicroDucts if, when performing the ring cut, the MicroDucts are cut as well. Always perform the ring cut as scoring the oversheath and remove it using a tearing action. If it is desired to perform a static pressure test upon an individual MicroDuct, that can be performed by capping one end of the MicroDuct and installing a valve upon the other end. Pressurize the MicroDuct to between 95 psi and 140 psi. Place a pressure gauge on the cap and monitor the pressure for five (5) minutes. The pressure should remain stable. If there is more than a 5% loss in pressure, all connections should be checked for integrity and the test repeated. Depending upon the length of the MicroDuct being tested, it may take up to several minutes to pressurize the entire length.

Once the test is repeated and pressure continues to fall, an air leak can generally be heard by standing close to the reel. If the leakage is determined to be the MicroDuct on the reel, either the reel can be rejected or the location of the leak can be cut out.

Some "quick-connect" apparatus that can be used to perform the sustained pressure testing of MicroDucts are shown. After connecting to the MicroDuct, open the shut-off valve and pressurize the MicroDuct to between 95 psi and 140 psi. Shut the valve and monitor the pressure with a gauge. Depending upon the length of the run, it may take several minutes for the air pressure to stabilize within the MicroDuct.

MicroDuct Testing Apparatus



Multiple MicroDucts may be tested simultaneously with the use of a Multiport Testing Manifold.

Bead or BB Test Procedure (Reel Test)

During the manufacturing process and while the MicroDuct is straight the BB used to test the conformity of a MicroDuct shall be of 80% fill ratio to the Inside Diameter (I.D.) of the MicroDuct being tested. After manufacturing and while the product is on a reel the BB used to test the conformity of a MicroDuct and all MicroDucts in a bundle of FuturePath shall be of no more than 60% fill ratio to the I.D. of the MicroDuct being tested. Since the MicroDucts were factory tested and passed the BB test, shipping damage would be the only reason for failure to pass a field MicroDuct BB test on the reel. The customer should carefully inspect each reel for shipping damage which may have occurred and either reject the shipment to the carrier, or perform their own retest of the BB conformity test.

When a reel of MicroDuct or a reel of FuturePath is to be field tested before installation and while still on the reel to test the conformity of a MicroDuct, it is recommended to use a BB of no more than 60% fill ratio to the I.D. of the MicroDuct being tested. After a MicroDuct or FuturePath has been taken off the reel and installed according to our recommended installation procedures, it is further recommended that the BB used to test the conformity of a MicroDuct be of no more than 80% fill ratio to the I.D. of the MicroDuct being tested.

Nylon or Delrin® acetate precision BBs are best and recommended for testing of BBs blown through MicroDucts propelled by high-pressure air travel at high speeds and can cause injury if contact is made with the BB during the exit phase of the test.

CAUTION Goggles should be worn and avoid glass or plastic BBs which can break apart during high-pressure testing.

Duct fill ratio can be calculated by taking the outside diameter of the cable (O.D.) and divide by the I.D. of the MicroDuct. For instance, a cable with a 5 mm O.D. divided by a 10 mm I.D. duct is a 0.5 ratio, or 50% fill. A 10 mm cable in a 13 mm I.D. MicroDuct is nearly a 77% fill ratio, which is approaching the upper limits of the size cable recommended.

Table 10—Recommended BB Size for MicroDucts

MICRODUCT SIZE (mm)	PRODUCTION TEST BB SIZE (mm) 80%	POST-PRODUCTION TEST BB SIZE (mm) 60%	FIELD TEST ON REEL BB SIZE (mm) 60%	FIELD TEST AFTER INSTALL BB SIZE (mm) 80%
18 x 15	12.0	9.0	9.0	12.0
18 x 14	11.2	8.4	8.4	11.2
16 x 13	10.4	7.8	7.8	10.4
16 x 11.76	9.4	7.0	7.0	9.4
12.7 x 10	8.0	6.0	6.0	8.0
12 x 10	8.0	6.0	6.0	8.0
10 x 8	6.4	4.8	4.8	6.4
8.5 x 6	4.8	3.6	3.6	4.8
7 x 5.5	4.4	3.3	3.3	4.4
5 x 3.5	2.8	2.1	2.1	2.8

Select the recommended BB size for the MicroDuct product from Table 10 above and insert it into the duct to be tested. If the exact size BB cannot be obtained, test with the next nearest BB in size, without exceeding the maximum recommended dimension. Attach the high-pressure air supply using a quick-connect fitting which is correct for the MicroDuct being tested. At the opposite end of the MicroDuct, cover the end of the duct with a sturdy mesh bag or sock, to collect the BB in once it has travelled the length of the MicroDuct. Secure the bag or sock with tape or a cable tie to help verify the BB does in fact exit the far end of the MicroDuct. Should a BB become lodged in the MicroDuct, apply high-pressure air at the far end of the duct and try to dislodge the BB. Be certain to move the bag or sock to the original end of the duct so the BB is contained, helping to verify that the BB did exit the MicroDuct. If applying air from the opposite end does not remove the BB, then blow the next smaller diameter BB from the far end to help dislodge the first BB. The BB can generally be heard travelling through the coils of MicroDuct on the reel. The BB will exit the MicroDuct quickly and with considerable pressure, so the sock or mesh bag helps limit any damage or injury a fast-travelling BB can cause.

BB Test Procedure (Span Test)

After the MicroDuct or FuturePath has been installed and removed from the reel, any ovalization that may have occurred due to the coiling of the product should be corrected. Should post-installation BB verification be required, it is recommended to test with a BB at least as large as the diameter of the cable to be installed, up to 80% of the duct fill ratio. If the cable is only to be about 5 mm O.D. and placed into a 10 mm I.D. MicroDuct, there is no advantage to BB test with an 8 mm diameter BB. The requirement is to test the span with a BB the same size or just slightly larger than the cable diameter.

Test the installed span of MicroDuct or FuturePath in a similar manner to the previous paragraphs. Select the correct size BB from Table 10. This test will generally require two people and they should be able to communicate between each other with hand signals, radios or cell phones since both ends of the MicroDuct will not be on the reel nor in the same vicinity.

Failure to pass the BB through the duct constitutes failure of the test. All air connections should be rechecked and the test performed again. Check the pressure on the air supply to verify it is at least 75 psi. All MicroDuct that do not pass the second I.D. clearance test will be considered non-conforming and subject to non-conforming corrective procedures. All connections along the route will have to be checked for proper connection. The test will have to be repeated until the trouble area can be isolated and repaired. Once the repair has taken place, the test should be repeated until the "BB" passes through the span.

BB's may be obtained by ordering directly from McMaster-Carr or other such suppliers. To simplify the BB selection process, a list of part numbers from McMaster-Carr (www.mcmaster-carr.com) is provided in the table below.

Table 11

MCMASTER-CARR PART NO.	DESCRIPTION	DIAMETER (mm)	DIAMETER (in.)
9614K71	White Delrin® Acetal Ball	2	0.079
9614K72	White Delrin® Acetal Ball	3	0.118
9614K73	White Delrin® Acetal Ball	4	0.157
9614K54	White Delrin® Acetal Ball	4.76	3/16
9614K74	White Delrin® Acetal Ball	6	0.197
9614K24	White Delrin® Acetal Ball	6.35	1/4
9614K57	White Delrin® Acetal Ball	7.94	5/16
9614K58	White Delrin® Acetal Ball	9.53	3/8
9614K59	White Delrin® Acetal Ball	12.7	1/2
9614K6	White Delrin® Acetal Ball	15.88	5/8

Locate Wire Continuity Test

The copper-locate wire, which is present in some FuturePath configurations, may be tested in the field while the FuturePath is on the reel. Using a common Ohmmeter, turn the test switch on the meter to ohms (Ω). Touch the leads of the meter to each other. The gauge should read close to zero ohms resistance. Connect the leads to each end of the locate wire, which will appear at the outside and inside end of the FuturePath. The meter should read zero to 10 ohms, depending on the tightness of the connections and length of the FuturePath on the reel. Each meter may read differently. The main thing is that the meter shows a resistance change fluctuation when the leads are connected to each end of the locate wire.

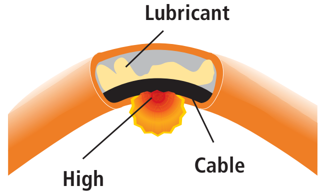
SILICORE®—The Permanent Lubrication Layer

SILICORE is a co-extruded permanent layer of uniform thickness, containing active or polymeric materials that are formulated to provide a permanent low friction boundary layer between the MicroDuct and cable for the anticipated service life of the MicroDuct. All FuturePath will be supplied with MicroDucts equipped with SILICORE super slick permanent liner.

SILICORE
SILICORE is co-extruded on the inside of Dura-Line's tough, durable, High Density Polyethylene (HDPE) conduit creating a super slick permanent lining. SILICORE-lined ducts allow for higher speed cable jetting and longer cable pulls. The permanent pathway remains for future repairs, replacements or upgrades.

- Super slick permanent lining
- Easier and faster cable installations
- Reduced coefficient of friction
- Flexibility for growth
- Cost effective repairs or upgrades
- Can be extruded with any product

How SILICORE Works



WITHOUT SILICORE	WITH SILICORE
Heat builds and lubricant dissipates causing direct contact between cable and HDPE duct. Installation friction increases causing damage where the cable contacts the duct.	Cable remains in contact with the permanent SILICORE. Reduced burn through, low coefficient of friction and easier and longer cable pulls.

Product Life

The quality of MicroDuct and FuturePath shall allow jetting (blowing) and replacement of cables over a life of at least 25 years after the installation.

Workmanship

The MicroDuct and FuturePath shall be free from holes, blisters, inclusions, cracks, or other imperfections, which would affect the performance or serviceability. The MicroDuct and FuturePath shall be homogenous throughout and the bores free from dimensional non-conformities as much as possible within the manufacturing process.

Material

The MicroDuct and FuturePath shall be constructed of polymeric materials that are lightweight, flexible, corrosion resistant and nonconductive. The base material shall be clean virgin grade high-density polyethylene (HDPE) that conforms to ASTM D3350-98a, Type III, Category 5, Class B or C and Grade P-34 per ASTM D1248-84 or equivalent.

Color/UV Protection Additive

Standard available colors shall be black, terracotta, red, orange, gray, yellow, green, blue, brown and white or as specified by the customer. FuturePath MicroDucts will either be individually colored or will be one color and each MicroDuct outer sheath will be numbered sequentially every two feet. The interior MicroDucts are numbered every two inches with an individual number identifier for each tube. The HDPE over sheath is available in different colors. All aerial FuturePath will have a black color only. Colors shall be protected from ultra-violet (UV) degradation by the incorporation of Hindered Amine Light Stabilizers (HALS). This will allow for two (2) years of outside storage UV protection. Aerial products shall incorporate a higher level of finely divided carbon black and HALS additives, which provide twenty (20) plus years of UV protection. The duct material shall be compounded with antioxidant additives to prevent thermal degradation.

Fire-Retardant MicroDucts

Typically inside buildings, fire-retardant MicroDucts are required to comply with local fire codes and the National Electrical Code Article 770.154 Sections A to C. Both riser-rated and plenum-rated MicroDucts must comply with the applicable requirements of the Standard for Safety for Optical Fiber and Communication Cable Raceway. The riser-rated MicroDucts must comply with UL-1666 and the plenum-rated must comply with NFPA-262 and be tested to the UL and applicable Standard by either UL/ETL or other approved testing facility and printed with the approval number and fire rating every two feet.

Performance Requirements and Tests

The MicroDucts and FuturePath can be jetted (blown) inside an outer duct. The cable can be installed inside the MicroDuct or FuturePath by the blowing method. The MicroDucts manufactured by Dura-Line will meet or exceed the following performance requirements. When the FuturePath is placed aerially or buried, cables can be installed by the jetting (blowing) method.

Coefficient of Friction

Typical values of sliding coefficient of friction for Dura-Line MicroDucts for cables with Polyethylene are optimized through the of Dura-Line's SILICORE super slick permanent liner.

Pull Strength

The pull strength for MicroDucts and FuturePath is the tensile force that can be used to pull it during the installation if required. The following table lists the safe pull strength for individual MicroDucts.

Table 12—MicroDuct Pull Strength

SIZE (O.D. X I.D.) (mm)	SAFE PULL STRENGTH (LBS)	SAFE PULL STRENGTH (NEWTONS)
12.7 x 10 (9.8)	227	1,009
8.5 x 6	115	511
5 x 3.5	38	169

Notes

1. MicroDucts are designed for cable to be jetted (blown) in with air, not pulled in the traditional sense, noted by the low pull or tensile strength of the MicroCables.
2. The pull and crush strength of a FuturePath 7 x 12.7 mm MicroDucts and an over sheath of 0.070 is the same as a 1-¼” SDR-11 inner duct.

Table 13—Pressure (Burst Strength)

SIZE (O.D. X I.D.) (mm)	SUSTAINED PRESSURE PSI (BAR)	BURST PRESSURE PSI (BAR)
12.7 x 10 (9.8)	227	1,009
8.5 x 6	115	511
5 x 3.5	38	169

eABF Cable Installation by Jetting Method

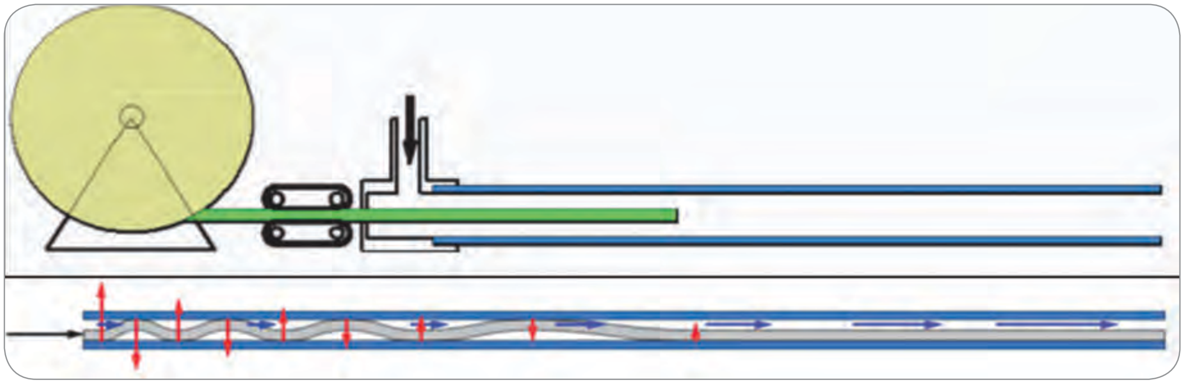
SAFETY: As noted in Chapter 1, discuss any local restrictions regarding work hours or any special precautions such as working in enclosed or confined areas, or health facilities. It is the responsibility of the Installer and/or their employers to be familiar with local, state and OSHA safety requirements. Check with the AHJ (Authority Having Jurisdiction) regarding specific safety requirements.

Safety Specific to Jetting Fiber

Jetting does require the use of high-pressure air and eye protection is recommended whenever jetting is employed. Improperly installed or defective connections may result in blowouts, which could cause injury. Always increase pressures slowly to help verify connections are secure. Hearing protection may be required as well if the noise level is uncomfortable to the operator or others in the immediate work area, or the noise level exceeds the safe level, as determined by local or OSHA safety regulations.

Jetting Process

Jetting requires a high-pressure air source to create high air speed over the cable along the length of the MicroDuct, toward the open end of the duct. This *viscous-drag* effect is essential to installing the cable through the pathway. Drive wheels or belts on the equipment help push the cable past the pressurized seal and into the duct and maintains the speed of the installation. However, it is the air passing over the cable at a high rate of speed that makes it possible to jet in cables over considerable distances. Distances obtained vary greatly: depending upon the cable stiffness and weight, fill ratio of the cable O.D. to duct ID, route layout, air pressure available, temperature, humidity, equipment used, etc.



Moves, Adds and Changes (MACS)

One advantage of an blown fiber installation is the ease in which moves, adds or changes to the fiber distribution network can be accomplished. Accurate mapping of the FuturePath and MicroDuct route can help ensure that new connections or connection transfers at junction locations can be made quickly and easily for placing additional fiber optic cables. Removal of existing fiber optic cables, possibly for use in other locations within the network, can be done by simply applying air pressure to one end of the route and relying on a "piston effect," pushing the fiber optic cable out of the far end. By adjusting the amount of air pressure applied, the cable being removed can be managed and returned to an empty reel or into a figure-8 layout for reuse elsewhere. For instance, a cable leaving room A, going through a junction point in room B and terminating in room C, can be removed back to room B, coiled up and subsequently jetted into a new room, D. Or, if the cable needs to be completely removed, the technician can apply air in room A, coiling up the cable in room B upon an available reel and replaced between rooms C and D, providing the length is sufficient for the second location.

Blowing Performance and Distance Factors

Air pressure

The higher the pressure, the more air drag or cohesive tension over the fiber. The larger I.D. of the MicroDuct, the greater amount of air flows over the fiber, allowing higher air speeds. The small O.D. of the eABF fiber creates less weight and friction during the jetting operation. The example below illustrates the importance of air pressure as it relates to the speed of the air over the cable:

Jetting Performance Example*

8.5/6 mm Riser MicroDuct
3.8 mm eABF OFNR-listed
Curves/Bends = 20 each, 90 degree at 1 Meter Radius (3.28 ft)
Max. Push Force = 100N

Table 14

METERS	BAR	KPH		FEET	PSI	MPH
1,763	16	200		5,783	232	124
1,466	12	160		4,808	174	99
1,316	10	145		4,316	145	90
1,162	8	125		3,811	116	78
1,003	6	110		3,290	87	68

***Note:** Results were calculated using proprietary software. Actual result may vary due to other variables such as trajectories, temperature, undulation of the cable or duct, tight radius bends, etc.

Temperature

Temperature can have a significant impact on the blowing performance of an eABF fiber optic cable. Different temperatures have higher or lower dew points, controlling the amount of moisture in the air. Air that is too dry can build static charge on the cable—causing it to be adversely attracted to the duct inner wall or, too saturated with moisture, which can affect distance that the cable can be blown. The optimum jetting temperature is between 14°F and 120°F (-10°C and 49°C).

Altitude

Air density or barometric pressure can affect the cable during the blowing process. Altitude can impact the cable blowing performance. At one-mile elevation, such as Denver CO, there is 19% less oxygen in the air than at sea level.

Cable Stiffness

Stiffer cables tend to be more 'pushable' but too much stiffness and the inherent memory can impede distance performance.

Fill Ratio

The relationship between the cable O.D. and the duct I.D. can affect distance performance. The ideal fill ratio is 50-70%; with a generally accepted range of 50-75% (calculated by the cable O.D. divided by the duct I.D. x 100). While it is possible to jet cables that have higher fill ratios up to 80% maximum, the distances expectations should be lowered. When placing cables with a fill ratio of less than 50%, there is a greater risk of curling/folding the cable in the duct, unless there has been careful consideration to setting the maximum push force on the jetting system being used. While a maximum push force test should always be performed—per the manufacturer's recommended procedures to minimize the potential for damaging the cable—it is especially critical for low fill ratio situations.

Determine Optimum Jetting Strategy

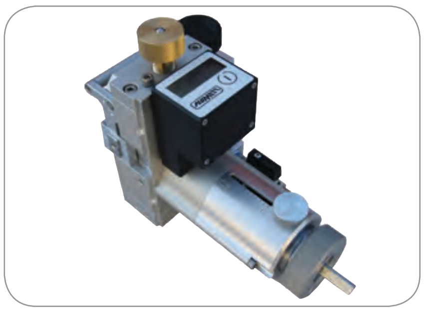
Jetting eABF® blown fiber optic cables or OSP micro cables requires equipment designed specifically for this application. These devices typically have either internal or external drive wheels, or external tractor belts, to push or feed the cable into the duct. The drive mechanisms are typically powered by a drill, electrical power source, compressed air or nitrogen and less commonly, hydraulics. The jetting systems are equipped with an air chamber to utilize compressed air to jet, or high-airspeed blow, the fiber media along the entire length of the pathway; effectively, pulling the cable by means of a viscous air drag method through the pathway. This combination of push/pull action allows for the placement of micro cables for substantial distances—far exceeding those possible with conventional cable pulling methods—in pathways that may include numerous vertical and horizontal turns and bends.

Dura-Line encourages the use of these state-of-the-art jetting systems, such as the Plumett line of equipment, which includes the UltimaZ® V-20, MicroJet® and MiniJet®. However, while comparable systems are available from other manufacturers, for the purpose of example of the jetting method and equipment requirements, only the Plumett jetting systems will be discussed in this document.

ATTENTION! The specialized equipment used for the jetting process involves rotating mechanical components and utilizes compressed air and thus, should only be operated by qualified personnel trained in the proper safety, set up, operation and maintenance of the equipment procedures, as determined by the equipment manufacturer.

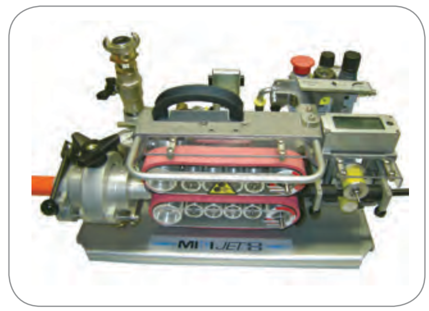
Equipment Overview

UltimaZ® V-20 is a drill-driven unit for ISP micro cable diameters 4 mm or less. For larger size micro cables up to 8 mm, the MicroJet is a pneumatic-drive unit that may be used for both ISP eABF micro cables and OSP micro cables, such as AFL's MicroCore® products. The MiniJet is a pneumatic-drive unit (hydraulic version available) and, although it can accommodate cable diameters as small as 4 mm O.D. and micro ducts as small as 7 mm OD, it is generally best suited for OSP environments involving 6 mm O.D. and larger micro cables and micro ducts 12.7 mm O.D. and larger. These Plumett jetting systems are available for purchase from Dura-Line. Alternately, a rental program is available from Dura-Line, based upon availability of equipment and personnel that may be necessary for on-site training.



UltimaZ V-20

MicroJet PRM-196



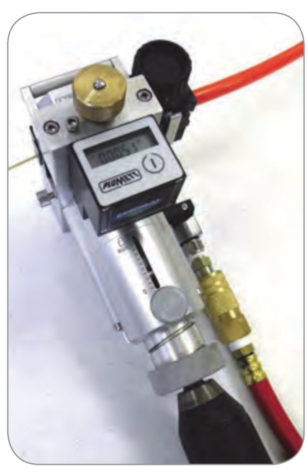
MiniJet

NOTE: Refer to the manufacturer's operations manual for detailed safety, set up, operation and maintenance regarding this equipment.

UltimaZ V-20 Fiber Jetting System is ideal for eABF cable installations inside the building. The fiber optic cable installation speed is dependent on many variables; however, cables can be typically placed from 80-165 FPM maximum at 12 BAR (175 psi) maximum air pressure rated.

The UltimaZ V-20 System is designed for installing fiber optic micro cables with diameters between 0.8 mm and 4 mm and MicroDuct O.D. from 3 mm up to 12.7 mm. It is equipped with a magnetic clutch to provide a variable torque from 0-20 N (4.4 lbs.) push force. Other standard features are a bidirectional drive system, digital backlit footage counter/speed indicator, air pressure gauge, standard tools, insert cartridge with cable guides; operator's manual, MicroLube and durable vinyl storage case.

Shown with optional stand



Power supply (customer supplied)—DeWalt 18 Volt cordless (or equivalent) or corded electric drill.

Air Supply (customer supplied)—Air volume required is 7-18 cubic feet minute (CFM). An air compressor or nitrogen bottle equipped with a regulator can be used. It should be noted that nitrogen has a drying effect (moisture purging) that may cause static electricity build up in the pathway. Static electricity can adversely affect jetting distance and speed. When using standard electric-powered portable compressors or utility gas/diesel compressors, depending on the environment (inside, outside), relative humidity and ambient temperature, it may be necessary to utilize an air aftercooler/water separator and possibly an air prep kit (equipped with a desiccant canister) for maximum productivity results.

UltimaZ V-20

MicroJet PR/PRM-196 System is ideal for eABF cable installations inside the building and campus environments. The fiber optic cable installation speed is dependent on many variables; however, they can typically be placed from 80-165 FPM maximum at 16 BAR (230 psi) maximum air pressure rated.

MicroJet PRM-196

The 196 Series system is designed for installing fiber optic micro cables with diameters 1 mm to 8 mm and MicroDuct O.D. from 3 mm up to 16 mm. Other standard features are a bidirectional drive system, digital backlit footage counter/speed indicator, air pressure gauge, standard tools, insert cartridge with cable guides, operator’s manual, MicroLube and storage case. The MicroJet is designed for jetting or blowing telecommunications eABF fiber optic cables and MicroCore fiber optic cables in pre-installed ducts and MicroDucts.

MicroJet PRM-196 features a magnetic clutch for variable torque capability from 0-25 N (5.6 lbs.) push force and is recommended for micro cables with an O.D. of less than 3.5 mm. The MicroJet PR-196 is a direct-drive system for from 0 to 150 N (34 lbs.) push force that covers a wide range of MicroCables up to 8 mm in diameter. It is ideally suited for the Dura-Line eABF cables having a diameter range of 3.5-3.8 mm.

Power supply—pneumatic driven motor will require up to 7 CFM of the available air supply.

Air Supply Requirements (customer supplied)—Magnetic clutch (PRM model) air volume required is 3.5-18 cubic feet minute (CFM). Direct drive (PR model) is 18-36 CFM. An air compressor or nitrogen bottle equipped with a regulator is also required. It should be noted that nitrogen has a drying effect (moisture purging) that may cause static electricity build up in the pathway. Static electricity can adversely affect jetting distance and speed. When using standard electric-powered portable compressors or utility gas/diesel compressors, depending on the environment (inside, outside), relative humidity and ambient temperature, it may be necessary to utilize an air aftercooler/water separator and possibly an air prep kit (equipped with a desiccant canister) for maximum productivity results.

NOTE: Refer to the manufacturer's operations manual for detailed safety, set up, operation and maintenance regarding this equipment.

The **MiniJet Pneumatic Drive System** is ideal for MicroCore cable installations in campus and outside plant (OSP) environments. The fiber optic cable installation speed is dependent on many variables however, cables can be typically placed from 100-330 FPM (feet per minute) at 16 BAR (30 psi) maximum air pressure.

The MiniJet System is designed for installing fiber optic micro cables, such as AFL's MicroCore OSP MicroCables, with diameters of 4 mm to 16 mm and MicroDuct O.D. from 7 mm up to 42 mm (1-1/4" SDR). It is equipped with a caterpillar drive system that provides 0-300 N (68 lbs.) push force. Other standard features are a mono-directional drive system, digital footage counter/speed indicator, air pressure gauge, standard tools, operator's manual, MicroJet Lube and storage and accessory cases.

Power Supply—pneumatic driven. The motor will require up to 28 CFM of the available air supply, at 7 BAR (100 psi)

Air Supply—Air compressor rated at 70-175 cubic feet minute (CFM; or higher) and a minimum 6 Bar (150 psi) air pressure; preferably, as close to 16 Bar (230 psi) as possible. **NOTE**—due to the high air volume requirement, bottled nitrogen is not recommended. When using standard utility gas or diesel-powered compressors, depending on the relative humidity and ambient temperature, it may be necessary to utilize an air aftercooler/water separator for maximum productivity results.

Table 15—General Specification (Plummett Systems)

	 **ULTIMAZ V-20 PNEUMATIC DRIVE**	 **MICROJET PRM-196 V-20-01 ADJUSTABLE**	 **MINIJET P-01 PRM-196**	
Part No.	**P-ZC-FJ0401101AD**	**P-FJ0501000**	**P-FJ0331000**	**P-FJ0331001**
Cable and Duct Range:				
Cable Diameter	0.16-0.63 in. (4-16 mm)	0.03-016 in. (0.8-4 mm)	**Mag. Clutch** 0.04-0.32 in. (1-8 mm)	**Direct Drive** 0.14-0.32 in. (3.5-8 mm)
Duct Diameter (OD)	0.28-1.65 in. (7-42 mm)	0.12-05 in. (3-12.7 mm)	0.12-0.55 in. (3-14 mm)	0.28-0.55 in. (7-14 mm)
Specifications:				
Mono-directional	YES	—	—	—
Bidirectional	—	YES	YES	YES
Maximum Speed	330 ft/min. (100 m/min.)	165 ft/min. (50 m/min.)	165 ft/min. (50 m/min.)	390 ft/min. (120 m/min.)
Recommended Speed	200 ft/min. (60 m/min.)	130 ft/min. (40 m/min.)	65 ft/min. (20 m/min.)	165 ft/min. (50 m/min.)
Maximum Pushing Force	68 lbf (300 N)	4.5 lbf (20 N)	5.6 lbf (25 N)	34 lbf (150 N)
Radial Loading (on the cable)	0-58 lbf/in. (1-100 N/cm)	0.5-18 lbf/in. (2-80 N/cm)	4.5-23 lbf/in. (20-100 N/cm)	3.4-41 lbf/in. (15-180 N/cm)
Maximum Air Pressure	230 psi (16 Bar)	175 psi 12 Bar)	230 psi (16 Bar)	230 psi (16 Bar)
Air Volume Required	70-175 cfm (2-5 m^3/min.)	7-18 cfm (0.2-0.5 m^3/min.)	3.5-18 cfm (0.1-0.5 m^3/min.)	18-36 cfm (0.5-1.0 m^3/min.)
Dimensions:				
Length	20.5 in. (520 mm)	7.4 in. (188 mm)	9.5 in. (240 mm)	9.5 in. (240 mm)
Width	14.75 in. (380 mm)	4 in. (102 mm)	6 in. (150 mm)	6 in. (150 mm)
Height	15 in. (380 mm)	5.8 in. (148 mm)	13.2 in. (335 mm)	10.0 in. (255 mm)
Weight:				
Machine Only	44 lbs. (20 kg)	0.8 lbs. (1.7 kg)	15 lbs. (6.5 kg)	15 lbs. (6.5 kg)
Machine Crated	66 lbs. (30 kg)	—	—	—
Tools and Accessories Case	18 lbs. (8 kg)	—	—	—
Machine with Tools and Accessories	—	8.1 lbs. (3.7 kg)	38 lbs. (17 kg)	38 lbs. (17 kg)
Total Equipment Weight	84 lbs. (38 kg)	8.1 lbs. (3.7 kg)	38 lbs. (17 kg)	38 lbs. (17 kg)

Specialty Compressors

Jetting with a high-output compressor, such as the Kaeser M17, with a capacity of up to 60 CFM at up to 200 psi, aids in obtaining maximum installation distances. This mobile compressor is easy to move around the jobsite when multiple setup locations are required. Standard utility compressors are available as high-output configurations, such as an Ingersoll-Rand, Sullair or Sullivan, rated at 185-375 CFM at 150-175 psi , but they are generally scarce and must be secured by prior arrangement with national or local rental outlets.

NOTE: Nitrogen is heavier than air and will seek lower levels and will displace breathable air in confined spaces. When used indoors, ensure adequate ventilation is present for workers.

The usage of nitrogen or air tanks requires a high-pressure regulator and a suitable length of hose, typically 3/8", equipped with universal air tool quick couplings for connection to the jetting equipment. Transport the nitrogen tanks in accordance with supplier's recommended safety procedures.

When utilizing bottled air, ensure there are enough tanks available to complete the installation. For longer lengths of cable, it is recommended to begin with a full tank, as stopping and starting the jetting installation is not recommended. Once the installation is initiated, it is best to maintain the installation speed and momentum on the fiber optic cable. Running out of air in a tank would require changing tanks and then start up the fiber push from a dead stop. If this occurs, let the air flow until the MicroDuct has good flow at the far end before starting the equipment propulsion mechanism.

Quality Air Preparation

Environmental conditions have a major impact on the air used with the jetting (blowing) equipment. The greatest detriment to speed and distance is the lack of properly conditioned air. If the air is too hot, the coefficient of friction increases between the cable and duct. If the air is too dry, static electricity is created as the cable advances through the duct, putting a 'drag' on the cable as the static charge attracts the cable to the duct wall; and thus, significant distances cannot be achieved. If the air is too moist, condensation can cause a buildup of water in the MicroDucts, further hampering productivity. For cooling and water separation on larger compressors that are typically used for the MicroJet or MiniJet OSP applications, a stand-alone air aftercooler can be used, such as the AC-10.

Table 16

AC-10 AIR COOLER
Portable air-to-air after cooler used to cool compressor air when using the Cablejet® System in hot climates.
Cools air to approximately 10°F over ambient.
Maximum air flow is 500 CFM.
Maximum pressure drop is 3 psi.
Connections are 1" two-prong quick couplings.

For ISP applications utilizing a small, portable air compressor for the UltimaZ or MicroJet, an air prep kit is recommended to condition the air prior to entry into the MicroDucts in order to get maximum jetting (blowing) speed and distance. The air prep kit typically will maintain the proper levels of moisture in the airflow.

Determine Optimum Jetting Strategy

The jetting (blowing) strategy is an evaluation of each point-to-point run and planning the jetting of the project in order to:

1. Minimize the amount of time required for set up and tear down.
2. Maximize material utilization and/or minimize waste.

Take advantage of any single point from which multiple runs can be jetted. Determine the distances of each run and try to limit waste of either eABF fiber optic cable or FuturePath MicroDucts by properly sequencing the runs. Typically, longest runs should be deployed from each reel first, followed by the next longest, etc.

Cable Caps (Fiber Tips) for eABF Cable

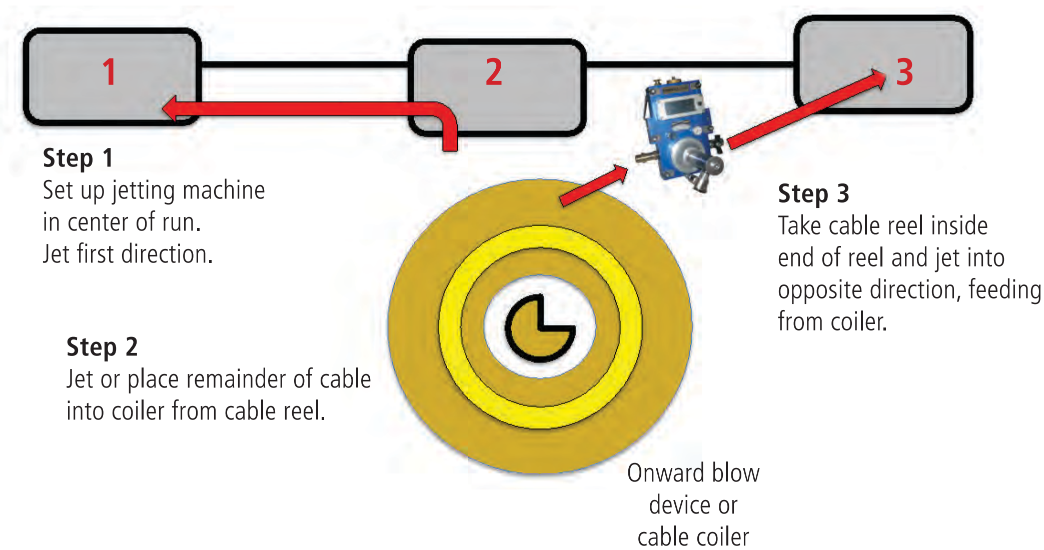
It is recommended to install cable caps (fiber tips) onto the ends of eABF cable to aid in the cable transitioning through coupler locations. These tips are brass or aluminum and are internally threaded for screwing onto the end of the fiber optic cable. When possible, install couplers in straight sections of MicroDuct, as slight gaps may be present if the coupler is installed in a bend due to torqueing of the MicroDuct. Fiber tips help keep the end of the cable from "hanging up" in a coupler.

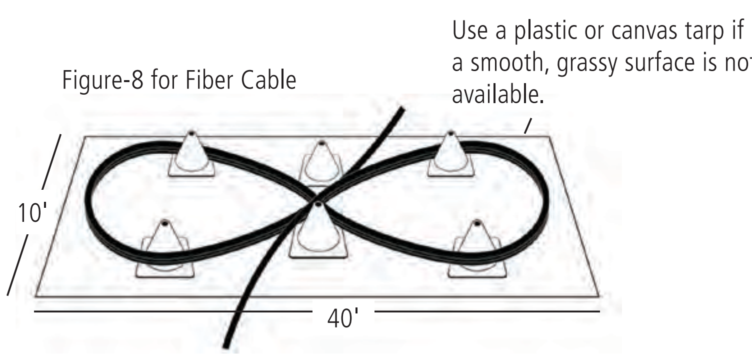
Jetting Deployment Scenarios

Point-to-Point

This is the most common and the simplest type of jetting installation. This method is used when the fiber being jetted can be jetted the whole way, falls within the maximum blowing distance of that particular MicroDuct (no illustration provided).

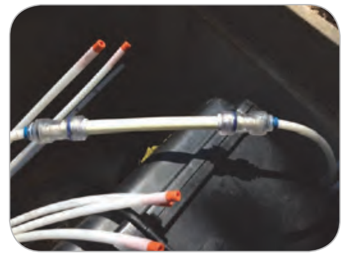
Center or Mid-Point Blow





OPTIONAL: In lieu of a coiler, a figure-8 may be formed in the central location, then take the inside end of reel and jet into the opposite direction, feeding from the figure-8.

The center or mid-point blow jetting method is where the installer can set up in the middle of a known distance that falls inside of the maximum jetting distance of the MicroDuct and fiber type. For example, there is a 2,000 ft run with a vault/hand hole in the middle or centrally located in the MicroDuct run. The installer would set up the jetting equipment in the middle of the run and jet in one direction. Once the fiber has been reached on the far end, the installer would payout the fiber left on the reel into a figure-8. After all of the fiber is off the reel and figure-8, the fiber is "flipped" to gain access to tail of the fiber. The jetting equipment is then turned, heading in the opposite direction and the fiber jetting process begins. Remember that the MicroDuct must be sealed with a coupler after the fiber has been installed, so it is important to place the straight coupler or close-down connector, if required, on to the first MicroDuct before the fiber installation. Otherwise, the installer would have to slide the straight connector over the entire fiber that has been figure-8, before jetting in the other direction.



Close-Down Connector

Cable Storage Device or Cable Coiler

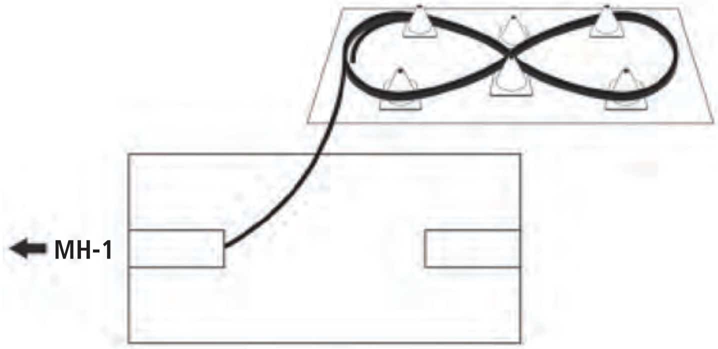
Equipment is available for storing or coiling fiber optic cable when it is removed from the reel for when the cable cannot be jetted from one end to the other due to route length or configuration. These units, occasionally referred to as figure-8 machines or onward blow devices, are sometimes helpful in jetting long distances. Use of this type equipment eliminates the need for forming a figure-8 slack loop on the ground. The coiler takes up less space to use than a figure-8 loop and helps protect the fiber optic cable during the installation. Always check to see if the cable to be jetted meets with the coiler's limitations and specifications. Typical use of a coiler and figure-8 is shown below.

Multiple setups or "cascades" may be needed for jetting extended distances

Two-Stage or Multi-Stage Blow

This method is used when the run exceeds the maximum jetting/blowing distance of the MicroDuct and there are one or more breaks in the run, like in a vault or hand hole. The installer would set up at the jetting equipment at the near or far end and start the jetting installation. Once the fiber reaches the first vault/hand hole, the fiber is paid out and arranged in a figure-8 onto the ground.
NOTE: there must be enough fiber to reach the far end. Once there is enough fiber at the second location, the fiber figure-8 is "flipped" to gain access to end of the fiber optic cable.

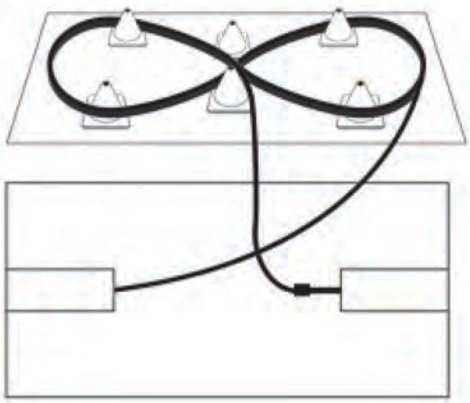
The jetting equipment must be brought from the first location to the second location and the jetting process begins again. It is recommended to place the figure-8 onto a clean tarpaulin to limit picking up dirt and debris onto the fiber optic cable sheath.



MH-2 Figure-8 Storage View

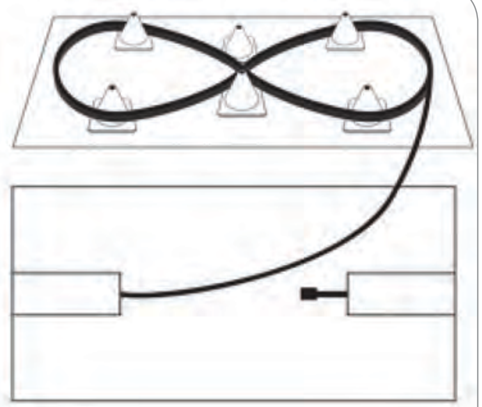
Step 1
Jet from starting point (MH-1) to MH-2 enough cable to make it to endpoint (MH-3).

Flip fiber optic cable figure-8 over to access the lead end.



MH-2 Jetting View

Step 2
Jet cable to MH-3 with second jetting device or move original jetting device from MH-1.



MH-3 Endpoint

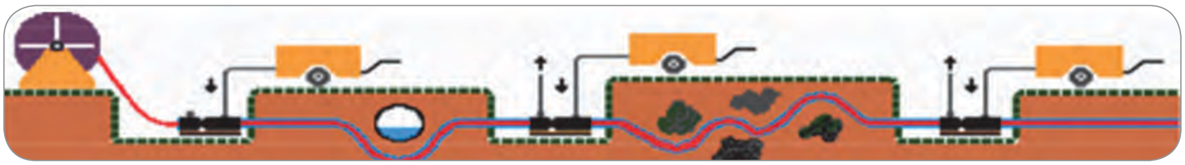
Step 3
Jet enough cable for adequate splicing.

NOTE: there must be enough fiber to reach the far end. Once there is enough fiber at the second location, the jetting equipment must be brought from the first location to the second location and the jetting process begins again.

Tandem Blow (Cascade or Mid-Assist Method)

Alternately, one or more additional jetting units (cascade method) can be used which can significantly reduce the frequency of coiling/ figure-eighting the cable; as well as speed up the overall installation process on long cable installation sections.

This is the most expensive method of jetting fiber because it requires two or more complete jetting equipment set-ups. This method of installation is where there is a run with one or more breaks in the MicroDuct, within the maximum blowing distance, located in a vault/ hand hole. The first set-up of jetting equipment is stationed at the beginning of the run and the second is placed at the next or closest vault/hand hole. The installer would start the jetting process and once it reached the next location a second installation crew would then set-up and begin the jetting procedure simultaneously.



Cascade or Mid-Assist Method

It is important to note that the straight coupler is placed onto the MicroDuct first, so it is possible to "close-down" and seal the MicroDuct after the fiber has been installed. It is equally important to have an extra installer to help manage the slack loop that is needed for a smooth installation. The second phase of this installation will not go as fast as the first section of the installation because the fiber has slowed during the first phase due to the length of the run and weight of the fiber.

Cable Installation Process Considerations

Regardless of the pathway and cable installation type, size, or environment (ISP or OSP), the planning and placement of the cable follows similar installation processes that should be considered:

- Comply with the following points several days prior to proceeding with the cable installation.
- Perform these checks on each section before starting jetting.
- In the event of problems with any of the points detailed below (type of duct or cable, steep gradients, difficult access etc.), do not hesitate to contact Dura-Line to obtain assistance.

Environment

- Knowledge of the pathway trajectory: identify verticals, horizontal runs, gradients, access points (TDUs) noted on detailed plans and elevation views and installation drawings.
- For optimal efficiency, if the ambient temperature is above 77°F (25°C), it is recommended to use a compressor equipped with an air aftercooler/water separator.

Duct Preparation

- If the duct ends are not plugged or inadequately plugged, check the interior for dirt and clean where necessary. Then cap or seal both ends until ready for use.
- If in doubt as to the quality of the duct and its installation, carry out the following checks (refer to the separate Conduit Conformance Test).
- Check the integrity of the duct by proper proof/mandrel method (e.g., BB test where 80% of the duct internal diameter must be free for most installations to succeed).
- To check the duct sealing, pressurize each of the sections per the conformance test procedures for your specific duct I.D., route length and compressor size.
- Soft or pliable cables require special precautions. Assess the rigidity of the cables on the basis of your experience.

Duct + Cable Association

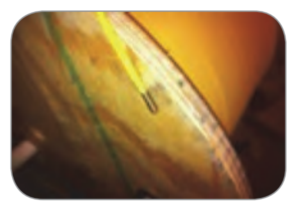
- Lubricant (if lubricant is used with pre-lubricated ducts, it requires a compatible lubricant). Use a lubricant recommended by the duct manufacturer such as Dura-Line's Hydralube AT-500, S&R MicroLube, or equivalent.
- Sponges or Spreaders (for cleaning and/or distributing the lubricant in the duct)

NOTE: Most standard lubricants for cable laying by pulling method (using a winch and pull media such as pull tapes, ropes, string, etc.) are NOT suitable for jetting/blowing applications. Lubricants specifically designed for jetting/blowing must be used.

Table 17

JETTING SYSTEM	CFM	PSI RANGE
UltimaZ V-20	7-18	115-175
MicroJet PRM-196 Mag. Clutch	3.5-18	115-230
MicroJet PR-196 Direct Drive	18-36	115-230
MiniJet P-01 Pneumatic Drive	70-175	115-230

Suggested Equipment, Tools and Accessories



- A compressor for each jetting unit
- Pair of reel support jacks, plates or a reel stand (for the fiber optic cable reel). Lightweight, portable stands or supports are recommended for working in confined areas inside buildings or structures.
- Duct couplers—Air-tight (for joining the feed duct from the jetting unit to the duct in the route, or for tie-throughs at mid-span locations, or for unexpected repairs).
- Short sections (10-15 feet, typical) of duct the same diameter as the duct in the route to provide a feeder tube connection between the jetting unit and the duct.
- Cable End Caps (aka Beads, Tips, etc.) attached to the end of the fiber optic cable to assist with passing through couplings and seal the end of the cable from air/water ingress during the installation.
- Tarps/Ground Covers (for OSP cable layout/figure-8 operations)
- Clean rags (for cleaning the cable, if necessary, as it enters the jetting unit)
- All proper duct clamps/seals and cable adapters required for the jetting unit have been identified
- Quality two-way radios or handsets for good communications
- Hand tools for duct preparation (such as conduit cutters, duct slitter). Refer to Recommended Tools List on next page.

Table 19—Recommended Tools List

PART NO.	DESCRIPTION	IMAGE
1-905560	MicroDuct Straight Cutter—used to make a 90° cut of the MicroDuct. Will also cut whatever is inside the MicroDuct.	
1-907162	MicroDuct Round Cutter—used to cut only the MicroDuct and not what is inside the MicroDuct.	
1-900418	Conduit Slitting Tool—used to make a 90° cut of the MicroDuct. Will also cut whatever is inside the MicroDuct.	
1-909040	FuturePath Oversheath Slitting Tool	
1-900420	Rachet Shears—for cutting FuturePath. Duct size range: 3/4" to 1 1/4" (0.83" to 1.66")	
1-900421	Rachet Shears—for cutting FuturePath. Duct size range: 1 1/2" to 2" (1.66" to 2.375")	

Collet Locking Tool (Part No. 1-909053, photo below left) is for tightening and releasing MicroDuct Coupler Collets. The collet locking tool is for use with push-fit couplers installed on MicroDucts 3/16" (4.76 mm) to 1/2" (12.7 mm).

MicroDuct Rerounding Tool (photo below right) commonly known as a Swaging Tool, is available from Home Depot, Lowe's, etc. Stepped diameters for use with a wide variety of MicroDuct sizes.

eABF Termination Procedures

Procedure for Fan Out of eABF® Cable

1. General

1.01 Integrating 24F, 36F and 48F eABF cable into the fiber management shelves (FMS) or in splicing enclosures may require a fan out kit to organize the fiber in the eABF cable into 12F groupings.

2. Procedure

2.01 eABF cables follow the TIA/EIA 598 B color code designation for optical fibers using the 12 basic color codes for 12F groupings. The fibers are further grouped by use of color-coded string binders to segregate the fiber groupings.

Fiber Color Code

FIBER NUMBER	FIBER COLOR	ABBREVIATION
1	Blue	BL
2	Orange	OR
3	Green	GN
4	Brown	BR
5	Slate	SL
6	White	WH
7	Red	RD
8	Black	BK
9	Yellow	YL
10	Violet	VI
11	Rose	RS
12	Aqua	AQ

Binder Color Code

BINDER NUMBER	BINDER COLOR	FIBER GROUPING
1	Blue	1 - 12
2	Orange	13 - 24
3	Green	25 - 36
4	Brown	37 - 48
5	Slate	49 - 60
6	White	61 - 72
7	Red	73 - 84
8	Black	85 - 96
9	Yellow	97 - 108
10	Violet	109 - 120
11	Rose	121 - 132
12	Aqua	133 - 144

3. Tools and Material

3.01 The listing of typical tools used for eABF Fan Out procedure is as follows:

Safety Glasses
Wire Stripping Pliers
Tape Measure
Permanent Marker
Kevlar Scissors
Foam Tape

3.02 The materials used in the eABF Fan Out procedure are as follows:

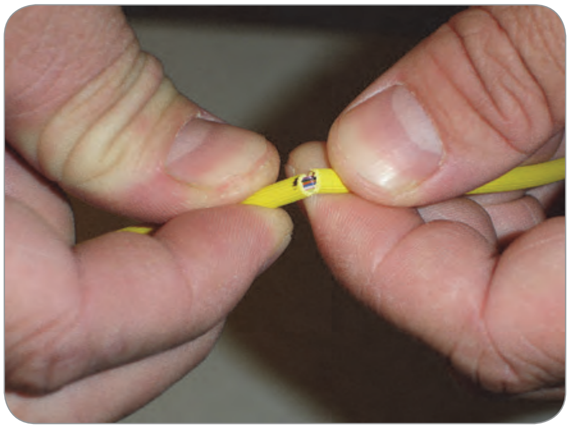
AFL PART NO.	DESCRIPTION
FC000070	1X6 Fan Out Kit (Router Kit)

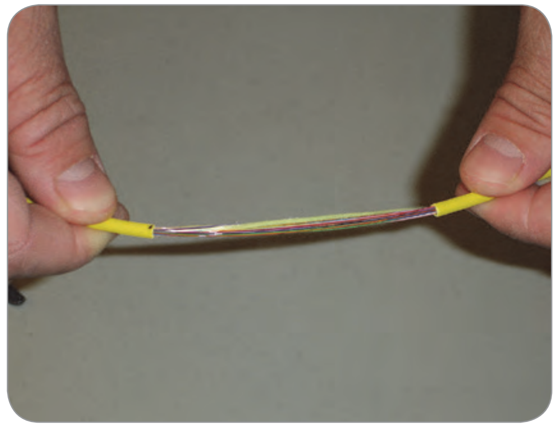
4.0 eABF Sheath Removal

4.01 Based on the sheath preparation procedures for the appropriate closure, enclosure or fiber management shelf, measure the cable preparation length using a tape measure and mark the cable jacket with a permanent marker.

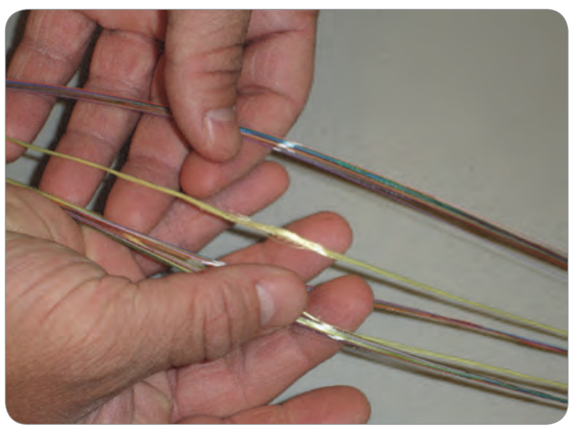
4.02 Using the wire stripping pliers, remove eABF cable outer jacket in increments of 24 inches until desired cable stripping length is achieved. **DO NOT** attempt to remove entire cable preparation length in one segment as it will strain or damage the optical fibers.

4.03 Sheath removal is best facilitated by scoring the outer jacket with the stripping pliers and then flexing the cable back and forth to cause the jacket to yield.

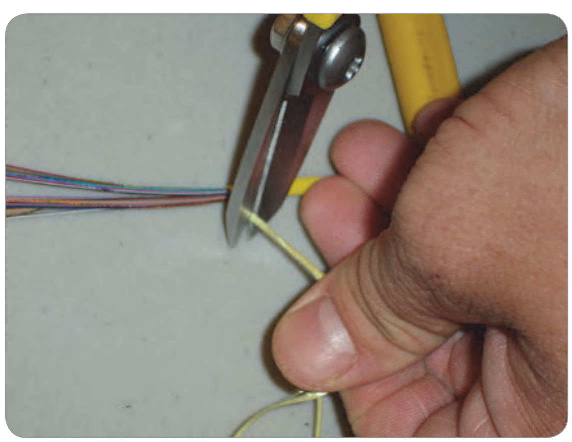




4.04 Taking care not to disturb the string binders, carefully unwind and untangle the yellow aramid yarns (Kevlar®) and white water blocking binders.

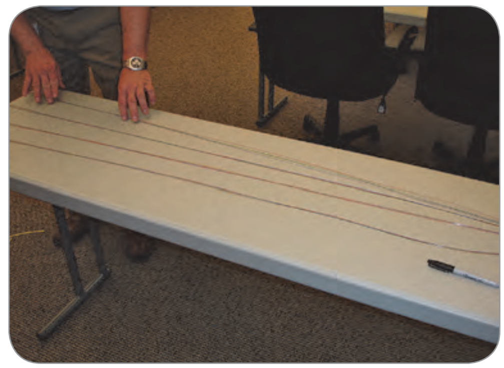


4.05 With aramid yarns and water blocking binder separated from fiber bundle groupings, carefully cut aramid and water-blocking binders at cable sheath cut.

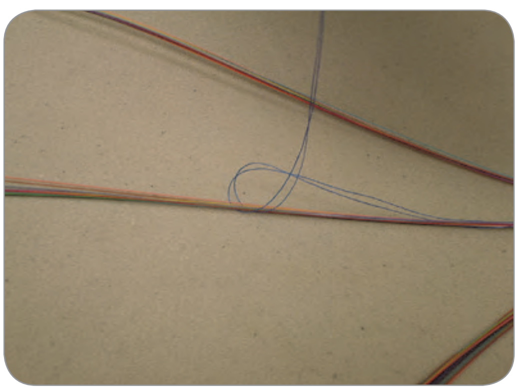


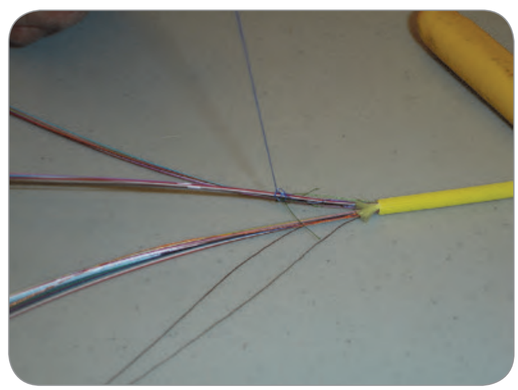
5.0 Fan Out of Fiber Bundles

5.01 Lay eABF fiber grouping out on a long table or piece of clean paper. Go to center of the exposed fiber and gently pull the fiber bundle apart. As the fiber grouping separates, you will notice that the fiber binder identifier groups will sub bundle into a segment of 12 fibers that are wrapped with two string color-coded binders for each grouping depending on the fiber count. Carefully continue to separate the fiber bundles until you have all the distinct groups of 12 fibers separated. Count the fibers in each group making sure there are 12 fibers of 12 different colors.



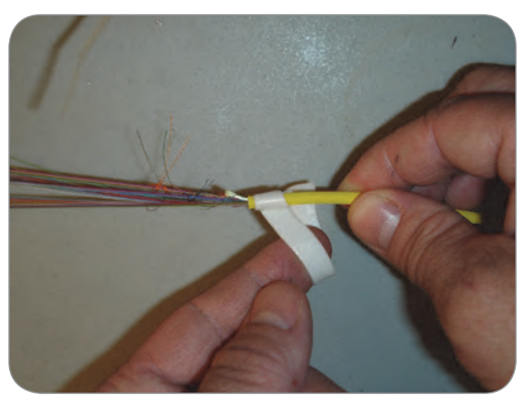
5.02 With the fiber bundles separated in the their respective 12 fiber groups, take the two color-coded binders for each fiber group and loosely tie a two-half hitch knot around each fiber group. This knot is only temporary and will be removed in the future.



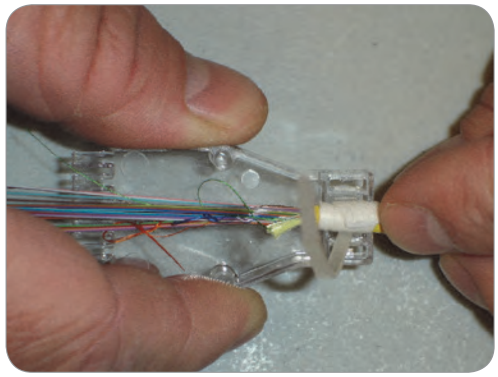


6.0 Assembly of Fan Out Router

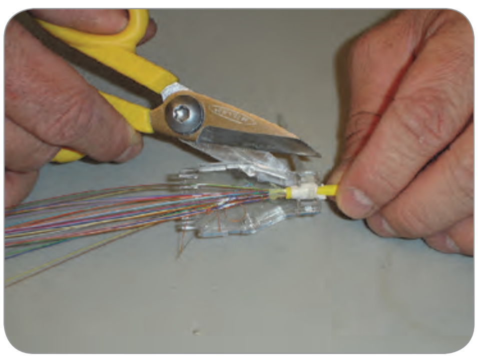
6.01 Prepare cable for attachment to the Fan Out Router by placing approximately ½-inch of double-sided sticky foam tape at the end of the cable jacket. Stretch the foam tape and half lap it securely to the end of the cable jacket. **DO NOT** build up the diameter of the cable too much as it will interfere with the tie wrap and router clip.

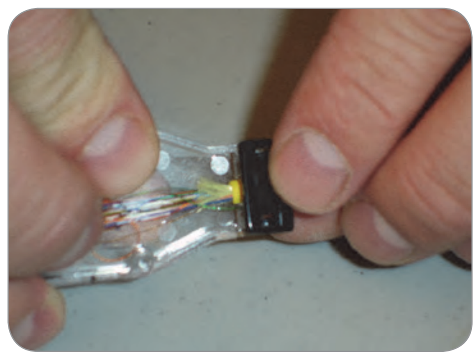


6.02 Place a small tie wrap through the mounting slots to attach to the eABF outer jacket and foam tape.



6.03 Secure the tie wrap snugly to the cable jacket and foam tape being careful not to over tighten and pinch the optical fibers. The router should be secure enough that you can not pull it off the outer cable jacket. Snip off the excess tie wrap and secure the clip.

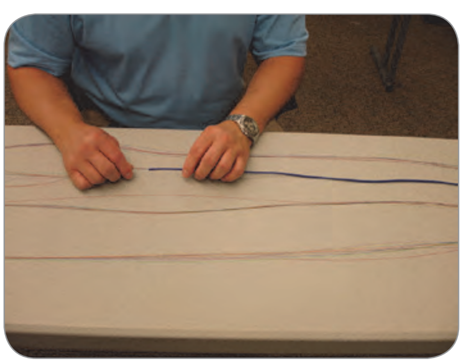


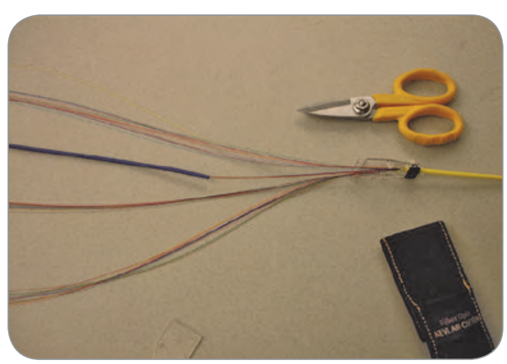


6.04 Depending on the closure, enclosure or fiber management shelf the length of the Furcation tubing my need to be shortened. If so, measure and cut the tubing to the desired length.

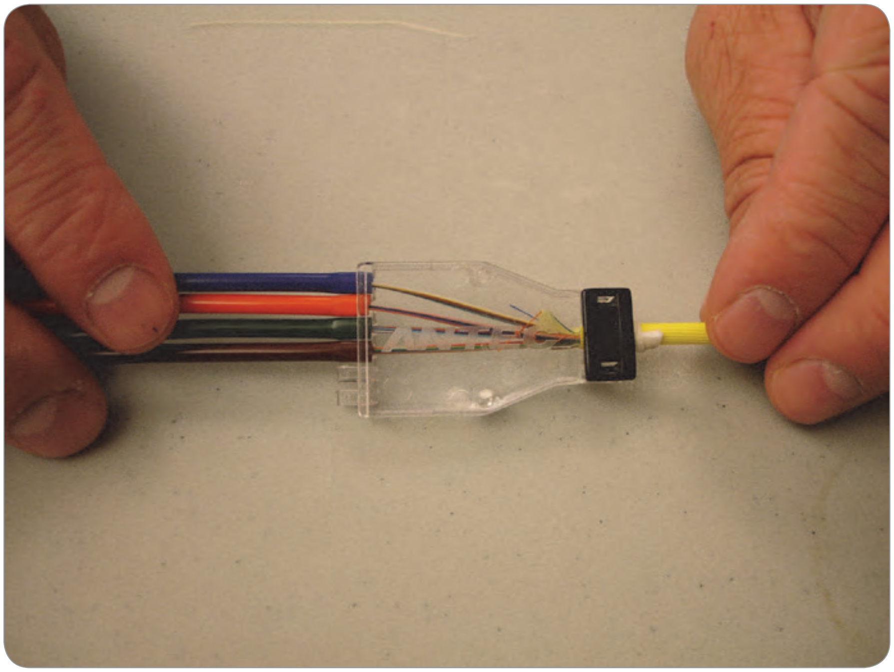
6.05 Take the Furcation tubing and slip the fiber through the tubing until they appear at the end of the tube. To make this easier, straighten the tubing before starting. Then hold the tubing vertically and feed the fiber group into the tube an inch at a time.

6.06 After the fiber group has appeared at the end of the tubing, hold the fiber and slide the tube into position at the router. Make sure the fibers are all the same length and none are missing from the bundle.





6.07 Slip the Furcation tube up to the router. Position the fiber grouping into the fork tine prior to slipping the Furcation tube over the end of the fork tine. Repeat this till each fiber group is segregated and in their respective Furcation tube. Clip the previously applied two half-hitched binder threads loose and apply the cover for the Router.



eABF® Fiber Optic Cable Testing Requirements

All eABF fiber optic cables shall be tested and documented using the following procedures. Hard and soft copies of all test results shall be provided to the engineer, end-user and the manufacturer certifying the project.

Prior to start of the installation, use an Optical Time Domain Reflectometer (OTDR) to test and document the quality of each cable reel verifying that no damage had occurred during shipment. Single-direction testing is acceptable. Compare the test results with the factory provided test acceptance data sheet. Be sure to use the correct effective group index of refraction.

Schematics/Layout

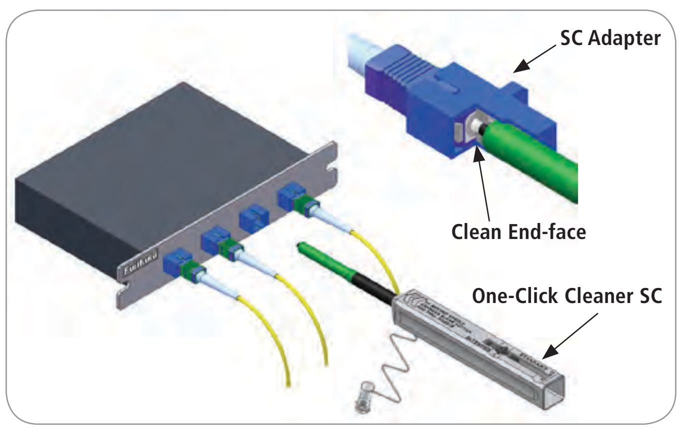
As part of the documentation package, a detailed schematic or job print must identify key elements of the system link design and layout. This schematic or job print must include the following items of both the vertical and horizontal components:

- Show all routes
- Show all distances
- Show fiber counts
- Illustrate locations of entrance facilities (EFs)
- Equipment rooms (ERs)
- Telecommunication rooms (TRs)
- Main cross connect (MCs)
- Intermediate cross connect (ICs)
- Illustrate locations of multi-user telecommunications outlet assembly (MUTOA)
- Telecommunication outlet (TOs)

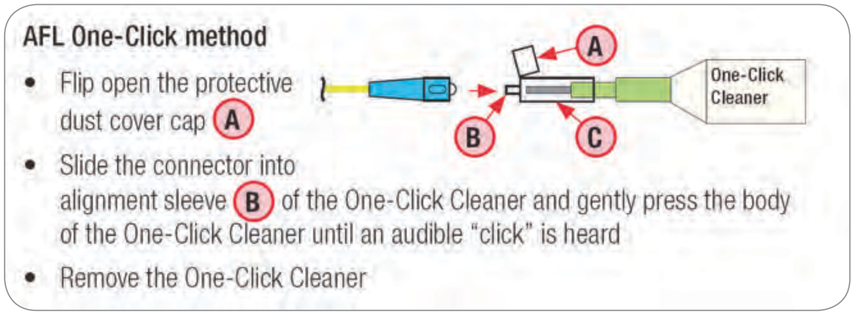
Connector Cleaning

Prior to any starting any testing and documentation of the fiber optic system links, each connector should be properly cleaned and visually inspected. Recommended cleaning methods use dry cleaning apparatus such as AFL CLETOP or One-Click cleaning apparatus. If wet cleaning methods are employed, they must use residue free non-flammable solvents and lint-free cleaning wipes.

CLETOP and One Click Connector Cleaning Tools
Connector Cleaning through Bulkhead with One-Click



Free Connector Cleaning with One-Click

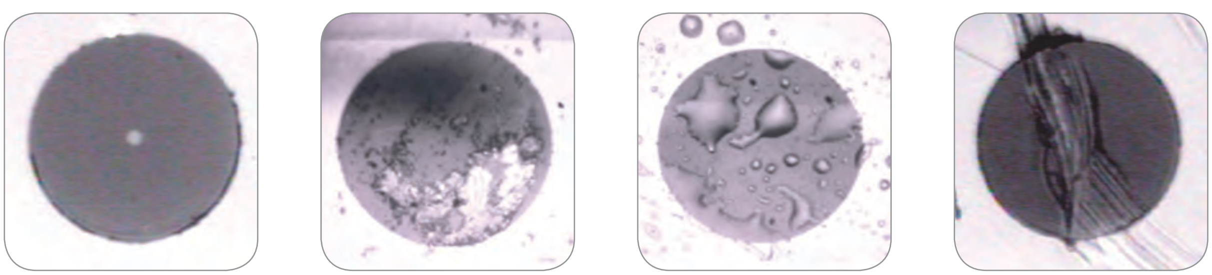


Inspection of the connectors should be accomplished with a minimum of a 200 power inspection scope that is laser filtered for eye safety or the use of a fiber optic inspection probe that can document the connector end face quality and cleanliness. New technology uses video scopes and viewing tablets like the AFL FOCIS System. These provide a means of picture capture and are used in conjunction with analysis software that views the images looking for dirt, oil or scratched that would impede signal measurement. If an anomaly is present, it should be documented by recording an image of the end face.

Quality test jumpers and launch/receive are critical to properly document completed fiber optic links. If connectors for test jumpers or launch/receive cable are damaged or dirty they should be properly cleaned and if necessary replaced.

FOCIS Connector Inspection System

Clean End-face	Dirt/Debris	Oil/Fingerprint	Deep Groove



Pass	Fail	Fail	Fail

Connector End-Face Pass/Fail Criteria

Link Insertion Loss Test

Using an Optical Power Meter and Light Source, measure the end-to-end attenuation for all installed cables. The total loss shall be measured and documented per the TIA/EIA 526 Standard. Multimode Systems (TIA/EIA 526-14) are to be tested at the 850 nm and 1300 nm and for single-mode systems (TIA/EIA 526-7) at the 1310 nm and 1550 nm wavelengths. Bidirectional measurements must be provided with a summary average loss for each fiber link and pass link loss values based on TIA/EIA 568.C3 criteria.

AFL Light Source and Power Meter
(SMLP5-5 Kit)

Link Event Loss Test

Using an Optical Time Domain Reflectometer (OTDR) and a minimum of 150 meter launch cable and 150 meter receive cable, test and document the optical integrity of all events of each fiber in every installed cable. Termination points and splice points should be identified on every trace. Total loss for the link needs to be identified on the test documents. Bidirectional testing is mandatory. Directional measurements must be provided with a summary average loss for each link event and pass link loss values based on TIA/EIA 568.C3 criteria.

AFL M700 SM/MM OTDR

TIA/EIA 568-C.3 Loss Values

For the purposes of link insertion loss pass/fail values, the cumulative loss must first be calculated based on the job print or schematic. The intrinsic loss of the fiber based on the point to point distance should be calculated using the loss table below and the maximum loss value. Additionally, each fusion/mechanical splice loss plus each connector loss must be added to the cumulative total. This becomes the absolute pass/fail value of the link in question.

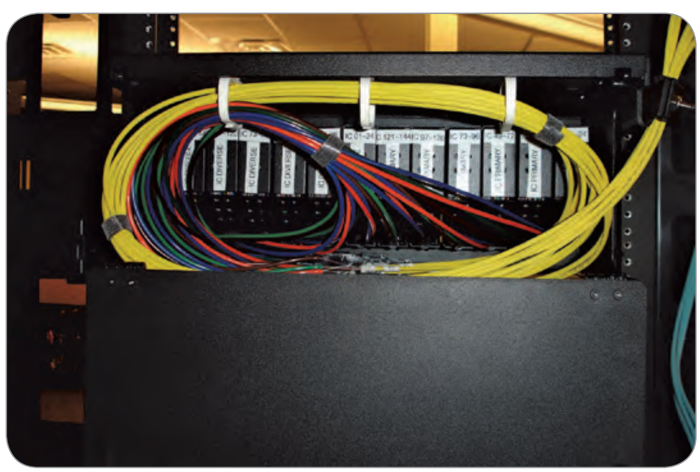
Table 1—TIA/EIA 568-C.3 Min-Max Loss Values

PARAMETER	FIBER TYPE	dB/km				
		MAX/MIN	LAMDA 1 850 NM	LAMDA 2 1300 NM	LAMDA 3 1310 NM	LAMDA 4 1550 NM
CABLE LOSS	62.5/125	Max	3.5	1.5	—	—
		Min	2.9	0.8	—	—
	50/125	Max	3.5	1.5	—	—
		Min	2.4	0.4	—	—
	SMF (OSP)	Max	—	—	0.5	0.5
		Min	—	—	0.3	0.2
	SMF (ISP)	Max	—	—	1.0	1.0
		Min	—	—	0.3	0.2
CONNECTOR LOSS	—	dB				
		Max	0.75	0.75	0.75	0.75
		Min	0.05	0.05	0.05	0.05
SPLICING LOSS	—	dB				
		Max	0.3	0.3	0.3	0.3
		Min	0	0	0	0

Each individual event (splice or connector) should also be analyzed with the OTDR to assure the individual event is within the parameters set by the TIA standard.

Fiber Termination Shelves

Using digital camera, document each fiber management shelf (FMS) by photographing the back plane of the FMS shelf to show cable and pigtail routing. When used with Poli-MOD® modules each module should be labeled and photographed independently. Provide PDFs of these photographs as part of the standard documentation package.



Example of Back of FMS Shelf Record

Insertion Loss Test Method—Multimode Fiber Links (One Jumper Reference)

Procedure

1. Turn on the OPM optical power meter and OLS optical light source. Allow the light source to stabilize (minimum of 2 minutes).
2. If not using the WAVE I.D. feature, set both instruments to the desired test wavelength.
3. Select the appropriate fiber optic transmit and receive test jumpers. The fiber type of these jumpers must match the fiber type of the link to be tested.
4. Wrap and secure the transmit jumper five times around the appropriate diameter mandrel. Note that 62.5/125 µm multimode fiber uses a 20 mm mandrel and 50/125 µm multimode fiber uses a 25 mm mandrel. Clean both ends of the transmit jumper prior to insertion into device!
5. Connect the transmit jumper to the multimode output port of the OLS.
6. Mount an adapter cap on the OPM that matches the free connector on the transmit jumper.
7. Connect the free end of the transmit jumper to the OPM. If necessary, press the dB/dBm key to display optical power in dBm.
8. If measured output power of the OLS is outside of the normal range (specified by manufacturer), clean all fiber connections or replace the transmit jumper. Repeat steps 4-7.
9. To set the reference level at the current wavelength(s): on the OPM, press and hold the Ref/Set key until the label HELD SET is displayed to store the currently measured level or pair of levels as the new reference levels. Once the new reference is set, the OPM switches to the loss dB measurement mode. The OPM should display 0 dB ± 0.05 dB.

NOTE: You may press the Ref/Set key to display the stored reference levels.

NOTE: When setting references from multiple wavelength identified sources, allow several seconds prior to setting the references for wavelengths to be identified and measured.

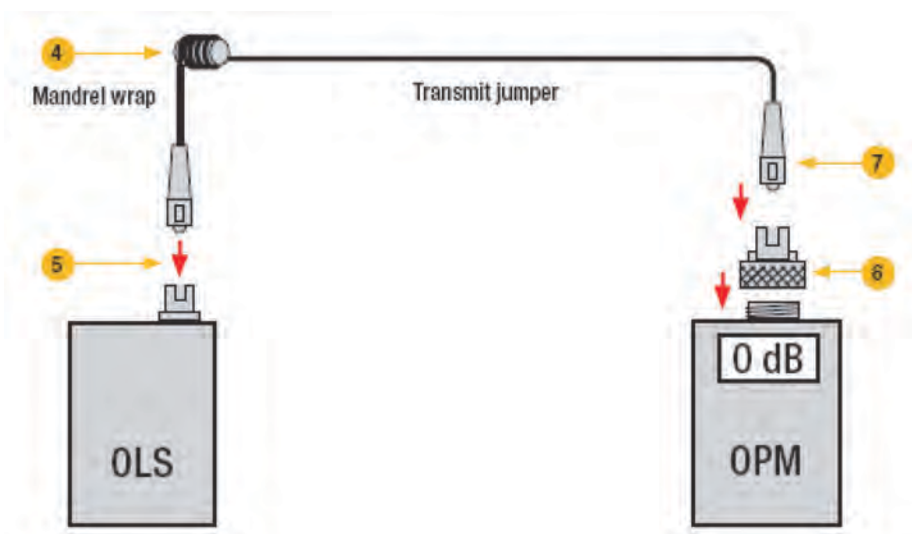


Fig. 1—Set Reference, Multimode Link

10. Disconnect the transmit jumper from the OPM. Do not disturb the transmit jumper at the OLS end!
11. If necessary, change the OPM adapter cap to match the connector on the receive jumper that will be connected to the OPM. Clean both ends of the receive jumper!
12. Connect the receive jumper to the OPM.
13. Mate the free ends of transmit and receive jumpers using the appropriate adapter.
14. Verify that the insertion loss of this mated connector pair is under 0.75 dB, the maximum allowed by the TIA (0.4-0.5 dB typical), as follows:
    - Observe the displayed power level. This is the mated connector pair insertion loss of the test jumpers in dB.
    - If the insertion loss is not acceptable, disconnect transmit and receive jumpers at the adapter, clean the free ends of both test jumpers and repeat steps 13 and 14.
    - If the insertion loss is still not acceptable, replace test jumpers and repeat steps 1-14.
15. If the insertion loss is acceptable, disconnect the transmit and receive jumpers at the adapter.
16. Move the OPM and OLS to opposite ends of the link to be tested.

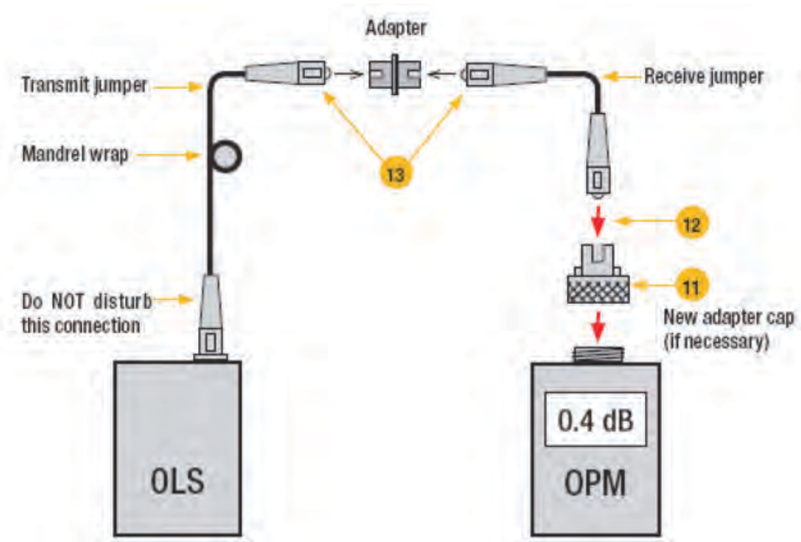


Fig. 2—Verify Test Jumpers, Multimode Link

17. Connect the free ends of transmit and receive jumpers to the multimode link under test. Clean jumper end that connects to patch panel prior to every test!
18. OPM will measure and display the insertion loss of the link under test.
19. Repeat steps 17-19 for all links to be tested at the current wavelength.

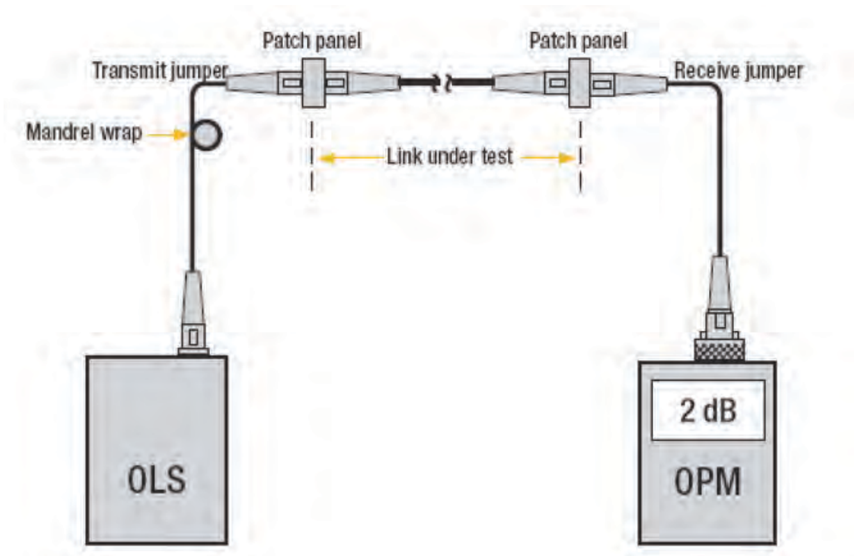


Fig. 3—Measure and Record Multimode Link Loss.

Insertion Loss Test Method—Single-mode Fiber Links (One Jumper Reference)

Procedure

1. Turn on the OPM optical power meter and OLS optical light source. Allow the light source to stabilize (minimum of 2 minutes).
2. If not using the WAVE I.D. feature, set both instruments to the desired test wavelength.
3. Select the appropriate fiber optic transmit and receive test jumpers. The fiber type of these jumpers must match the fiber type of the link to be tested.
4. Make a 30 mm (1.2 in.) loop in a transmit jumper and secure it with a piece of tape (TIA testing only). Make sure the loop remains in place during referencing and in all testing steps. Clean both ends of the transmit jumper!
5. Connect the transmit jumper to the single-mode output port of the OLS.
6. Mount an adapter cap on the OPM that matches the free connector on the transmit jumper.
7. Connect the free end of the transmit jumper to the OPM. If necessary, press the dB/dBm key to display optical power in dBm.
8. If measured output power is outside of the normal range (specified by manufacturer), clean all fiber connections or replace the transmit jumper. Repeat steps 4-7.
9. To set the reference level at the current wavelength(s): on the OPM, press and hold the Ref/Set key until the word HELD SET is displayed to store the currently measured level or pair of levels as the new reference levels. Once the new reference is set, the OPM switches to the loss dB measurement mode. The OPM should display 0 dB ±0.05 dB.

NOTE: You may press and the Ref/Set key to display the stored reference level for the currently selected wavelength or pair of wavelengths.

NOTE: When setting references from multiple wavelength identified sources, allow several seconds prior to setting the references for wavelengths to be identified and measured.

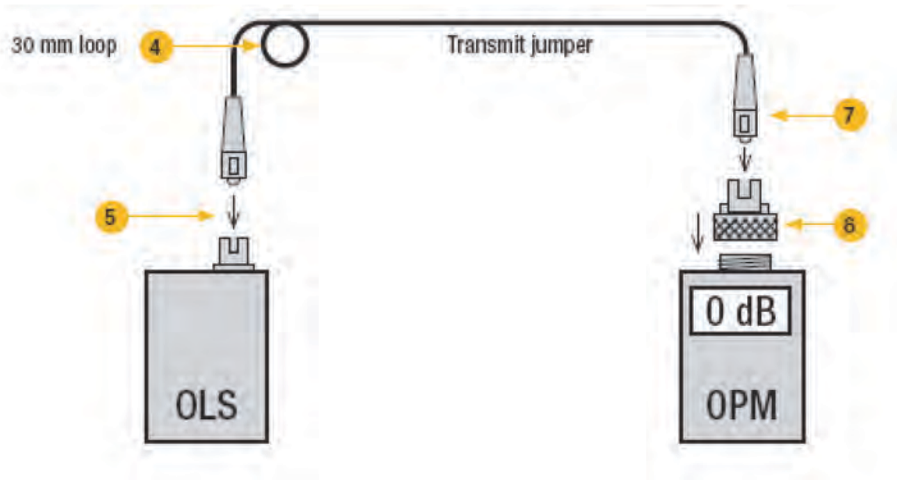


Fig. 4—Set Reference, Single-mode Link

10. Disconnect the transmit jumper from the OPM. Do not disturb the transmit jumper at the OLS end!
11. If necessary, change the OPM adapter cap to match the connector on the receive jumper that will be connected to the OPM. Clean both ends of the receive jumper!
12. Connect the receive jumper to the OPM.
13. Mate the free ends of transmit and receive jumpers using the appropriate adapter.
14. Verify that the insertion loss of this mated connector pair is under 0.75 dB, the maximum allowed by the TIA. (AFL recommends 0.4-0.5 dB typical), as follows:
    - Observe the displayed power level. This is the mated connector pair insertion loss of the test jumpers in dB.
    - If the insertion loss is not acceptable, disconnect the transmit and receive jumpers at the adapter, clean the free ends of both test jumpers and repeat steps 13 and 14.
    - If the insertion loss is still not acceptable, replace test jumpers and repeat steps 1-14.
15. If the insertion loss is acceptable, disconnect transmit and receive jumpers at the adapter.
16. Move the OPM and OLS to opposite ends of the link to be tested.

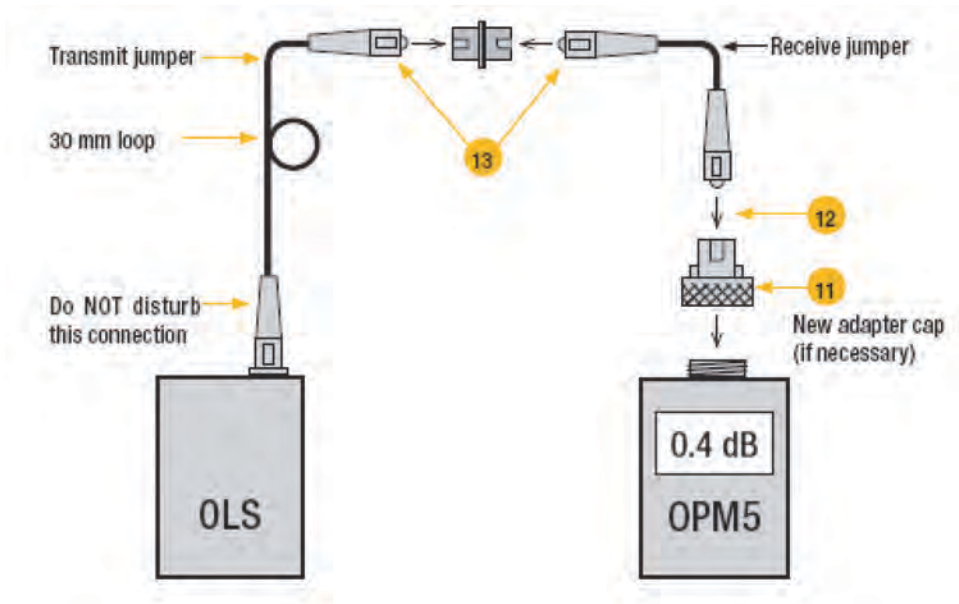


Fig. 5—Verify Test Jumpers, Single-mode Link

17. Connect the free ends of transmit and receive jumpers to the single-mode link under test. Clean jumper end that connects to patch panel prior to every test!
18. OPM will measure and display the insertion loss of the link under test.
19. Repeat steps 17-19 for all links to be tested at the current wavelength.

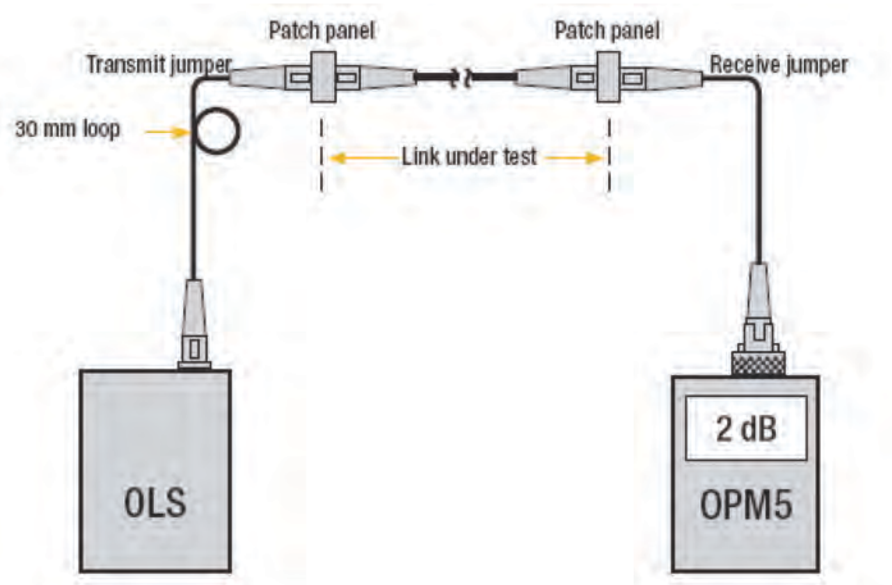


Fig. 6—Measure and Record Single-mode Link Loss

Measure and Record Events with Optical Time Domain Reflectometer (OTDR)

Procedure

1. Turn on the OTDR. Allow the unit to stabilize (minimum of 2 minutes).

2. If not using the Auto Test Mode feature, set the OTDR instrument to the desired test wavelength.

3. Select the appropriate fiber launch and receive test rings. The minimum length should be 150 meters. The fiber type of these launch rings must match the fiber type of the link to be tested.

4. Clean the connectors on both ends of the launch/receive rings.

5. Connect the launch jumper to the appropriate output port (SM or MM) of the OTDR. Clean the input connector of the link under test and connect the launch jumper and OTDR.

6. Take the receive ring to the far end of the link under test and clean the link connector. Connect the receive ring to the far end connector. If measuring optical return loss then a optical terminator must be applied to the unterminated connector.

7. Review the set up menu of the OTDR. If available set to auto test mode. Prompt through the parameters to assure, fiber type, launch/receive cables, wavelengths and other general testing parameters are correctly set. Key elements of the test are the Group Index of Refraction (GIR) and Backscatter Coefficient are properly set.

For Group Index of Refraction, refer to eABF cable test report shipped with cable reel packing list. If the GIR is not known, use the following general values:

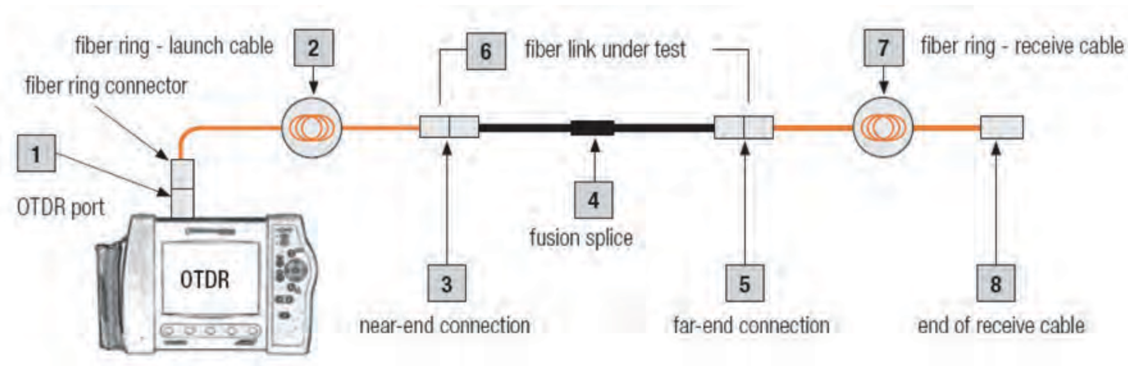
MM	850 nm	1.496
MM	1300 nm	1.491
SM	1310 nm	1.4677
SM	1550 nm	1.4682

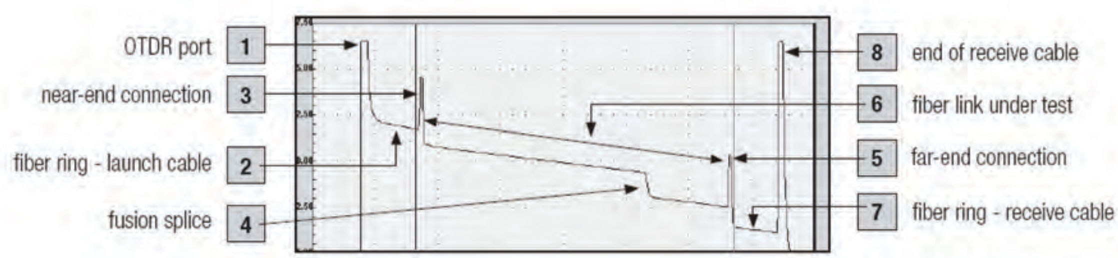
For Backscatter Coefficient, use look up values provided by the OTDR or research the fiber manufacturer's data Sheet. If the specific backscatter coefficient is not known, use the following values for 1 ns pulse width:

MM	850 nm	-70 dB
MM	1300 nm	-75 dB
SM	1310 nm	-79 dB
SM	1550 nm	-81 dB

8. Push the test button and wait for the OTDR to acquire the traces. Allow the OTDR time to complete the testing and clean up the trace display.

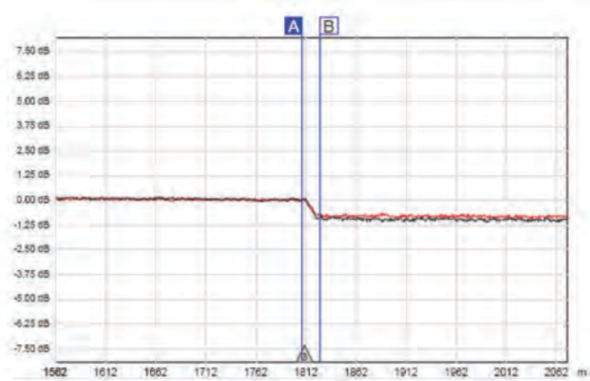
9. Position the first cursor or "A" cursor at the start of the first connector of the fiber link. Position the second cursor or "B" cursor at the start of the last connector of the link. Confirm the length of the fiber length against the job schematic.





10. Next, review the event table for the summary results of the insertion loss and location of each event of the fiber link. These should be checked against the job schematic and the maximum loss values of the Table 1. TIA/EIA 568 C.3 Min/Max loss values.

11. Variances to maximum loss values of any event should be investigated by repositioning the "A" and "B" cursors just before and just after the event and comparing the measured value to the value of the event table. If the event is still above the allowed loss values, then an investigation and corrective action must be initiated.

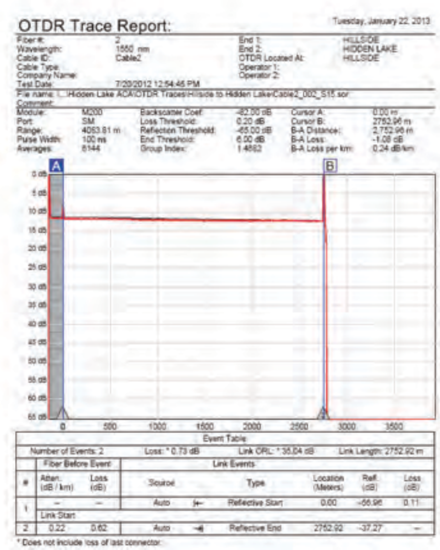


3	*0.34	0.38	Auto	⌐	Single Non-Reflective	1810.38	--	0.89

OTDR Event Analysis Compared to Event Table

12. Once all values are measured and compared to TIA/EIA acceptable values, then the trace record should be recorded and saved for the test acceptance package.

13. Repeat the test acceptance process by measuring the link under test in the opposite direction and recording the results. Each fiber of each link shall be tested at both operating wavelengths and both direction as part of the test documentation package.



OTDR End-to-End Record Trace

Records Documentation Package

The following information is to be included in a records documentation package.

Project Schematic or Diagram—this schematic or job print must include the following items of both the vertical and horizontal components:

- Show all routes
- Show all distances
- Show fiber counts
- Illustrate locations of entrance facilities (EFs)
- Equipment rooms (ERs)
- Telecommunication rooms (TRs)
- Main cross connect (MCs)
- Intermediate cross connect (ICs)
- Illustrate locations of multi-user telecommunications outlet assembly (MUTOA)
- Telecommunication outlet (TOs)

Composite Schematic—the composite schematic is a straight-line schematic identifying the construction sequence of cable reels, meter markings to major construction points such as splice points and cross connects. The cable reel section length and a cumulative cable length should be marked each of these points. Also, the cable and fiber type and count shall be identified for each reel section.

Circuit Diagram—the circuit diagram is a schematic that identifies the actual fiber circuits, system number, working and protected fibers, fiber/buffer colors, priority sequence during restoration and other pertinent information such as transposed fibers.

Test Acceptance Sheets—the test acceptance sheets are the recorded values of the transmitter output power, receiver input power and measured attenuation levels at the receiver.

Other information to be included in the test acceptance package is:

- Insertion loss link values—bidirectional and both wavelengths
- OTDR traces—bidirectional and both wavelengths
- Fiber management shelf photos—front and back
- Connector end face photos (optional)
- Splice loss table—fusion splicer (optional)

Manufacturer-provided Documentation—the manufacturer-provided documentation would include: cable data sheets of each cable reel and documentation provided on the optical fiber.

Procedure for OSP MicroCore® into Poli-MOD® Fiber Management Module

Issue

Questions from customers on how to organize a 6 tube 144-fiber OSP MicroCore with 24 fibers per buffer tube into a Poli-MOD Module fiber management system.

Alternative 1

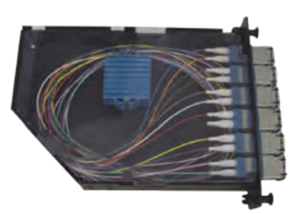
Use a 24-fiber Poli-MOD module and terminate each of the 24-fiber buffer tubes to a dedicated module.

Alternative 2

Using a 1X6 router, split each 24-fiber buffer tube into two 12-fiber segments and route to a 12-fiber Poli-MOD module.

Details of Alternative 2

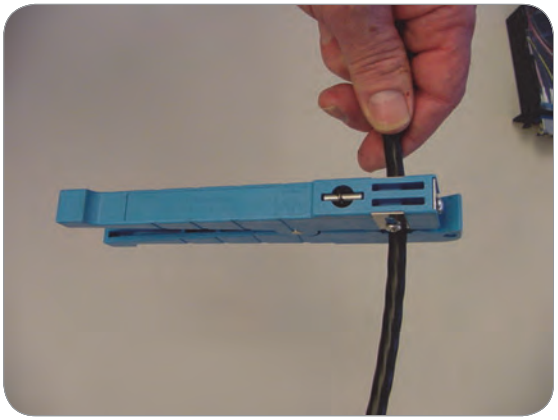
Kits and Part Numbers

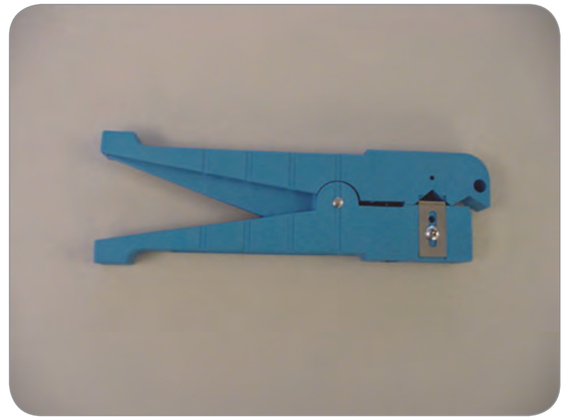
AFL PART NO.	DESCRIPTION	IMAGE
FC000070	1X6 Fan Out Kit (Router Kit)	
FM000742	Poli-MOD SMF module with SC pigtails	
MC144DA6-9.2	OSP MicroCore 144F with 24 fibers per tube	

AFLglobal.com or (800) 866-7385
Duraline.com or (800) 847-7661

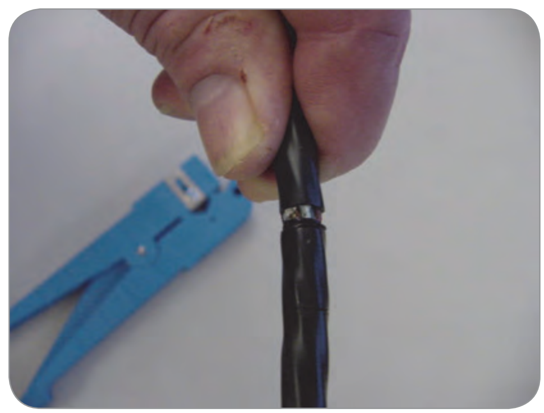
Sheath Preparation of MicroCore Cable

1. Use an Ideal 45-164 to ring cut the sheath of the MicroCore cable approximately 96" from the end of the cable. Be sure to adjust the blade depth so that the sheath is scored and not cut completely through. This will prevent damage to the buffer tubes under the sheath.

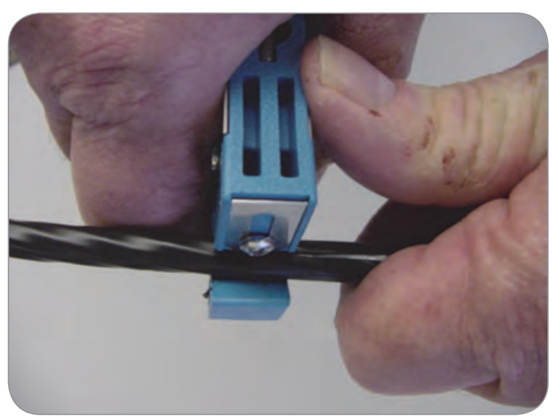




2. Flex the scored jacket until the cut yields the jacket and exposes the MicroCore cable.

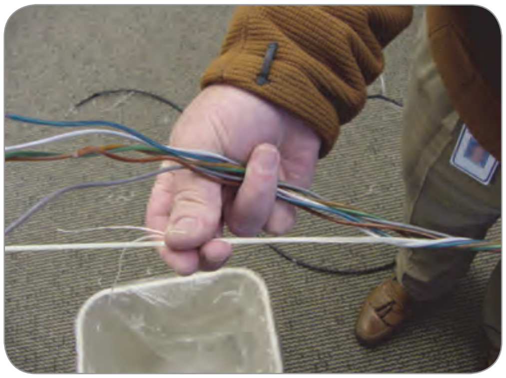


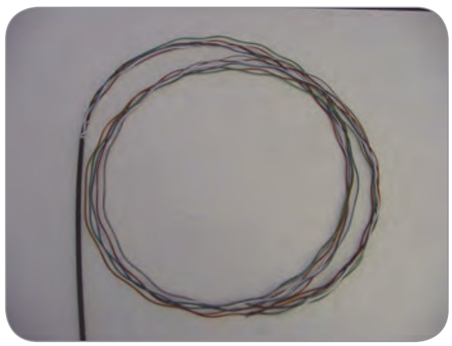
3. Using the longitudinal slitting blade of the sheath stripper, carefully score the cable jacket from the ring cut to the end of the cable length of 73." Make sure the blade depth is minimal so the jacket is scored not cut.



4. Peel outer cable jacket away from the cable core and inspect tubes and binders for nicks or indications of damage. This is very important to assure no damage prior to moving to the next steps. If tube are nicked or damaged, cut back cable and start cable preparation with new section of cable.

5. Remove outer binders and spiral the buffer units away from the central strength member (CSM). Inspect each buffer tube as they are separated from the cable core. When all tubes are clear, cut the CSM at 1.5 inches from sheath ring cut.

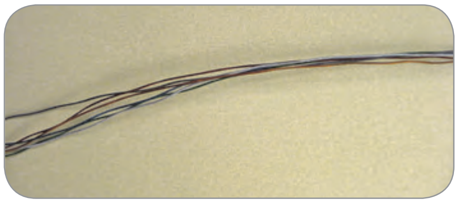


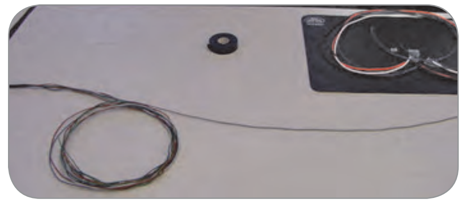


Cable Core Preparation

1. After careful inspection of each buffer tube for cuts or damage, use a heat gun on a low setting to relax the memory in the buffer units. This will make them more pliable and easier to route and store in the fiber management shelf.

2. Use caution with the heat gun to not melt through the buffer unit. Keep the gun moving over the cable and keep at least 12 inches from the tip of the gun to the cable.

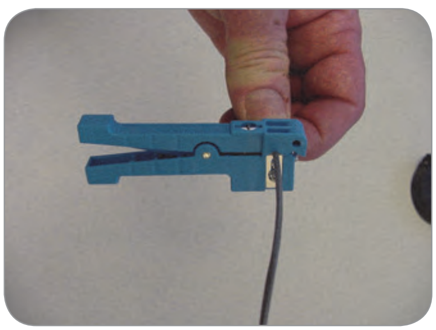


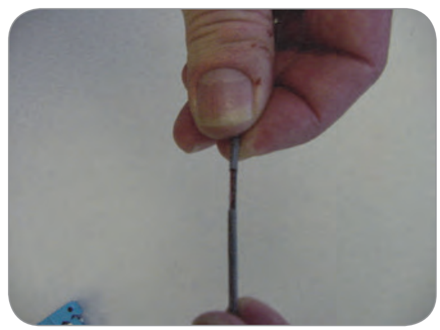


3. Coil all the tubes but one buffer tube unit to provide protection during the tube preparation process.

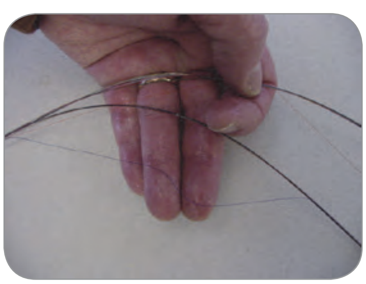
Buffer Tube Preparation

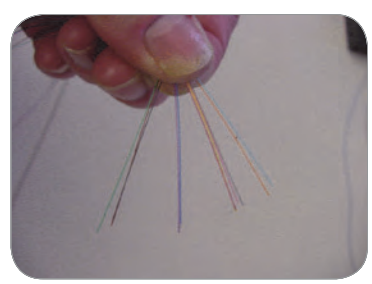
1. Remove 24 inches of buffer tube at a time using the Ideal 64-163 buffer tool until there is 32 inches of buffer tube left. Do not cut through the tube. Use the buffer tool to score the tube, then snap the tube by flexing being careful of minimum fiber bend radius and stressing the fibers.





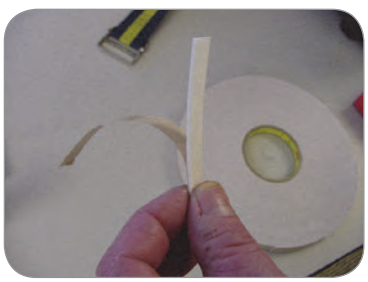
2. Carefully separate the 12-fiber groups of fibers inside the tube. Each group will be loosely bound with a blue thread and the other an orange thread. After the fiber groups are separated, loosely use the thread in two half hitches to keep the fiber groups separated. Count and verify that all 12 fibers are in each group.

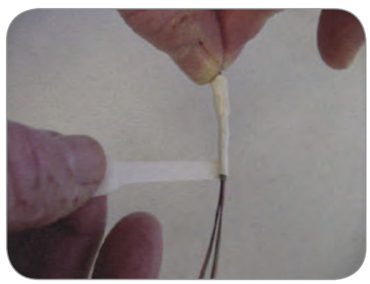


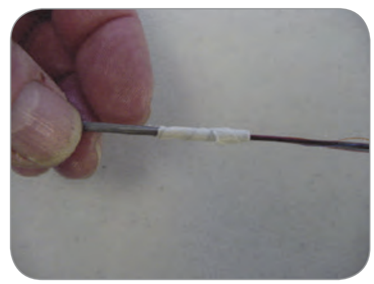


3. Clean fibers with fiber cleaning solution and dry using lint-free cleaning towels. Get the fibers as clean and dry as possible.

4. Using foam double-stick tape, half lap the buffer unit to provide a build up and a better gripping surface for attaching the buffer tube to the 1X6 splitter unit.

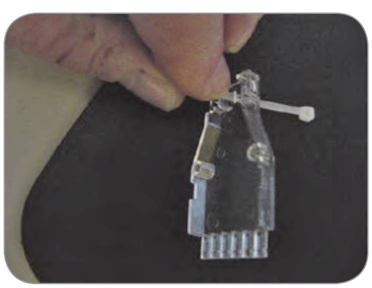


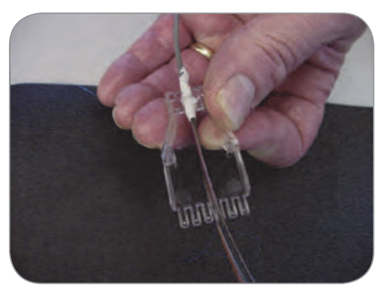




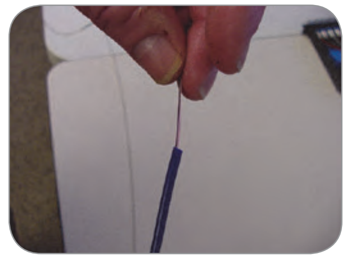
Installation of 1X6 Router and Furcation Tubing

1. Run small tie wrap through the tube retention slots of the 1X6 Router. Secure tie wrap to tube and foam tape snugly.



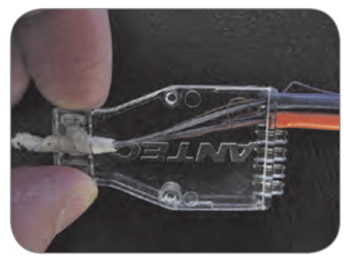


2. Slide string binder identifiers inside the splitter router to keep identification of the units for the future. Snap small cover over the buffer tube retention area. Slide furcation tubing over the fiber bundle based on the color code of the binder group matching the color of the furcation tubing.

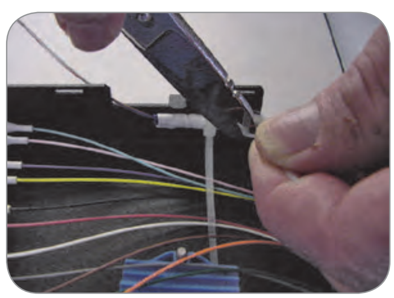
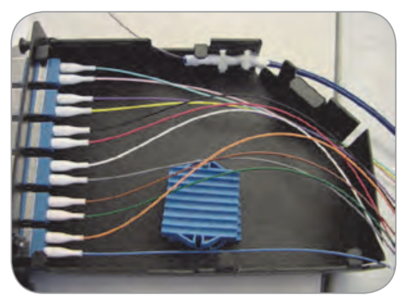



3. Slip the blue furcation tube over the first available fork and the orange furcation tube over the second fork. Snap the cover over the splitter unit.





4. Wrap the end of the blue tube with foam double-stick tape for adhesion to the Poli-MOD unit. Attach the furcation tube to the Poli-MOD module with two tie wraps.

5. Route and measure the fibers and the pigtails to accommodate the fusion splicing inside the Poli-MOD. Continue and complete the rest of the buffer units.