Leveraging Fiber Properties to Our Advantage
Agenda

• Fiber Properties
• Air Blown Fiber Components
• How It Works
• Design Considerations
We add layers of sheathing and pull it through facilities just like we install copper cabling.
Can we use these Properties to our Advantage?

Fiber is Inherently

- Thin
- Light weight
- Flexible
Series of Pathway Bundles & Interconnect Boxes are connected to form a backbone highway.

Fiber is jetted along the highway from point to point.

Air Blown Fiber (ABF)

1, 2, 3, 4
7, 12, 19, 24 Pathway Bundles

Single Mode Fiber
Multi Mode Fiber
1 Gigabit Fiber
10 Gigabit Fiber
How ABF Works

150 ft. per minute
How ABF Works

150 ft. per minute
**Conventional Fiber Install**

- 2 Days
- 4 Installers
- 64 Man-hours

$4.30 per ft.
(Labor & Hardware)

**Air Blown Fiber w/Tube Install**

- 2 Days
- 3 Installers
- 48 Man-hours

$5.58 per ft.
(Labor & Hardware)

**Cost $1.28 per ft. more**

**Purchased**
- Pathway Bundles
- Interconnect Boxes

**Reduced Man-hours**
- Mitigates some Hardware Costs
How ABF Works
How ABF Works
How ABF Works

96% Savings

- No additional conduit required
- Less installers required
- No fiber purchased
  - Reused fiber from 3rd floor
  - Leeds credits
- Fiber installed at 150 ft per minute

Reduces planning effort
Increases planning accuracy
Capital allocated to known needs

Conventional Fiber Install
1 Days
4 Installers
32 Man-hours

$4.49 per ft.
(Labor & Hardware)

Air Blown Fiber Modification
1 Hour
2 Installers
2 Man-hours

$.16 per ft.
(Labor & Hardware)
Pathway Bundle vs. Conduit

19 Pathway Bundle
X 2
38 Pathways
X 24 Fibers per

912 Fiber Strands

3 1” innerducts
X 144 fibers per

432 Fiber Strands

More than Doubling the fiber capacity within conduit
Design Considerations

Interconnect Boxes are available in a variety of sizes as well as custom built for any application.
Design Considerations

Interconnect Boxes placed in Low Traffic Areas for strategic access to technical areas.

- IDF Rooms
- Utility Cabinets
- Chaseways
- Walls / Ceilings / Floors
Design Considerations

System easily Scaled for Phased Implementation
Pathway Bundle Specs

- **Outside Diameter:** .77 – 2.13 inches
- **Bend Radius:** 7 - 21 inches
- **Temperature Tolerances:** -65 - +180 F
Pathways are Numbered

• Accurate Install
• Accurate Documentation
Unused Pathways are Plugged

• Prevent Obstructions (Insects, Water, etc)

• Use in Clean Agent Environments
Pathway Bundles can be installed in:

- Existing Conduit
- Cable Trays
- Chaseways with limited support
- Under Computer Flooring
- Above Ceilings
- Outside Plant
Pathway Bundle Installation Limitations:

- No installation in Elevator Shafts
- Do Not Lash Tubing to
  - Water Pipes,
  - Electrical Conduits,
  - HVAC Ducts,
Design Considerations

Selecting Pathway Bundle Size

- Backbone Infrastructure (Based on Facility Size)
  - 19 Pathway Bundle
  - 12 Pathway Bundle

- Horizontal Paths (Based on Fiber Needs)
  - 19 Pathway Bundle
  - 12 Pathway Bundle
  - 7 Pathway Bundle
  - 4 Pathway Bundle
Master Control Room
One Interconnect Box
Horizontal Path:
1-4 Pathway Bundle or
7 Pathway Bundle
IDF Room
One or More Interconnect Boxes
Horizontal Path:
19 - 4 Pathway Bundle
Equipment Room
Multiple Interconnect Boxes
Horizontal Path:
19 Pathway Bundle or
12 Pathway Bundle
Large Area Design
Horizontal Pathway Design

Interconnect Tube

Reducing Tube
Regular Fiber Jumpers are used to connect Fiber Management Panels to individual devices

Maximum Flexibility
Jetting Options

Fiber Air Blown Only

Fiber jetted with Air Assistance
Jetting Tests

• **Pressure Test**
  - Tubes pressurized between 150-200 PSI
  - Duration: 10 sec

• **Obstruction Test**
  - BB Blown through Tubing
Jetting Limitations

Jetting equipment limited to 3000 – 6000 ft. runs

Tandem Blow allows fiber runs of any length
Fiber Options

- Must be ABF Fiber
- Variety of Bandwidth
  - Multimode
  - Single Mode
  - 10 gig
  - 1 gig
- Variety of Sizes
  - 1, 2, 4, 6, 12, 18, & 24 strand bundles
Working with Fiber Properties:

- Maximizes Conduit Capacity
- Reduces Installation Time & Cost of Modifications
  - Reuse Fiber
  - Mitigate Obsolescence
  - Decrease Disaster Recovery Time
- Increases Budget Accuracy
  - Decrease Planning Time
  - Allocate Capital on Known Requirements
  - Scalable to Address Technical and Financial Goals

Purchase Infrastructure Once...Modify as Needed
Leveraging Fiber Properties to Our Advantage

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Abstract. A strand of optical fiber is inherently thin, flexible, and light weight. How can we leverage these properties to improve the fiber installation process and make it easier to adapt to changing facility needs?

A new infrastructure / installation technology called “Air Blown Fiber Infrastructure” facilitates this approach. Using a point-to-point network of high density tubes as a highway, 3000 ft. of 24 strand-fiber can be jetted (installed) from source to destination across a facility in just 30 minutes. Once the tube network is in place, changes can be made at a fraction of the time and cost of conventional fiber networks, without disruption to the network or the facility.

Technical Discussions include:

- What is an Air Blown Fiber System
- Conventional Fiber vs. Air Blown Fiber System ROI Comparisons

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• Design Considerations (intra-building, campus)
• Tube Bundle Design Consideration and Limitations
• Fiber Bundle Installation Considerations and Options
• Jetting Specifications, Limitations and Testing

**Keywords.** Fiber Optical Cable, Fiber Optics, Air Blown Fiber, Fiber, Infrastructure Technology, Next Generation Digital Infrastructure, Wide Bandwidth Infrastructure, Evolving Technology for Broadcast Facilities, High Performance Networks
Introduction

If anyone had told us even 10 years ago that fiber could be installed at 150 ft. per minute or removed from one location and reused in another, we would have said it was impossible. We have traditionally treated all infrastructure the same whether it is copper or fiber, by wrapping it in thick sheathing, lifting floor tiles, and pulling it through the facility to the desired locations.

However, by leveraging fiber's inherently thin, flexible, and lightweight properties, an Air Blown Fiber system provides an adaptable and green infrastructure that can cost effectively keep pace with both the changes in technology as well as the pace at which we now do business.

What is an Air Blown Fiber (ABF) System?

The heart of the system is a highway of microduct pathways that are installed in place of traditional innerduct. See Figure 1. Pathway interconnect boxes (junction boxes) are strategically placed at intersection points to allow fiber to be routed to various parts of the facility. This is accomplished by inserting interconnect pathways with air tight couplers inside the interconnect box to form a complete point to point path from source to destination. See Figure 2. Up to 24 strands of fiber, available in a variety of configurations, can be jetted through the pathway at speeds of 125 to 180 feet per minute.

Spare pathways are added during the initial installation allowing changes to the network simply by jetting the fiber out, re-routing the pathways within designated interconnect boxes and jetting fiber back into a new network configuration.

Fiber can quickly be added for growth, upgraded to increase bandwidth, reconfigured to match new network needs or even replaced to recover from a catastrophic event (tornado, fire, etc.). It is this flexibility that makes ABF a high performance network infrastructure which mitigates obsolescence during rapid technology advancements and evolving business needs.
Conventional Fiber vs. ABF System Comparisons

Conduit vs. ABF Pathway Bundle Capacity

Conventional fiber typically uses a combination of conduit and innerduct to protect fiber bundles from source to destination. A 4” conduit accommodates three (3) 1” innerducts each allowing a maximum fiber count of 144 strands per innerduct. Therefore, a 4” conduit can accommodate a total of 432 fibers.

In comparison, the same 4” conduit can accommodate two (2) 19 pathway bundles resulting in a total of 38 pathways. Installing one 24 strand fiber bundle in each pathway allows a total fiber count of 912. Conduit space is maximized by more than doubling the amount of fiber that can be installed within the same 4” conduit.

Conventional Fiber vs. ABF Installation Return on Investment (ROI)

The most meaningful way to illustrate differences between conventional fiber installation and an Air Blown Fiber system is using a real life example. Figure 4 (below) shows two e-mail servers located on the top two floors of a facility. Both servers need fiber connectivity to a main server on the first level of a building. 920 ft. of 24-count single-mode fiber was installed using both installation methods.
Conventional fiber method included the installation of 640 ft. of innerduct in addition to 920 ft. of 24-count single-mode fiber. Four (4) installers were needed for two (2) days to complete this installation.

The Air Blown Fiber system included the installation of five (5) lengths of 2 pathway bundles, totaling 640 ft., that connected three Interconnect Boxes. As shown in Figure 4, the ABF system cost $1.28 more per foot for the initial installation of the system. This is due to the purchasing of interconnect boxes and pathway bundles. However, because the fiber could be installed at 150 ft. per minute, the total man-hours required to complete the project actually decreased, thereby mitigating some of the additional hardware costs.
In Figure 5, the network needs changed. The e-mail server on the 3rd floor was moved to the 2nd floor. 460 feet of 24-count single-mode fiber was installed using both installation methods. Using conventional fiber, the fiber initially installed on the third floor will remain there dark and available for future use. 420 ft. of new innerduct and 460 ft. of new fiber were installed along the route from the 1st to the 2nd floor in 8 hours at a cost of $4.49 per foot.

Conversely, using an ABF infrastructure, this network modification was accomplished in only one hour at a cost of 16 cents per foot. Here are the factors that reduced the cost by 96%.

- No Additional conduit was required. The infrastructure was already in place. Pathway bundles and interconnect boxes installed during the initial project accommodated this change easily.
- Less installers were required. Only two installers were needed for this modification, one to jet the fiber at the source, and one to monitor the fiber at the destination point. Modifications at interconnect boxes took minutes to complete.
- No fiber was purchased. Fiber was jetted out of the third floor and re-installed between the 1st and 2nd floor locations. The fiber was purchased once and can be reused many times in an ABF infrastructure. The only limitation is fiber length. In additional to cost savings, this “green” feature of ABF systems qualifies for LEEDS credits and a more environmentally friendly facility.
- Fiber was removed and reinstalled at 150 feet per minute, substantially reducing the installation time to complete the project.
The real benefit of an ABF system occurs when the network is modified. Adding fiber connectivity, moving equipment to other locations, replacing fiber with a higher bandwidth fiber bundles becomes inexpensive and fast to implement.

The cost and time it takes to install conventional fiber has traditionally forced managers into a long term infrastructure plan, installing dark fiber to address estimated needs up to five years in the future. Risks include this dark fiber may or may not meet the bandwidth requirements of future technology or be installed in the exact location when the need arises.

Since modifications to an ABF system require minimal time at a nominal cost, long term forecasting is no longer necessary. Infrastructure planning decreases to a six month or one year capital expense exercise based on known project goals and bandwidth requirements. This reduces planning time, allows capital expenditures to be more accurately forecasted, and capital allocated to known needs.

**ABF Design Considerations:**

**Pathway Interconnect Box Design Considerations**

The core of an ABF system design is pathway interconnect box placement. These enclosures should be located near technical source and destination points as well as intersection or branching sites to form a logical, efficient pathway throughout a facility. Ring, bus, or star configurations can be implemented within a floor, between floors of a single facility, or even between multiple buildings in a campus environment. There are no limitations on the number of interconnect boxes that can be utilized within a design.

Pathway interconnect boxes are ideally placed in low traffic areas that allow easy access for interconnect pathway modifications or expansions over the life of a facility. Within technical areas such as equipment rooms, IDF rooms ("Intermediate Distribution Frame" rooms delivering connectivity to a localized area such as a building floor, or technical area), master control rooms, and operation centers, enclosures are generally mounted on walls or under raised flooring along the perimeter of the room for easy distribution.

Placement of interconnect boxes used as backbone infrastructure are generally dictated by cable management and structural design. Locations include risers, chaseways, above drop ceilings, and under computer flooring. Office space and high traffic areas should be avoided whenever possible. This allows maintenance of the system to occur without disrupting workflow as much as possible.

Large IDF rooms or equipment rooms may have multiple interconnect boxes to accommodate redundant fiber paths and high density fiber connectivity throughout the space. Figure 6 below illustrates redundant paths within a very large equipment room. Perimeter locations allow maximum availability to/from the equipment room without depleting valuable cable management space within cable intensive areas. Pathway interconnect box layouts are based on fiber connectivity and equipment location within the room. In the case below, the boxes are located every three to four rack rows to accommodate connectivity needs to multiple routers.
While it is generally best to consider the whole facility during the planning stage of ABF system design, it must be noted that ABF systems are scalable and phased implementation is easily accommodated. Pathway interconnect boxes and microduct pathway bundles can be added at anytime to match both technical and financial objectives.

Microduct Pathway Bundle Design Considerations:

All interconnect boxes are then joined together with microduct pathway bundles to form a point to point highway between technical areas. Once the pathway bundles are installed, the need to pull up floor tiles and disrupt the facility no longer exists. Any changes to the fiber network are literally conducted at out of the way pathway interconnect boxes. This is a useful benefit if there are secure areas where installers could jeopardize research & development or have access to sensitive information.

Pathway bundles are available in multiple configurations (listed below) to address the varying fiber density requirements within each area of the facility and will accommodate one (1) fiber bundle per pathway. Pathway bundles should always be specified larger than the current need to allow for future growth or changes in the network design.

<table>
<thead>
<tr>
<th>Microduct Pathway Bundle Configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Single Pathway</td>
</tr>
<tr>
<td>2 Pathway Bundle</td>
</tr>
<tr>
<td>3 Pathway Bundle</td>
</tr>
<tr>
<td>4 Pathway Bundle</td>
</tr>
<tr>
<td>7 Pathway Bundle</td>
</tr>
<tr>
<td>12 Pathway Bundle</td>
</tr>
<tr>
<td>19 Pathway Bundle</td>
</tr>
<tr>
<td>24 Pathway Bundle</td>
</tr>
</tbody>
</table>
Pathway bundles are specified based on function: backbone infrastructure or horizontal pathway. As illustrated below in Figure 7, main trunks of the ABF backbone generally require larger pathway configurations (19 or 24 tubes) which are dictated as much by facility size as fiber density.

![Figure 7 Enterprise Design Example](image)

Horizontal pathways are designed to the fiber density requirements at each destination. For example a large equipment room will probably require 19 or 24 pathway (tube) bundle configuration to address extensive fiber connectivity. However, a control room or audio booth may only require a 4 pathway Bundle (or less) to address both current fiber requirements and possible future needs.

As the fiber network and infrastructure grows, pathway bundles may become congested if not completely filled between key technical areas. This is easily addressed by installing another pathway bundle between existing interconnect boxes already located in these areas. This allows the network to grow organically without the need to plan five years into the future.

As seen in Figure 7, all technical areas are interconnected, allowing fiber to be jetted from and to any floor or area between the two buildings. This flexibility not only allows the network to grow or be modified easily, but also reduces the impact of a catastrophic event. Should a fire damage equipment on the 3rd floor of Building 2, fiber can be routed throughout the facility, bypassing damaged areas, for quicker disaster recovery. If sections of the pathway bundles are damaged, these sections can be replaced with fiber jetted in hours verses the days required for conventional fiber installation. This reduces the risk to on-air revenue streams and well as lost productivity.
Horizontal Pathway Design Considerations

In order to achieve the maximum flexibility of horizontal pathways, fiber is terminated directly to fiber management panels as shown below in Figure 8. Fiber pathway bundles can be run from either the top of rack, under raised flooring or both depending on the standard operating procedures practiced at the facility. Notice that the pathway bundles are actually installed inside of the rack. This protects fiber bundles from being snagged or damaged by cables pulled to/from other locations.

Best practices dictate that fiber bundles should be exposed as little as possible to prevent breakage. Normally, single pathways fill this function within interconnect boxes. However, cable management space is limited within the racks themselves. A reducing tube, approximately ½ the diameter of a single pathway, is used to protect fiber from the end of the pathway bundle to the fiber management panel termination point.

Fiber jumpers are then used to connect fiber management panels to individual devices.

Figure 8 Horizontal Pathway Design Considerations

ABF Pathway Bundle Installation

The actual installation of the pathway bundles themselves is as flexible as the system design. Bundles are available in Riser, Plenum, and Outside Plant (OSP) specifications which can be installed in:

- Existing conduit
- Cable trays
- Risers/Chaseways with limited support
- Above drop down ceilings
- Under raised flooring, as well as
- Between buildings (Direct bury underground)
- Through fire rated walls without special or additional firestop requirements

Detailed information regarding pathway bundles is provided in Figure 9.

<table>
<thead>
<tr>
<th>Dura-Line Microduct Pathways</th>
<th>Plenum</th>
<th>Riser</th>
<th>OSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Diameter</td>
<td>0.77&quot; - 2.13&quot;</td>
<td>0.77&quot; - 2.13&quot;</td>
<td>0.77&quot; - 2.13&quot;</td>
</tr>
<tr>
<td>Bend Radius: Static</td>
<td>7.7&quot; - 21.3&quot;</td>
<td>7.7&quot; - 21.3&quot;</td>
<td>7.7&quot; - 21.3&quot;</td>
</tr>
<tr>
<td>Bend Radius: Dynamic</td>
<td>15.4&quot; - 42.6&quot;</td>
<td>15.4&quot; - 42.6&quot;</td>
<td>15.4&quot; - 42.6&quot;</td>
</tr>
<tr>
<td>Operating Temp (F)</td>
<td>-40 to +180</td>
<td>-40 to +180</td>
<td>-40 to +180</td>
</tr>
<tr>
<td>Fire Rating</td>
<td>NFPA 262</td>
<td>UL 1666</td>
<td></td>
</tr>
<tr>
<td>Crush Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Load (lbs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reel Length</td>
<td>1000'</td>
<td>1000' - 6000'</td>
<td>1000' - 6000'</td>
</tr>
<tr>
<td>Weight per Foot</td>
<td>0.081 - 0.614</td>
<td>0.081 - 0.614</td>
<td>0.081 - 0.614</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sumitomo Tube Bundles</th>
<th>Plenum</th>
<th>Riser</th>
<th>OSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Diameter</td>
<td>0.9&quot; - 1.7&quot;</td>
<td>0.9&quot; - 1.7&quot;</td>
<td>0.9&quot; - 1.7&quot;</td>
</tr>
<tr>
<td>Bend Radius: Static</td>
<td>9&quot; - 17&quot;</td>
<td>9&quot; - 17&quot;</td>
<td>9&quot; - 17&quot;</td>
</tr>
<tr>
<td>Bend Radius: Dynamic</td>
<td>18&quot; - 34&quot;</td>
<td>18&quot; - 34&quot;</td>
<td>18&quot; - 34&quot;</td>
</tr>
<tr>
<td>Operating Temp (F)</td>
<td>32 to 158</td>
<td>10 to 140</td>
<td>-65 to +158</td>
</tr>
<tr>
<td>Fire Rating</td>
<td>NFPA 262</td>
<td>UL 1666</td>
<td></td>
</tr>
<tr>
<td>Crush Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Load (lbs)</td>
<td>120 - 500</td>
<td>120 - 500</td>
<td>200 - 500</td>
</tr>
<tr>
<td>Reel Length</td>
<td>1000'</td>
<td>1000' - 3000'</td>
<td>1000' - 3000'</td>
</tr>
<tr>
<td>Weight per Foot</td>
<td>0.089 - 0.75</td>
<td>0.14 - 0.574</td>
<td>0.087 - 0.433</td>
</tr>
</tbody>
</table>

Pathway Combinations: 2, 3, 4, 7, 12, 19, 24
All Pathways Have Silicone Lining To Improve Jetting Capabilities By Reducing Friction

Website: www.duraline.com
Website: www.futureflex.com
Website: www.duraline.com/enterprise
Website: www.futureflex.com/futureflex-products/tube-cables.html

Figure 9 Pathway Bundle Comparisons

The only limitation to pathway placement is state building code restrictions which may vary depending on facility location. Here are a few we have encountered.

- No lashing of pathway bundles to water pipes, electrical conduits, and HVAC ducts.
- No installation of pathway bundles in elevator shafts
Individual pathways within a pathway bundle are numbered to assist with accurate installation as well as documentation and are arranged with the highest number in the center of the bundle. Interconnect tubing is installed starting with this center pathway and working outward to keep installation as unencumbered as possible.

Unused tubes are plugged to prevent obstructions such as insects, dust, or water to accumulate over time and hinder future fiber installation. Plugs also assist with use in clean agent environments (areas using gaseous fire suppression systems such as FM200) causing little or no impact on pressure testing or fire suppression.

**ABF Fiber Jetting Methods**
There are several fiber jetting methods available in the marketplace today. All use a combination of a pressure wheel (maintains consistent tension on the fiber to prevent kinking during installation), a guide wheel (used to direct fiber bundles into the pathway) and dry compressed air to assist with fiber bundle installation. The main design difference between these methods is how the wheels are powered. Some utilize air driven motors while others use electric motors such as a cordless drill as the main propellant. Air is used to reduce resistance by “floating” the fiber bundle along the pathway. Please refer to Figure 12 for more information on these jetting methods.

There is no limitation on how far fiber can be installed. While jetting devices are generally limited to a range of 3000-6000 ft., longer fiber runs can be implemented by inserting an additional jetting device at an interconnect box near the 3000 - 6000 ft. limit. This is called a “tandem blow” and allows another 3000-6000 feet of fiber to be installed without splicing.

Regardless of the jetting method employed, a couple of pre-tests should be conducted before actually jetting fiber bundles through the pathway infrastructure. A pressure test should be conducted on each pathway at 150-200 PSI for a duration of 10 seconds. This insures that all couplers and interconnect tubing are securely seated to guarantee airtight pathway continuity.

The second pre-test to be conducted is an obstruction test. This consists of blowing a BB from the beginning of the path to the final destination. If the BB arrives at the endpoint, there are no kinks in the tubing or other obstructions to impede the fiber bundle from arriving at the destination.

<table>
<thead>
<tr>
<th>Dura-Line/Plumett</th>
<th>Ultima V20</th>
<th>Sumitomo FutureFlex</th>
<th>Blowing Head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle Diameter</td>
<td>6 - 4mm</td>
<td>Bundle Diameter</td>
<td>2 - 3mm</td>
</tr>
<tr>
<td>Duct Diameter</td>
<td>3 - 12.7mm</td>
<td>Duct Diameter</td>
<td>8mm</td>
</tr>
<tr>
<td>Bi-Directional</td>
<td>Yes</td>
<td>Bi-Directional</td>
<td>N/A</td>
</tr>
<tr>
<td>Max Speed</td>
<td>75m/min</td>
<td>Max Speed</td>
<td>33m/min</td>
</tr>
<tr>
<td>Max Pushing Force</td>
<td>20n</td>
<td>Max Pushing Force</td>
<td>Sel by Air Pressure</td>
</tr>
<tr>
<td>Max Air Pressure</td>
<td>175psi</td>
<td>Max Air Pressure</td>
<td>100psi</td>
</tr>
<tr>
<td>Max Jetting Distance</td>
<td>5000'</td>
<td>Max Jetting Distance</td>
<td>3000'</td>
</tr>
<tr>
<td>Weight</td>
<td>8.1lbs</td>
<td>Weight</td>
<td>67.5lbs</td>
</tr>
</tbody>
</table>

Uses “3/8” Cordless Drill as the Prime Mover to Jet Fiber Through the Pathways
Air Assisted with Dry Compressed Air or Compressed Nitrogen

Fiber Bundle: 12, 18, 24

Website:
www.affglobal.com/Products/Fiber-Optic-Cable/Enterprise.aspx

Uses Air Driven Motor as the Prime Mover to Jet Fiber Through the Pathways
Air Assisted with Dry Compressed Air or Compressed Nitrogen

Fiber Bundle: 6, 12, 18, 24

Website: www.futureflex.com
www.futureflex.com/futureflex-products/fiber-bundles.html

Figure 12 Jetting Equipment Comparisons
AFB Fiber Bundle Considerations

ABF infrastructures require fiber bundles with ridged or dimpled sheathing as seen in Figures 13 & 14. These uneven surfaces are specifically designed to provide resistance against the air and help propel the fiber bundle along the pathway.

Figure 13 Ridged Air Blown Fiber Bundle

Figure 14 Dimpled Air Blown Fiber Bundle

ABF Fiber bundles come in a variety of bandwidths (multimode, single mode) and number of fiber strands (1-48 strand bundles) to accommodate multiple connectivity requirements as seen in Figure 15.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Diameter</td>
<td>.12&quot; - .15&quot;</td>
<td>.12&quot; - .15&quot;</td>
<td>.12&quot; - .15&quot;</td>
<td>Outside Diameter</td>
<td>0.08&quot; - 0.12&quot;</td>
<td>0.08&quot; - 0.12&quot;</td>
<td>0.08&quot; - 0.12&quot;</td>
</tr>
<tr>
<td>Min. Bend Radius</td>
<td>1.8&quot; - 2.2&quot;</td>
<td>1.8&quot; - 2.2&quot;</td>
<td>1.8&quot; - 2.2&quot;</td>
<td>Min. Bend Radius</td>
<td>1.5&quot;</td>
<td>1.5&quot;</td>
<td>1.5&quot;</td>
</tr>
<tr>
<td>Bandwidth: 850nm</td>
<td>500 MHz/km</td>
<td>1500 MHz/km</td>
<td>500 MHz/km</td>
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<td>1500 MHz/km</td>
</tr>
<tr>
<td>Bandwidth: 1310nm</td>
<td>500 MHz/km</td>
<td>500 MHz/km</td>
<td>500 MHz/km</td>
<td>Bandwidth: 1310nm</td>
<td>N/A</td>
<td>500 MHz/km</td>
<td>500 MHz/km</td>
</tr>
<tr>
<td>Operating Temp (F)</td>
<td>32 to 158</td>
<td>-40 to +158</td>
<td>-40 to +158</td>
<td>Operating Temp (F)</td>
<td>-58 to +158</td>
<td>-40 to +158</td>
<td>-40 to +158</td>
</tr>
<tr>
<td>Install Speed (ft/min)</td>
<td>up to 200</td>
<td>up to 200</td>
<td>up to 200</td>
<td>Install Speed (ft/min)</td>
<td>up to 150</td>
<td>up to 150</td>
<td>up to 150</td>
</tr>
<tr>
<td>Distance: 850nm</td>
<td>600m @1Gbps</td>
<td>550M @ 10G</td>
<td></td>
<td>Distance: 850nm</td>
<td>550m @ 1Gbps</td>
<td>550M @ 10G</td>
<td></td>
</tr>
<tr>
<td>Distance: 1310nm</td>
<td>600m @1Gbps</td>
<td>300m @ 10G</td>
<td></td>
<td>Distance: 1310nm</td>
<td>550m @ 1Gbps</td>
<td>300m @ 10G</td>
<td></td>
</tr>
<tr>
<td>Tensile Load (kps)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>Tensile Load (kps)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Reel Lengths</td>
<td>up to 15000'</td>
<td>up to 15000'</td>
<td>up to 15000'</td>
<td>Reel Lengths</td>
<td>up to 14000'</td>
<td>up to 14000'</td>
<td>up to 14000'</td>
</tr>
</tbody>
</table>

Fiber Bundle: 12, 18, 24

Website:
www.aflglobal.com/Home.asp
www.aflglobal.com/Products/Fiber-Optic-Cable/Enterprise.asp

Fiber Bundle: 6, 12, 18, 24

Website:
www.futureflex.com
www.futureflex.com/futureflex-products/fiber-bundles.html
It is important to note that an ABF infrastructure is only unique in the way fiber is deployed. Once the fiber is in place, termination and testing is conducted in the same manner as conventional fiber.

**Conclusion**

Conventional fiber installation offers high bandwidth connectivity between two specific points. It is a reliable and valuable installation method for organizations with static network needs that do not require many network moves, adds, or changes over time.

For dynamic organizations that are dependent on technology, Air Blown Fiber installation offers a flexible infrastructure system providing connectivity between all technical areas within a floor, between floors, as well as campus-wide.

ABF infrastructures increase the return on investment (ROI) by:

1. maximizing conduit capacity,
2. substantially reducing installation time and cost of network modifications,
   - maximizing fiber purchases by reusing fiber bundles throughout the life of the facility,
   - mitigating infrastructure obsolescence by jetting older fiber bundles out and installing higher bandwidth fiber bundles to meet new technology requirements,
   - protecting revenue streams and productivity by decreasing disaster recovery time,
3. increasing budget accuracy while decreasing planning time,
   - allocating capital on known fiber requirements verses estimated needs,
   - providing a scalable infrastructure that can organically grow to fit both technical goals and budgetary constraints.

Working with fiber’s inherently thin, flexible, and lightweight properties, an Air Blown Fiber system provides an adaptable and green infrastructure that can cost effectively keep pace with both the changes in technology as well as the pace at which we now do business.