COMMSCOPE®

Broadband applications & construction manual

E_2O™ products

Contents

The confidence of being prepared

For today's cable multisystem operator (MSO), there are few absolutes. Two things you can count on, however, are: the cost to upgrade your outside plant will be higher tomorrow than it is today; and, when it's time to upgrade, speed and efficiency mean dollars saved and service revenue.

Maintaining an open migration path without jeopardizing your quality of service; being able to bring new services on line with minimum cost, downtime and impact—issues like these are what keep cable operators awake at night.

At CommScope, we support many of the largest tier-1 cable MSOs in the world. When it comes to ensuring their outside plant has the built-in flexibility and high performance they need, they trust our E_2O solution—and sleep just fine.

E_2O solutions—build for the future

CommScope's Electrical to Optical (E_2O) product line is a highly customizable solution that combines coaxial cable, optical fiber and/or microducts inside a single ruggedized sheath. The flexible design enables you to build in the capacity and space you need to handle future upgrades with little to no associated installation costs.

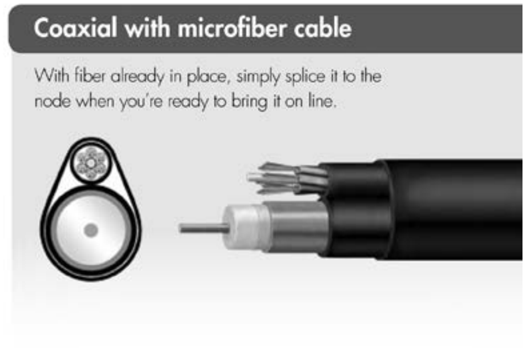
With E_2O, you can:

- Optimize node splits to allow for future fiber extensions at minimized cost
- Build the capacity you need for the immediate future, reserving microducts for additional fiber that can be blown in at any time—at a fraction of the cost of replacing your outside plant
- Create a complete FTTx solution with all coaxial and fiber components pre-installed, and bring individual conductors on line as your channel and bandwidth needs grow. In other words: with E_2O, your next outside plant upgrade could be your last for a very long time.

FTTx 32 premise to 1 fiber	
Fiber count	Premises served
60	1920
72	2304
96	3072
120	3840
144	4608

In other words: with E_2O, your next outside plant upgrade could be your last for a very long time.

What does your migration path look like?



These are just a few of the many different configurations available with the E_2O family of solutions from CommScope. E_2O gives you the ability to include and combine:

- P3®, QR®, MC2® distribution coaxial cable
- Distribution and drop fiber-optic cables
- Microduct for future microfiber blow-in
- Standard conduit
- Can be contained by a single jacket or in larger conduit—Cable in conduit (CIC)

The connectivity professionals at CommScope will work with you to customize a solution that fits your needs and budget.

Microfiber and microduct pairing

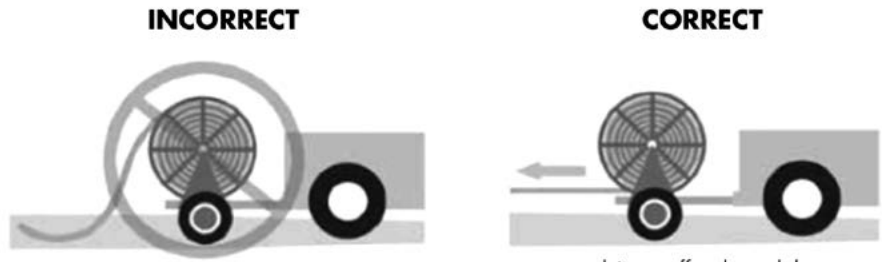
Successful installations begin with pairing the appropriate microfiber and microduct. The optimum fill range for blowing is 50 to 70 percent. Anything less than 30 percent could begin to cause issues with gathering or looping of the fiber in the duct. Anything greater than 70 percent could restrict the airflow, lowering placement efficiency and distance as well as making it around bends more difficult.

Microduct			Microfiber			
Size	OD, in.	ID, in.	MF, count	OD, in.	OD, mm	% fill
16/13	0.625	0.500	122–144	0.36	9.15	52
16/13	0.625	0.500	98–120	0.32	8.13	41
16/13	0.625	0.500	74–96	0.28	7.11	32
16/13	0.625	0.500	62–72	0.23	5.84	21
12.7/10	0.500	0.394	98–120	0.32	0.32	66
12.7/10	0.500	0.394	74–96	0.28	7.11	51
12.7/10	0.500	0.394	62–72	0.23	5.84	34
12.7/10	0.500	0.394	2–60	0.22	5.59	31

E_2O CIC general installation practices

Pay-off

When installing E_2O CIC, pay off the reel from underneath and in as direct a line as possible to the trench or bore to avoid unnecessary bending of the conduit or rubbing of the conduit against the reel flange. When feeding E_2O CIC into a manhole, pay-off should occur from the top of the reel—with the manhole on the side opposite of the direction of pull.



Cable/microduct/tone (locate) wire withdrawal

E_2O CIC conduit is slightly longer than the cables/microducts/tone wire it contains. Allow an average of 1.5 percent of cable/microduct withdrawal back toward the reel during unspooling (example: 2000 feet of conduit will yield 1970 feet of cable). The withdrawal will be greater as you approach the end of the reel.

Cut the restraint

Prior to installing E_2O CIC, remove the conduit end cap and cut the cable restraint. This relaxes the cable and transfers all of the pulling tension to the conduit.

Keep capped

To maintain conduit integrity, make sure both ends are capped during the installation. Foreign objects and debris entering an uncapped conduit can result in damage of installed cables and may cause blockage—making future cable replacements difficult.

Attaching to E_2O CIC

Some installation methods require an attachment to the E_2O CIC conduit to facilitate pulling. The following tools work particularly well for this: the "basket pulling grip," the "thread in eye", and expansion eye.

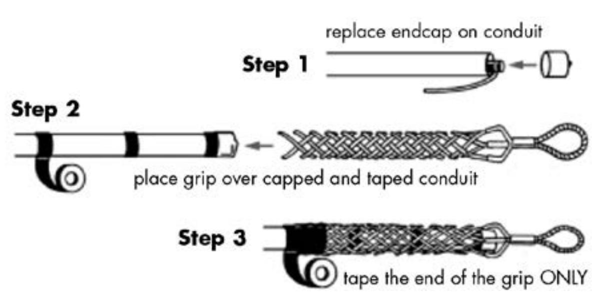
Basket pulling grip

When using the basket pulling grip it is important to remember: the tool is designed to compress and grip the surface of the object it is pulling. **NOTE:** Basket pulling grips should not be used on conduit sizes larger than 1¼ inches.

Unlike cable, conduit has an extremely rigid surface that does not allow for a good grip. In order to achieve a solid grip on conduit, a more pliable surface—such as duct tape or electrical tape—needs to be applied.

Apply bands of tape at 5-inch (2-cm) intervals from the conduit cap back to the point where the basket pulling grip will end. The tape only has to be applied in single-width bands but must be at least 1/16-inch (.03-cm) thick. Place the grip over the capped conduit and bands, then pull the grip to tighten its grasp on the conduit. To help hold the grip in place, tape needs to be applied to the conduit and then wrapped onto the end of the grip. Do not extend the tape beyond the first three inches of the end of the grip.

Inner duct pulling eye with swivel



The thread-in eye provides a pulling attachment that does not produce an increase in the outer diameter of the conduit. This is an added benefit not found in other devices. The installation of this device simply requires it to be screwed into the end of the conduit. The device has an eyehole for the attachment of a winch line or attachment to a plow blade.

Conduit pulling eye with swivel

This tool should be considered when pulling into a directional bore. All benefits of the inner duct pulling eye apply.

Note: This tool is not recommended for pulling inner duct.

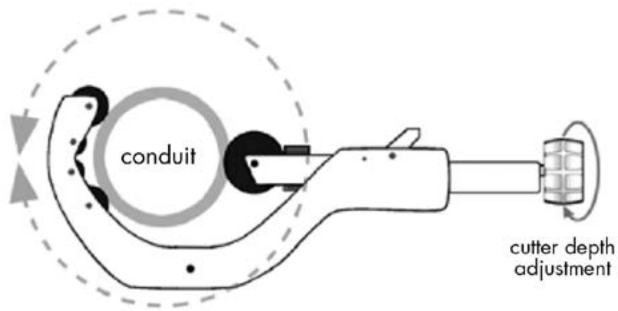
Cutting E_2O CIC

Several tools have been found useful for the purpose of cutting E_2O CIC conduit. While selection of the tools is usually defined by the user's preference, there are some application restrictions based on tool designs.

For ConQuest up to 1.25" (3.2 cm), use a ratchet shear

For ConQuest up to 2" (5 cm), use a tubing shear

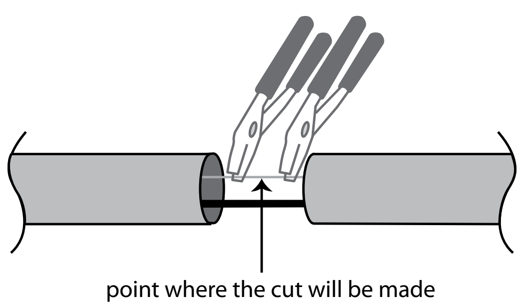
To cut E_2O CIC, open the tool and place it around the conduit at the point where the cut is to be made. While applying pressure to the conduit with the cutting edge, begin rotating the tool around the conduit—increasing pressure as you go and being careful not to cut or score the cable and microducts inside. To provide an even cut, it is often helpful to rotate the tool in opposite directions with each full pass around the conduit.



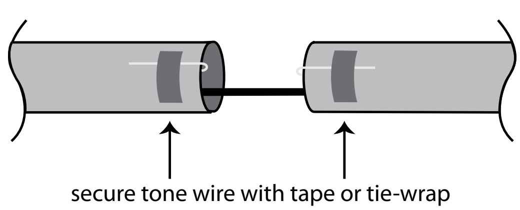
Note: **This is the preferred method for cutting conduit with pre-installed cable and microducts.**

When a tone (locate) wire is present in the E_2O CIC, it is important to restrain the wire prior to cutting it to prevent the wire from withdrawing into the conduit.

The best method to accomplish this is to apply a pair of vice grips on both sides of where the cut will be made.



Once cut, the tone wire can be folded back over the edge of the conduit and secured with tape or a tie-wrap.

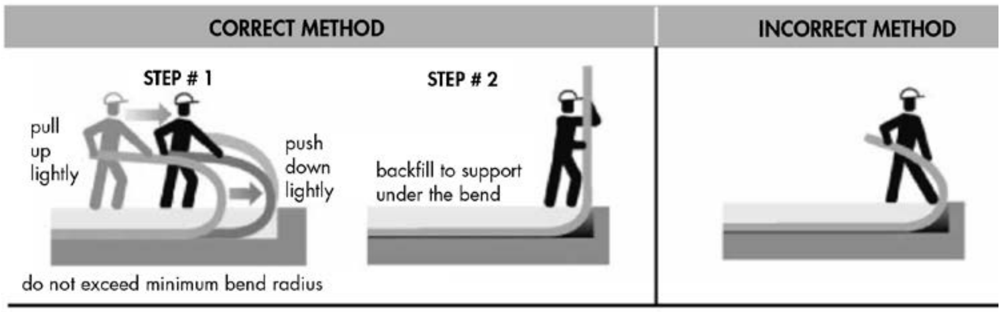


Only secure the ends of the tone wire on E_2O CIC that has been placed in the ground.

DO NOT secure the end of the tone wire on the end of E_2O CIC that is still on the reel—it will cause too much tension on the wire during installation and will result in damage to the product as well as severe withdrawal at the next cut.

Bending E_2O CIC (underground)

E_2O CIC can be easily shaped by rolling a bend into it. Take 10–12 feet (3–3.5 meters) of conduit and pull the free end of it toward you—forming a "horizontal U." Push into the bend lightly and roll the entire radius of the conduit forward. DO NOT bend the conduit any further if it begins to show signs of ovality, i.e. begins to bulge.



DO NOT press down on the conduit with your foot as you bend it.

Bending radius (all)

Conduit is often routed around corners during placement and pulling tension must be increased to apply adequate force to the conduit to bend it around the corner.

CommScope's specified minimum bend radius is the static (unloaded) bending radius of the conduit. This is the minimum radius to which the conduit can be bent without mechanically degrading the performance of the conduit.

The bending radius of conduit and cables during the construction process is controlled by construction techniques and equipment. Use the largest bend radius possible to help reduce overall pulling tension.

Size	Minimum bend radius (lbs.)	Maximum pulling tension (lbs.)
2" SDR13.5	26	2,580
1.5" SDR13.5	20	1,455
16/13mm	8	210
12.7/10mm	6	120

WARNING: Exceeding the minimum bending radius can result in permanently ovalizing the conduit, which may restrict cable installations. Exceeding the minimum bending radius of cables can damage the electrical or optical performance.

Regardless of the installation method, mechanical stress is of great concern during conduit and cable placement.

Exceeding the maximum allowable pulling tension can damage conduit and cable. Pulling tensions for E_2O CIC conduits can be found in specifications at the end of this manual.

Pulling tension

There are three general causes that affect pulling tension during the installation of conduit or cable: conduit or cable weight, sidewall pressure, and tail loading.

- **Weight** of the conduit or cable can be directly associated to pulling tension as a factor of force required to move an object weighing a number of pounds over a given distance. The more the conduit or cable weighs, the greater the pulling tension. The longer the distance, the greater the pulling tension.
- **Sidewall pressure** or loading is the radial force exerted on a conduit or cable when pulled around a bend or sheave. Excessive sidewall pressure can crush the conduit or the cable.
- **Tail loading** is the tension on the conduit or cable caused by the mass of the conduit on the reel and reel brakes.

Tail loading is controlled by two methods. It can be reduced using minimal braking during the pay-off of the conduit from the reel at times. Generally, no braking is preferred. Rotating the reel in the direction of pay-off can also minimize tail loading.

WARNING: Exceeding the maximum pulling tension can result in the conduit drawing down in size. While it may recover after a period of resting, the mechanical properties of the conduit are permanently degraded, which may reduce the life expectancy of the conduit. Exceeding the maximum pulling tension of cables can damage the electrical or optical performance.

Break-away swivels should be placed on the conduit to ensure that the maximum allowable tension for that specific conduit or cable type is not exceeded. The swivel is placed between the conduit/cable pull member and pulling grip.

A break-away swivel is required for each conduit or cable.

Pedestal and vault locations

Managing E_2O at pedestal and vault locations is simple. Generally, it is recommended to leave a minimum of five feet of tail on each E_2O CIC at a pedestal or vault location. The preferences to terminate all cable and microducts—or to pass through some or all cable and microducts—are both acceptable practices. It is simply a matter of how a network engineer wants to deploy the product.

These are a few examples:

Terminating all cable and microducts
Here, the entire E_2O CIC is simply cut off at the vault or pedestal to the desired length. The run may include a single or multiple outputs from the location, which also consist of E_2O CIC cut end(s).

Terminating coaxial cable and passing through microducts
In this application, the coaxial cable is being cut to feed an RF device while the microducts are passing through this location to another pedestal or vault downstream. There are two methods to accomplish this.

The first method is to simply bring the desired length of a cut end of E_2O CIC for both the input and output of this location and then join the microducts using the proper coupling procedure.

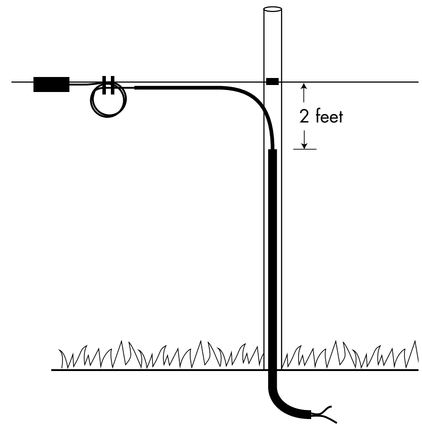
The second method is to overpull the E_2O CIC and create a loop of the length the cable tails need to be. The next step is to cut away the outer conduit, using a conduit slitter, to expose the cable and microducts. The cable can now be cut and the microducts are left complete and routed appropriately in the pedestal or vault to prevent kinking or damage.

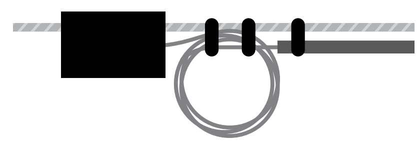
Passing through all cable and microducts
This application may be used where there is a need to have future access to the microducts for fiber access and there is no immediate planned use of the coaxial cable. This also leaves enough coaxial cable available for use in powering a future optical receiver/node at this location.

The procedure to accomplish this is to overpull the E_2O CIC and create a loop of the length the cable and microducts are to be. Then, cut away the outer conduit, using a conduit slitter, to expose the cable and microducts. The cable and microducts need to be carefully routed in the pedestal or vault to store the excess length without kinking or damaging them.

How much cable and microduct there should be at each vault and pedestal should be determined by a system engineer or construction head.

Aerial installations





Both E_2O CIC and the microducts themselves may be lashed to a bare strand. Microducts may be overlashed to existing strand and cables.

DO NOT lash microfiber. The microfiber cannot withstand lashing.

When transitioning from underground with E_2O CIC, it is recommended that the E_2O CIC is run vertically up the pole to provide protection for the microducts and cable(s). The outer conduit should stop about two feet below the strand attachment height to allow a good radius sweep of the microducts and cable(s) from the riser to the strand.

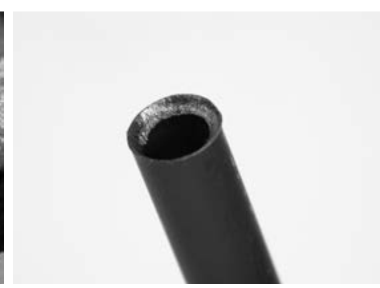
The only place the microfiber should be exposed is at a splice closure. The microfiber should be coiled to slightly larger than the minimum bend (minimum bend plus 1/2 inch) radius of the cable that is being used. The coil should be positioned so it nearly touches both the microduct and the splice closure. Using a polymer strapping system such as the Allied Bolt ABstrap™ lashing strap system is recommended.

Microduct end preparation

Properly preparing the ends of the microducts is critical to successfully blowing fiber. The first step is to ensure a clean, square end cut. The use of microduct cutter GMP 89565 is recommended.

Next, the ends at every set-up location and every coupler location must be cleanly beveled to eliminate a potential hang-up point for the fiber prior to installing the fiber.

The recommended method for beveling the microduct is to use a 5/8-inch countersink bit, such as the Ryobi SpeedLoad Plus 5/8-inch high-speed steel countersink model #A10CS08 on a hand bit driver. If possible, point the microduct end toward the ground to prevent the waste material from going into the duct.



The microduct beveled end should be smooth and clear of burrs or loose material.

Capping and coupling the microduct

Once preparation of each end is completed, it is recommended that the microducts either be capped or coupled. This will prevent particles and moisture from accumulating in the microduct, which can impede the installation of the fiber. Caps will need to be removed prior to blowing in fiber.

The caps and coupler simply push on the microduct until fully seated, which can be observed through the transparent portion.

Caps and couplers can be removed and reinstalled by simply pushing the rear cam ring forward while removing the cap or coupler.

Here is a list of the corresponding cap and coupler part numbers:

Straight coupler 16/13mm	BCA16MUC16M
End cap 16/13mm	BCA16MCAP
Straight coupler 12.7/10mm	BCA8UC8
End cap 12.7/10mm	BCA8CAP

Preparing the microduct for fiber blowing

Prior to blowing in the fiber, the microduct should be cleaned and lubricated. Clean and dry the tubing by blowing a tight-fitting foam sponge through the microduct with high pressure. If excess water or dirt comes from the microduct, repeat the process. Trapped water can block the air flow. The recommended size of the foam sponge is 24mm (0.945 inch) diameter x 35mm (1.378 inch) length.

Tech tip: Number the foam sponges to keep track of them. If one of them becomes lodged in the microduct it will prevent the fiber from blowing through it.

Squeeze the recommended amount (see table) of Polywater Prelube 5000® into the duct. The lubricant is spread by blowing a foam carrier or sponge through the microduct as many times as necessary to avoid puddling at the front of the duct.

Microduct size (OD/ID)	Lube quantity per 1,000 feet: volume required	Lube quantity per 1,000 feet: fill length of tube
16/13 mm	0.30 fl. oz. (9 ml)	3 inches (8 cm)
12.7/10 mm	0.25 fl. oz. (7 ml)	4 inches (10 cm)
10/8 mm	0.20 fl. oz. (6 ml)	5 inches (12 cm)

Fiber blowing equipment

There are many types of equipment available in the market for blowing fiber. Since it would be difficult to detail all in this manual, the GMP Airstream® 89300 will be used for the purpose of this discussion on how to set up and blow the microfiber into the microduct.

NOTE: It is important to refer to the manufacturer's instructions on use of the specific equipment being used for your installation.

At minimum, in addition to the fiber blowing equipment, an air compressor is required. When considering an air compressor, air pressure—referred to in bars—is more critical than volume of air, which is typically referred to in cubic feet per minute (CFM).

15 bars is the ideal and maximum pressure that should be used, while 10 bars of pressure is the minimum.

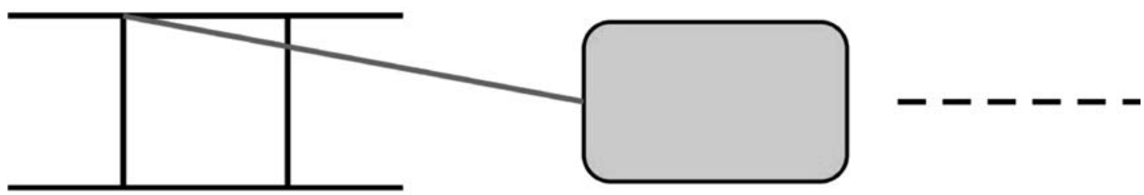
With 15 bars of pressure, the air flow should be 35 CFM minimum and 180 CFM maximum. At 10 bars of pressure, however, the ideal and maximum air flow should be 180 CFM.

While not required, it is strongly recommended that a compressor aftercooler with a water separator be used on the supply line to the fiber blowing equipment. An air compressor running continuously for 24 hours at 75°F and 75 percent humidity will produce about 18 gallons of water per day. A compressor aftercooler with a water separator can remove about two-thirds of the moisture and lower the compressed air temperature to within 15°F of ambient air temperature. The GMP compressor aftercooler #89009 is a suitable unit.

Since water and high temperatures in the microduct work against the process of blowing fiber, it is important to eliminate it. Doing so will increase the efficiency of blowing fiber, which will make it possible to blow through longer and more difficult runs.

Setting up for fiber blowing

Position the machine in line with the route of the duct. Position the cable reel or figure-eighted cable behind the machine and in line with the machine.



Cable reel / figure-eighted cable

Airstream

Microduct Route

It is possible to pay the fiber directly off the reel, but, due to the speed at which the cable pushes the fiber, two people may be required to assist the pay-off. Therefore, it is recommended that the length of cable that will be blown in is taken off the reel first.

Managing the cable when it is off the reel can be achieved using one of several methods. The methods selected should be based upon several factors:

- The amount of space available to the lay the cable out
- How clear of obstacles, debris, dirt/mud, and traffic the area is
- How many experienced people there are to support the feeding of the cable

The methods are to:

- Figure-eight the cable
  - Use a tarp in areas of dirt/mud, leaves, deep grass, and other debris
  - Figure-eight must be carefully watched to prevent entanglements, which are more common with microfiber because of their flexibility
- Figure-S the cable
  - Use this in areas where there is a lot of space with very little or no debris, no obstacles, and no traffic
- Cable fleeter
  - Optimum for limited space and high-traffic areas
  - Ideal for small crews as it can be monitored by the individual operating the blowing equipment

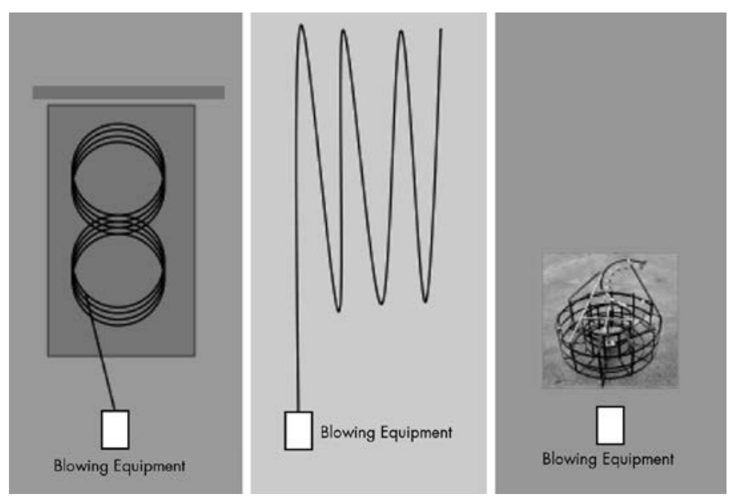
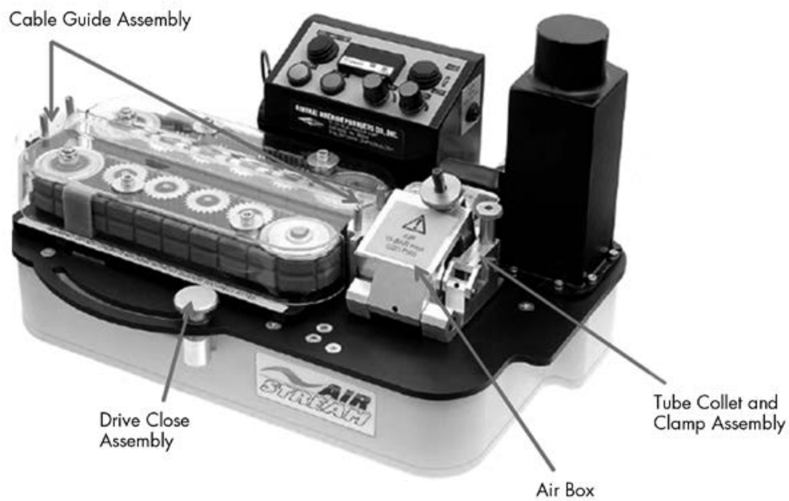


Figure-eight

Figure-S

Cable fleeter

Ensure the machine is fitted with the appropriate guides and collets to suit the cable being installed and tubes into which the cable is to be installed. For assistance, refer to the table in the appendix of this manual.



Tech tip: In dry air conditions, it is recommended to ground the machine using the ground lug to prevent static charges.

1. Loosen the knob on the drive close assembly and slide the assembly to the far right, opening the drive belts.
2. Loosen the knob on the air box and open the air box.
3. Loosen the knob on the tube collet and clamp assembly and open the assembly.
4. Slide the correct size O-ring over the end of the tube. Fit the tube into the end of the air box housing so it protrudes approximately halfway into the housing. Position the O-ring so it sits against the seal face, as shown.
5. Once the tube has been positioned, the tube clamp may be closed, the swing bolt swung down and the thumb nut tightened. The tube is now secure.
6. Insert the cable into the machine by feeding the cable through the first cable guide assembly, through the open drive belts, and through the second cable guide assembly, through the appropriate sized cable seal, and then into the microduct about one foot.
7. While holding the cable in place, slide the drive close assembly to the left. Apply enough force for the belts to grip the cable firmly and then tighten the knob on the drive close assembly.
8. Close the air box and tighten the knob to achieve a tight seal for the air box.

Tech tip: Cut a slit into a clean, dry sponge and lay the cable into the slit at the entry point to the blowing equipment. This will help reduce the amount of debris entering the machine and microduct during the blowing process.

To begin the fiber installation, set the torque at 50 to 60 percent, set the speed at around 30 percent, and set the machine to forward. The high/low torque selector should be set on low for the 2- to 60-ct fiber (5@1) and the 62- to 72-ct fiber (6@1), and set to high for all other cables.

The machine may now be started with the air off. Slowly increase the speed. The cable should be installed at a rate of 200–220 feet per minute. Installing at a faster rate can create too much friction, which may result in permanent damage and/or installation difficulties.

Once 100–300 feet of cable is installed, the air should be turned on. Slowly opening the air valve will prevent the initial airflow and pressure from working against the cable. It should take about 15–20 seconds to fully open the air valve.

Tech tip: Do not stop the blowing operation until the appropriate amount of fiber has been delivered to the desired location—unless there is a problem. Once the fiber stops, it is harder for the machine to start moving the fiber again, particularly as the distance increases or the runs become more complex.

Cable entry

Microfiber mid-sheath entry

Midsheath entry of microfiber cable is performed using a jacket slitter and buffer slitter while following the simple process that is outlined here.

Identify where the buffer tubes, winding switchback is located nearest to the center point of where the mid-sheath entry is going to be. This point is now the center of the mid-sheath entry. Mark this point by placing a band of tape around it.

The next step is to identify the choke points, where the mid-sheath entry begins and ends. To do this, measure from the center point in both directions half of the length that is going to being placed in the enclosure. Mark each choke point with a band of tape around it.

As an example:

When using the CommScope BOS-ENC-BG-2000 below ground splice closure, the recommended buffer tube length is 68". Each choke point would be measured 34" from the center point.

Remove the tape from the center point to allow the jacket slitter to pass unimpeded from one choke point to the other choke point.

Using one of these jacket slitters, open the jacket to each choke point. It is important to read the operating instructions provided with the tool for proper adjustment and operation.

Miller® (Ripley®) Tools
www.ripley-tools.com | 800-528-8665
ACS2 Armored Cable Slitter
Part No.: 37897
For Up to 144ct microfiber

Miller® (Ripley®) Tools
www.ripley-tools.com | 800-528-8665
400 Series Slitter

For up to 72ct microfiber
Part Number: 80835-012
5.6–6.0mm Dark Blue Guide 400 Guide Block Set

For 98-120ct microfiber
Part Number: 80835-013
8.1–8.5mm Orange Guide 400 Guide Block Set

For 144ct microfiber
Part Number: TBD
9.1mm Guide 400 Guide Block Set

Jonard Industries
www.jonard.com 914-793-0700
CSR-1575
For up to 144ct microfiber

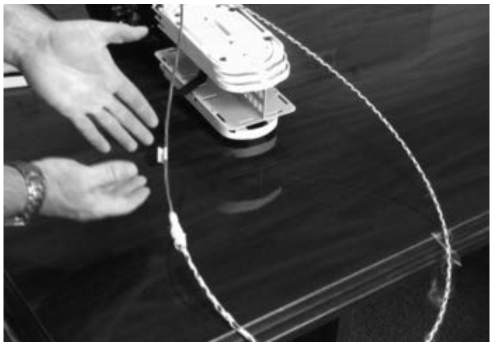
Tech tip: leave the rip-cord intact, forming a small coil, and tape the coil to keep it together; that way, if more length is needed, the rip-cord is already available.

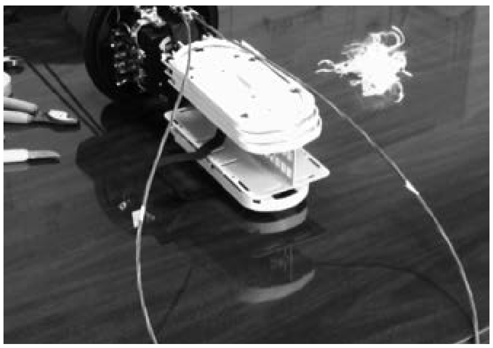
Remove the cable core from the jacket and trim the jacket at the choke points.

Working at one choke point, cut each aramid yarn binder being careful not to loosen the bind beyond the area where the cutting is being done.

Slide the binders just enough to create a space where a band of tape can be wrapped around the cable's core. Now continue sliding the binders until the first switchback is exposed. Being careful to keep the buffer tubes in their proper switchback positions, place a band of tape around the core of the cable. It is helpful to wrap the tape in the direction of the switchback. This process is continued until the binder reaches the other choke point. When complete, there should be a small tape wrap located at each switchback location.

Carefully cut away all the binder



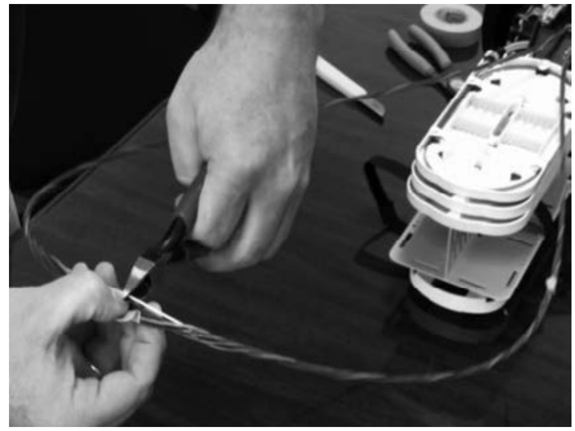


At one choke point, gently and slightly untwist the core just enough to access the central strength member and cut the central strength member to the required trim dimension for the enclosure based on the closure manufacturer's recommendations.

As an example:
When using the CommScope BOS-ENC-BG-2000 below ground splice closure, the recommended central strength member length is 0.625".

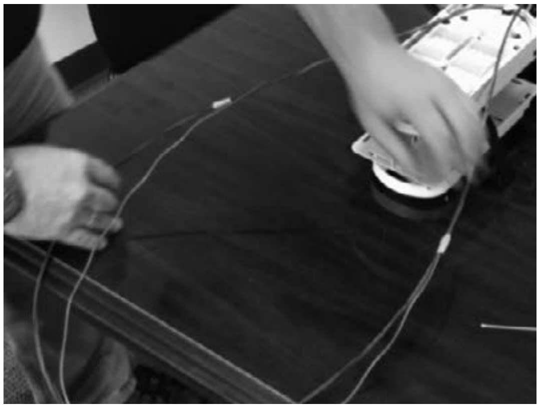
Repeat this process at the opposite choke point.

Partially remove the band of tape from the center switchback, then slightly untwist the core just enough to access the central strength member and cut the central strength member. Carefully pull out each piece of central strength member from the core. It is important to keep the core from untwisting while doing this, maintaining the core's integrity.

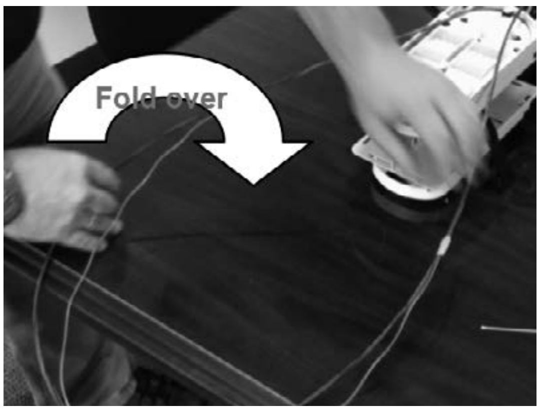


Next select the buffer tube that is to be accessed in this closure and start to untwist it from the core, making sure to keep the remaining buffer tubes in their wrapped position. This process starts at the center switchback, and requires that the tape be loosened. Separate the buffer tube from the core, and replace the band of tape around the switchback.

Continue separating the buffer tube from the core until the next switchbacks are reached. At only one switchback, partially remove the band of tape and separate the buffer tube past it; then, replace the band of tape around the core, keeping the core as it was. Repeat this process for the other switchback. This process is continued until the choke points are reached.



Now the cable core can be folded into a coil that will be placed in either the tray or the slack storage basket.



The buffer tube that is to be accessed for splicing can now be slit using a mid-sheath buffer tube slitter. Cut away the buffer tube from the fibers according to be required trim dimension for the enclosure based on the closure manufacturer's recommendations.

To perform a midsheath entry on the buffer tube, use one of these buffer tube slitters. It is important to read the operating instructions provided with the tool for proper adjustment and operation.

The fiber may now be stored in the splice tray.

Miller® (Ripley®) Tools
www.ripley-tools.com 800-528-8665
400 Series Slitter
For 1.6mm buffer tube
Part No.: 80950 | 400-1.8mm

Miller® (Ripley®) Tools
www.ripley-tools.com 800-528-8665
MSAT Micro: Part No.: 81460
MSAT Micro insert 1.6 mm | Part No.: 81516

Jonard Industries
www.jonard.com
914-793-0700
Mid Span Slitter MS-15

Restoration of E_2O CIC, microducts and microfiber

As with restoring any conduit product, there are many ways to restore E_2O CIC—from setting a new vault/pedestal at the point of damage to replacing the span from vault/pedestal to vault/pedestal.

One advantage E_2O CIC offers over traditional restoration is that the microduct can be quickly repaired, the damaged cable blown/pulled out, and a new one blown in over significant distances in a very short amount of time.

Should the restoration be done as a repair in place instead of setting a new vault/pedestal, it is recommended that the outer conduit be repaired as well as the microducts. This will provide the necessary protection for the microducts so fiber can be blown into them. The same previously given techniques used for coupling the microducts should be used.

The outer conduit can be repaired using a split duct repair solution available in the market. Or a larger conduit can be split in half in the field, banded together with zip ties and epoxy-sealed around the joints to prevent water and mud migration into the conduit.

Appendix—Specification and packaging

MICROFIBER PHYSICAL SPECIFICATIONS

Fiber count	Catalog number	Cable outer diameter	Subunits	Weight	Minimum bend radius		Max. tensile window		Max. vertical rise
					Loaded	Unloaded	Short term	Long term	
2–60	B-XXX-LN-XYFZZNS/16G[1]	5.5 mm; 0.21 in	5	20 kg/km; 14 lbs./kft	8.2 cm; 3.2 in.	5.5 cm; 2.1 in.	324 N; 73 lbs.	97.2 N; 22 lbs.	488 m; 1,600 ft.
62–72	B-XXX-LN-XYFZZNS/16G[1]	6.0 mm; 0.23 in	6	26 kg/km; 17 lbs./kft	8.9 cm; 3.5 in.	6.8 cm; 2.7 in.	600 N; 135 lbs.	180 N; 40 lbs.	721 m; 2366 ft.
74–96	B-XXX-LN-XYFZZNS/16G[1]	7.0 mm; 0.28 in	8	39 kg/km; 26 lbs./kft	11.0 cm; 4.3 in.	11.0 cm; 4.3 in.	1490 N; 335 lbs.	447 N; 100 lbs.	1,177 m; 3,860 ft.
98–120	B-XXX-LN-XYFZZNS/16G[1]	8.1 mm; 0.32 in	10	50 kg/km; 34 lbs./kft	12.1 cm; 4.8 in.	11.0 cm; 4.3 in.	1512 N; 340 lbs.	453.6 N; 102 lbs.	925 m; 3,034 ft.
122–144	B-XXX-LN-XYFZZNS/16G[1]	9.1 mm; 0.36 in	12	62 kg/km; 42 lbs./kft	13.7 cm; 5.4 in.	11.0 cm; 4.3 in.	1566 N; 352 lbs.	469.8 N; 108 lbs.	769 m; 2,521 ft.

Variables in the Catalog Number

XXX – XXX	[1] B-XXX-LN-XY-FZZNS/16G/AAaaa/BBbbb	Composite Cable with multiple fiber types. See information above for requested total fiber count.

PACKAGING

Product	Weight in pounds	Reel size (height x drum x width)	Length (ft.)
E_2O200T135875JCASS-16MT-12.7MB - TW	2355	90 x 48 x 43"	2500'
E_2O200T135715JCASS-16MT-12.7MB - TW	2447	96 x 48 x 43"	3000'
E_2O200T135625JCASS-16MT-12.7MB - TW	1982	90 x 48 x 43"	2400'
E_2O200T(TD)135-16MT-16MTTB-12.7MB-12.7MBTT	1887	90 x 48 x 43"	2500'

BLOWING EQUIPMENT SETUPS

Fiber count	Tubes	Part #	Description
122–144	12@1	89517	Cable seal 9.5–11mm
		89304	Guide cable assembly 8.5–11mm
		89373	Seal cable assembly 9.5–11mm ARST
98–120	10@1	89516	Cable seal 8.0–9.5mm
		89304	Guide cable assembly 8.5–11mm
		89379	Seal cable assembly 8.0–11mm ARST
74–96	8@1	89516	Cable seal 8.0–9.5mm
		89304	Guide cable assembly 8.5–11mm
		89379	Seal cable assembly 8.0–11mm ARST
62–72	6@1	89514	Cable seal 6.4–8mm
		89303	Guide cable assembly 6–8.5mm
		89378	Seal cable assembly 6.48mm
2–60	5@1	89513	Cable seal 5–6.4mm
		89307	Guide cable assembly 3–6.4mm
		89377	Seal cable assembly 5–6.4mm

Microduct	Part #	Description
16/13mm	89317	Tube collet and clamp assembly 16.0mm OD
	89555	Tube seal O-ring 14mm
12.7/10mm	89315	Tube collet and clamp assembly 12.7mm OD
	89552	Tube seal O-ring 12–12.7mm
All	89691	Spare seal cord

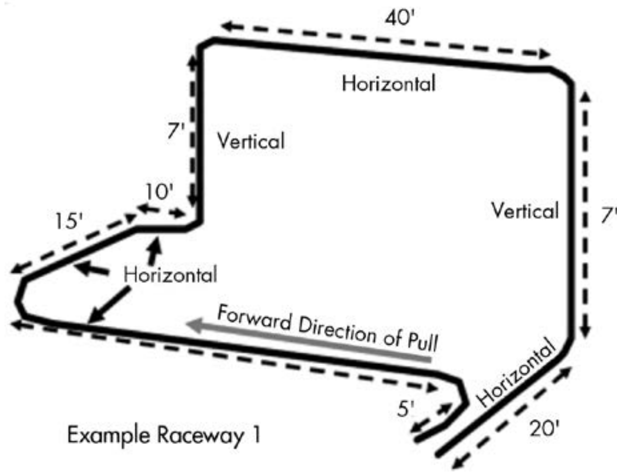
Telcordia trial

This trial is defined in Telcordia Technologies Generic Requirements GR-3155-CORE Issue 1, November 2007 Generic Requirements for Microducts for Fiber-Optic Cables.

The test configuration and conditions describe generic raceway examples and duct configurations wherein the test raceway shall include at least:

- Six (6) x 90-degree bends
- Two (2) straight horizontal runs of at least 25–35 feet
- Two (2) straight vertical runs of at least 6–10 feet

Example: Raceway 1 was selected as it presented the most complex configuration. The trial was built with the lower horizontal runs underground, the verticals transitioning from underground to above ground, and the horizontal run atop the verticals was above ground as well. The underground portion was built with two-inch SDR 13.5 conduit in which the three different microducts were placed for additional protection.

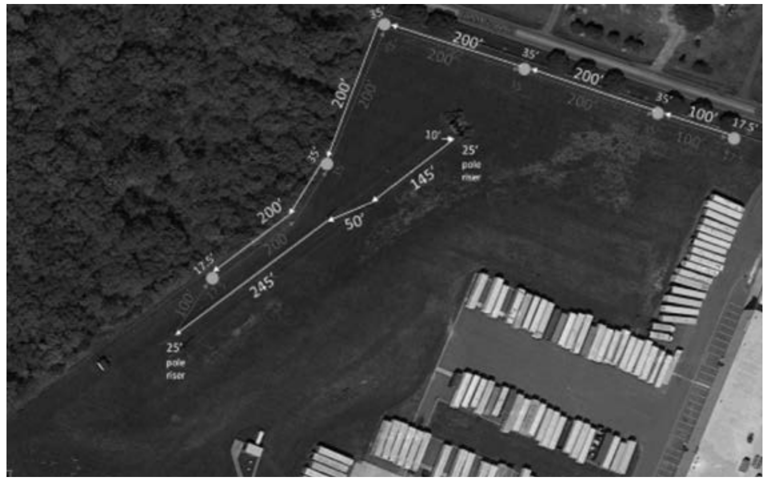


This raceway was used to successfully blow in the following microduct/microfiber matrix:

Microduct			Microfiber		
Size	OD, in.	ID, in.	MF, count	OD, in.	% fill
10/8	0.396	0.315	2–60	0.22	49
10/8	0.396	0.315	62–72	0.23	54
12.7/10	0.500	0.394	2–60	0.22	31
12.7/10	0.500	0.394	62–72	0.23	34
12.7/10	0.500	0.394	74–96	0.28	51
12.7/10	0.500	0.394	98–120	0.32	66
16/13	0.625	0.500	74–96	0.28	32
16/13	0.625	0.500	98–120	0.32	41
16/13	0.625	0.500	122–144	0.36	52

The installation in this trial required no lubricant or air to assist in pushing the fibers. No failures.

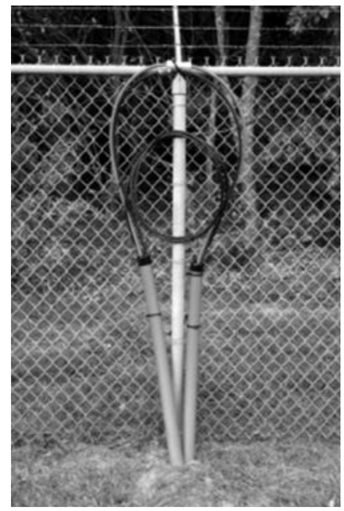
FTTH trial



This trial was developed to simulate typical subdivision construction for FTTH. It incorporates both aerial and underground segments. The entire run is 2950 feet. The time for fiber installation was 13.5 minutes.

The aerial segment at 500 feet is intended to represent a major road that passes a subdivision with aerial plant. The aerial plant transitions to an underground build into the subdivision. For the aerial segment, the 16-, 12.7-, and 10-mm microducts were overlashed to a 145-foot span of ¼" strand with QR875JCA already lashed to it. The microducts then continue to be lashed to a bare ¼" strand on a 50-foot 45-degree angle pole to another bare ¼" strand for 245 feet. The risers on both ends of the aerial run are 25 feet.

The underground segment totals 2450 feet. It has 11 simulated pedestal locations: nine at 200-foot spacing to simulate every other lot line, and two at 100-foot spacing to simulate single lot lines. All of the pedestal locations are set back 10 feet from the "easement," which makes four 90-degree bends at nine of the pedestals and two 90-degree bends at two of the pedestals. Each pedestal also has a 180-degree loop through to the next pedestal. The pedestal has a rise of seven feet.



The seven-foot rise of the microduct along with the 180-degree loop creates a length of 15 feet of microduct that, after the cable is blown in, can be slit and removed to expose the fiber cable. The 15 feet is the recommended length of cable needed for entry into an optical tap. This length can be adjusted to suit specific customer requirements.

Pedestal
Additionally, at each pedestal, the microducts were cut and coupled to increase the difficulty of the installation. Each coupler presents a transition obstacle through which the cable must pass. Placing the couplers in the 180-degree loop presents an added level of difficulty as well.

Here is the complexity of the runs:

Total

- 180-degree bends: nine
- 90-degree bends: 44
- 45-degree bends: five
- 25-foot verticals: two
- 7-foot verticals: 21

Underground

- 180-degree bends: nine
- 90-degree bends: 40
- 45-degree bends: three
- 7-foot verticals: 21

Aerial

- 90-degree bends: four
- 45-degree bends: two
- 25-foot verticals: two

FTTH trial

This raceway was used to successfully blow in the following microduct/microfiber matrix:

Microduct			Microfiber		
Size	OD, in.	ID, in.	MF, count	OD, in.	% fill
12.7/10	0.500	0.394	2–60	0.22	31
12.7/10	0.500	0.394	62–72	0.23	34
12.7/10	0.500	0.394	74–96	0.28	51
12.7/10	0.500	0.394	98–120	0.32	66
16/13	0.625	0.500	122–144	0.36	52

Everyone communicates. It's the essence of the human experience. *How* we communicate is evolving. Technology is reshaping the way we live, learn and thrive. The epicenter of this transformation is the network—our passion. Our experts are rethinking the purpose, role and usage of networks to help our customers increase bandwidth, expand capacity, enhance efficiency, speed deployment and simplify migration. From remote cell sites to massive sports arenas, from busy airports to state-of-the-art data centers—we provide the essential expertise and vital infrastructure your business needs to succeed. The world's most advanced networks rely on CommScope connectivity.

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