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Micro Cables, Application (Ducts & Accessories, Equipments, Installation)

AUTHOR Timo Perttunen

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#### ABSTRACT

Microcables have been developed in purpose to utilize existing and new duct systems more effectively by accommodating more fibers in given sub-duct network. Another benefit is its light weight compared to conventional loose tube cables. By reducing cable weight installation lengths increase as in blowing installations cable weight is one of the main parameters that define how long lengths can be blown in to the duct. Also overall cable handling becomes easier because lighter cables do not require that robust and heavy drums nor heavy equipments. This all could lead to cost reduction during cable deployments. One drawback, if it can be considered, is that microcables are naturally not that robust than other cable designs that are deployed and used in the same applications, like conventional loose tube cables and ribbon cables. This document provides the information of applications of Microduct and Microcable.

#### **KEYWORDS**

FTTx, FTTH, Access / Metro networks, Backhaul (Backbone), Duct, Microducts, Direct buried, Armored, Dielectric, Blowing installation, Jetting, Figure 8, Aerial cables, Fiber type, CFU(Compact Fiber Unit), 200micron

#### Introduction

Usual applications and deployment locations for Microcables are Access / Metro and (air blown) Drop cabling for FTTx networks, like Fiber To The Home (FTTH). Number, size and design of ducts are to be decided by network topology as well as equipments for installation. This document provides information about microducts, microduct cables, and how to install this type of fiber optic plant. It provides information on how the microduct system differs from more traditional plant using full size cables. The advantages of the microduct system concept are presented. It includes the economic issues that play an important role in justifying the use of the microduct system. Special equipment is normally used to place microduct cable in its micro-ducts; this equipment is described and generic installation procedures are presented.

The microduct concept was developed to take advantage of the economics related to providing service to match telecommunication demand at the time the demand exists. The microduct system allows small diameter, very compact fiber cables to be placed using modern, cost effective installation procedures in small diameter, protective micro-ducts located in available space in underground plant or direct buried plant or in microducts inside of sub-ducts lashed to aerial messenger strands. When new service develops, new microduct cables can be placed in previously installed spare microducts.Since empty microducts contribute little extra infrastructure cost at the time of initial construction, they provide considerable flexibility and cost savings. Microduct systems use small ducts and compact, small diameter fiber cables to enable the unique microduct system to work. Next chapters show examples of microducts, multiple chamber microduct units, and Sterlite Technologies microduct cables. In addition to the special ducts and cable, equipment specially tuned to place microduct cables in microducts is available. This equipment will be briefly described in this

**Note:** however, each equipment manufacturer publishes instructions on how to use their equipment. The manual associated with the equipment being used should be read, understood, and consulted before any installation operation is attempted.

## 2. Micro Ducts

Traditionally, full-size underground fiber cables have been placed in polyethylene subducts often called innerducts, nominally 25-51 mm in diameter. Innerducts are located in conventional telecommunications duct systems, 75 to 100 mm inside diameter made of PVC, concrete, clay tile, or bituminous fiber. Usually 3 to 4 innerducts can be placed inside a 100 mm main conduit. One telecommunications standard size optical cable is generally placed in each innerduct. By using smaller diameter microducts matched to the size of small diameter microduct cables, the telecommunications conduit system can be divided into many small, but secure, locations for the smaller diameter "microduct" fiber cables to be placed. These micro-ducts can be placed in innerducts, sub-ducts, or larger telecommunication conduits already in place in the outside plant (OSP). A related multiunit product is produced by factory installing microducts into new innerducts or sub-ducts; alternately, microducts can be factory installed into larger casings that group multiple microducts into a flexible over cased unit (see FIG1) which can be placed into the underground conduit system or direct buried. These microducts allow fiber cable to be installed to match current service demands along with spare duct space to be used at a later date to provide space to place new cables to match future demands when those demands arise.



#### **FIG1 Microduct**

The individual microducts in the multiduct unit are assembled in the factory and enclosed with an oversheath. As with individual microducts, they are color coded with respect to their diameter. Both individual microducts and multiduct units are coiled on large reels in long lengths to match the job requirements. The microducts provide the cables they house with additional mechanical protection at splice closures, cable splice chambers, and in the actual outside plant system along the right-of-way. The protection includes the microduct, innerduct or over casing, and the underground duct system, if present. Microduct cable used and the protection required.

The microducts provide an air tight enclosure for the cables which enables air jetting (blowing) to be used as a cable placing technique. The inside bore of many microducts are coated with a low friction material to ease cable placing forces. The microduct also contributes to the protection of its cable from its surrounding environment.

There are many microduct and sub-duct manufacturers that produce high quality, robust ducts that remain serviceable with good pressure resistance for future cable jetting installation many years after installation. These ducts are made from materials that will remain specially tuned for the microduct cable system and jetting procedure and remain stable for many years. Heavy wall microducts retain sufficient crush resistance for them to be used in buried plant for cable placement many years after installation.

Microduct systems have been used successfully as a standard cable system throughout Europe, the Americas and other worldwide locations for the last decade.

#### 3. Micro Cables

Cables that can be called as "Microcable" varies from design, application and manufacturers choice. But usually as microcables are considered designs where cable weight and OD (Outer Diameter) is significantly reduced compared to conventional cables. For example 12F conventional Unitube Drop cable's OD can vary between 4 to 8mm, when similar Micro design is 2.5mm OD or even down to 1.6mm (Air Blown CFU). Another example is 288F Microcable which nominal OD is 10.5mm (even down to 9mm with 200micron fibers) when conventional (Duct) cable ODs are > 18mm.

Main microcable designs include stranded loose tube, central tube (for example with multiple micromodules) and unitube designs. What's common for all of these is low weight, OD and reduced amount of jelly in jelly filled designs. Usually microcables comes unarmored (no metal, dielectric) and hence cannot be used in deployments where cables are to be direct buried. Microcable designs are available for both Indoor and Outdoor environment and with or without jelly. Even when micro loose tubes (or micromodules) are jelly filled, amount of jelly is considerably lower than in conventional loose tubes and almost never manufacturers offer designs with wet core (flooded cable core) but designs are Dry core, Wet or Dry loose tubes. Much lower amount of jelly plays crucial part in reducing cable weight.



#### 1. CENTRAL STRENGTH MEMBER

- 2. MICRO LOOSE TUBE WITH FIBRES & GEL
- 3. WS YARNS
- 4. CORE WRAPPING
- 5. RIPCORD(S)
- 6. OUTER SHEATH



#### 3.1 Sterlite Micro DUCT-LITE Cables

Sterlite Micro DUCT-LITE fiber optic cables are compact optical cables designed to be used as part of the microduct system. They are cables with diameters ranging from 6.0 to 10.5 mm with compact fiber counts ranging from 12 fibers to 288 fibers. Currently, Sterlite's Micro DUCT-LITE fiber optic cable series is all multiple tube construction with color coded individual buffer tubes and fibers, (see FIG3). The optimal service for which the microcable is used will be determined by the fiber that it contains, i.e., ITU-T G650 series fiber. So these cables can be configured to serve both FTTH and long haul markets by careful cable and fiber selection. The Sterlite Micro DUCT-LITE cable is designed especially for enhanced jetting performance and can be installed in currently occupied ducts. These cables will continue to meet future telecommunication needs, as well. Dry core, small diameter and reduced weight make them ideal for jetting long distances. Water blocking compounds in the buffer tubes and core provide longitudinal water protection. Multiple tube designs allow for easy mid-span access. The cable series uses a specially developed low shrinkage, high-density polyethylene sheath with a nominal thickness of 0.5 mm. The Sterlite Micro DUCT-LITE cable jacket is made from a special low friction, high density polyethylene (HDPE) that has a surface finish intended to create sufficient air drag during air jetting to lift the cable off the inside wall of the microduct and provide a uniformly distributed assisting force along the outer perimeter of the cable.



Fig3 - Cable diagrams of Microcable

The below table provides a complete listing of Sterlite's Micro DUCT-LITE fiber optic cable series.

250 Micron Optical Fibre							
Fibre Count	Design	Fibres per tube	Sheath Material	Nominal Cable Diameter (mm)+0.3mm	Max. Tensile Strength(N)	Crush Resistance (N/100mm)	Duct Size, OD/ID, mm
12F-72F	72F(12FX6 LT)		HDPE	5.6	700	500	(10/8) or (12/8)
96F	96F(12Fx8 LT)		HDPE	6.5	1000	500	(10/8) or (12/8)
144F	144F(12FX12 LT)	12	HDPE	8.4	1000	500	(16/12)
144F	144F(12FX12 LT)		Nylon	8.2	1000	500	(16/12)
288F	288F(12FX,9+15)		HDPE	10	1000	500	(18/14)
288F	288F(12FX,9+15)		Nylon	9.8	1000	500	(18/14)
				1	1	1	
144F	144F(24Fx6 LT)		HDPE	7.0	1000	500	(12/10) or (14/10)
144F	144F(24Fx6 LT)	24	Nylon	6.8	1000	500	(12/10) or (14/10)
192F	192F(24FX8 LT)		HDPE	8.2	1000	500	(16/12)
192F	192F(24FX8 LT)		Nylon	8	1000	500	(16/12)
432F	432F(24F,6+12LT)		Nylon	12.2	1000	500	(22/18)
576F	576F(24F,9+15LT)		Nylon	14.8	1000	500	(32/26)

 Table 1.1 - Sterlite Micro DUCT-LITE Fiber Optic Cable Series Multitube Single

 Jacket Microduct Fiber Optic Cable

200 Micron Optical Fibre								
Fibre Count	Design	Fibres per tube	Sheath Material	Nominal Cable Diameter (mm) + 0.3mm	Nominal Cable Weight (kg/km) 10%	Max. Tensile Strength (N)	Crush Resistance (N/100mm)	Duct Size, OD/ID, mm
196F	96F(12Fx8 LT)		HDPE	5.8	33	700	500	(10/8) or (12/8)
288F	288F(12FX(9+15)LT)	12	HDPE	8.8	72	700	500	(16/12)
288F	288F(12FX,9+15)		Nylon	8.6	70	700	500	(16/12)
144F	144F(24FX6 LT)		HDPE	5.9	32	1000	500	(10/8) or (12/8)
144F	144F(24FX6 LT)	24	NYLON	5.7	31	1000	500	(10/8) or (12/8)
192F	192F(24FX8 LT)		HDPE	6.8	50	1000	500	(12/10) or (14/10)
192F	192F(24FX8 LT)		NYLON	6.6	48	1000	500	(10/8) or (12/8)
288F	288F(24FX12 LT)		HDPE	9.1	75	1000	500	(16/12)
288Fi	288F(36FX8 LT)		HDPE	8.2	70	1000	500	(14/10)

#### Table 2 - Sterlite Next Gen Micro DUCT-LITE Fibre Optic Cable

#### 2. Application (Microcables for Duct installation)

#### 2.1. Advantages

Micro-duct systems have become popular because they provide those that employ this system with the following benefits that compare favorably to traditional OSP construction methods:

- OSP space is used more efficiently; more fibres can be placed into a standard telecommunications innerduct and sub-duct. Any vacant space is a potential candidate for microduct fibre optic cables. By reducing wasted conduit space, Micro DUCT-LITE Cables allow maximum utilization of all current and future telecommunications infrastructure.
- Fibre technology and service demands are dynamic; as a result capital investments (CAPEX) in cable infrastructure can be made to match current fibre optic needs with microduct cables without investing in a capital intensive cable for future needs. With this philosophy, you can utilize the latest in fibre technology as it becomes available, without speculating in future needs.
- Capital investments in cable can be made to match the revenue generating service demands that exists at the time the cable is placed; fibres do not need to remain in place for long periods without earning revenue.
- Cables can be placed in long lengths without intermediate assistance. It is not uncommon to place microduct cable in continuous lengths, without intermediate assist, of 2000 to 4000 meters depending upon the mapping of the right-of-way.
- By placing a few sub-ducts with micro-ducts into new telecommunication conduit systems or when cable is trenched in place, most concerns of future expansion are solved inexpensively. Future cable placement to meet future demands will be rapid and not interrupt existing services.
- Since the cable consists of many varied pathways, it enables greater flexibility to inexpensively meet unexpected service demands (OPEX).

- A large number of micro-duct pathways provide high levels of mechanical and environmental protection to the cable; existing service is provided better diversity and protection than conventional cable. Alternate routing to detour around maintenance issues is expedited with micro-duct systems.
- Since there are very few excess fibres in place, the investment risk at any given time is lower.
- The color-coding, separation of cables, and organization of cables provided in the micro-duct system, provide a system that is easier to maintain than conventional fibre cable.

## 2.2. Installation Environment

The microduct system is suitable for use in all types of outside cable applications. It initially appears that the system is only useful in underground systems. While there may be more microducts used in underground, it is not the only cable in which it is advantageously used. The microduct system can also provide robust performance over a long service lifetime in both buried and aerial cable. The same favorable economics exist for each type of outside cable for which it is used.

Sterlite Micro DUCT-LITE cable can be used to meet long-haul service applications as well as local FTTX demands. Micro DUCT-LITE cable is available in a variety of sizes, fibre counts, and fibre types to make it a good fit for nearly every application.

In addition to always installing micro-duct systems in unused conduit, the microduct system can be used to "overbuild" existing cable cable in the underground cable system. Microducts can be jetted (blown) into conduit or innerducts already occupied by optical cable. Overbuilding existing cable can be cost effective and provide high quality cable facilities as long as the maximum fill ratio discussed in Section 5.3 is not exceeded.



FIG4 - Examples of "Overbuilding" in 1" - 32/27mm and 11/4" - 40/33mm Innerducts

## 2.3. Fill ratio, Duct packing density

Normally, micro-duct cables are jetted into an appropriately sized micro-duct. To insure that the jetting operation can be done efficiently, micro-duct should be selected to have some space between its inner diameter (ID) and the cable it contains. The recommended fill ratio has been empirically determined from actual jetting experience. It varies depending upon the length of the cable, the number and severity of the bends in the microducts, and the air pressure used. Using the following formula for FILL RATIO, the fill ratio should be no greater than 60 to 70%, although cables have been successfully jetted at higher fill ratios using higher air pressures.

FILL RATIO =  $(d^2/D^2) \times 100$ 

Where,

d = outside diameter of cable and, D = inside diameter of microduct

This fill ratio should assure sufficient air movement and jetting force can be developed to enable the cable to be placed in its microduct. At very low fill ratios, the placing operation is less effective than at a greater fill ratio. The same formula can be used for microducts being jetted into innerducts or sub-ducts. Based upon the fill ratio formula, above, a Fill Ratio of approximately 60 to 70%, and empirical data from previous field experience the information in Table 3 has been assembled to show the number of different size microducts that can be field installed in standard sized innerduct.

Innerduct Nominal Diameter (in)	12/10mm Microducts	10/8mm Microducts	7/5.5mm Microducts	
3/4	None	1	3	
1	2 3		5	
1 1/4	4	5	10	
11/2 6		8	15	
2 8		10	20	

#### Table 3 - Micro-Ducts That Can Be Field Installed in Innerduct

Using a 60 to 70% maximum fill ratio, each microduct is sized to accept cables up to a maximum diameter, unique to the ID of the microduct in which it is placed. Table 4 relates this unique maximum diameter for each microduct to the fibre range of Sterlite Micro DUCT-LITE cables encompassed by this microduct size.

When cables are installed into conduit or innerduct, the maximum cable diameter attempted / recommended will normally not exceed 50 to 60% of the conduit or innerduct ID.

#### 3. Equipments, accessories and Installation procedures

#### 3.1. Euipment, accessories

The microduct system is based on a combination of small diameter ducts and more compact optical cables using more efficient placing methods and equipment specially tuned to the duct and cable to produce the benefits listed in Section 5.

The following table shows examples of the special placing equipment and hardware that is used to place microduct and cable.



 Table 3 - Typical Placing Equipment Used to Place Microducts and Microduct Cables



#### 3.2. Installation, placing procedures

Main installation method for Microcables is Blowing / Jetting where cable is pushed ahead by air flow. In Jetting, blowing machine pushes cables ahead as well with "caterpillar". On markets there's widely available different blowing and jetting machines for different cable dimensions for duct installations. Correct duct size, blowing machine and other details for installation of any microcable can be calculated and simulated (for example with available commercial softwares) when maximum blow length would always be dependent also on weather conditions (cold/warm/moist/dry), route design (corners, its angle, uphill/downhill sections) and deployment itself (cable handling/cleanliness, lubrication used or not). The force to install a cable into a duct is caused by sidewall forces between cable and duct and between cables (for ducts containing more than one cable), resulting in friction. Microducts and micro cables are each designed to optimize the use of available space in the right-of-way. The placing methods discussed in this section have been developed to enable microducts and micro cables to be placed, safely, efficiently, and economically.

Both microducts and micro cables can be placed using several procedures:

- Pulling, a system to place cables or ducts for shorter length runs of underground cable and in previously installed buried and aerial microducts. Both ducts and cables can be placed with the pulling method. Pulling tends to be more popular in larger diameter ducts or sub-ducts.
- Jetting (=blowing & pushing), used in longer lengths of underground cable and in previously installed buried and aerial microducts. Both microducts and micro cables can be placed using jetting. Jetting is most effective in smaller ducts of 50 mm diameter or less. It is possible to place microduct cable using jetting in continuous lengths of 1200 to 2000m (4,000 to 6,000 feet), depending upon the geometry of the right-of-way.
- Lashing, used on aerial sub-ducts or microducts. Lashing attaches micro-ducts to an aerial messenger strand, or aerial cable. Once in place, the micro-duct can have cable pulled (not usually recommended) or jetted into place. Self-supported figure-8 sub-ducts are available to be attached to aerial support structures. The self-supported sub-ducts can be filled using pulling for sorter length cables or using jetting for longer length cables.

## 3.2.1. Pre-Cable placement

- An engineering pre-placement survey should be made to determine the placing and pulling manholes, staging areas, access issues with respect to the right-of-way, and the details of the cable placement operation. The pre-survey shall be summarized in drawings made available to the placing crew.
- Cables and microduct (if required) shall be delivered to a staging area designated in the pre-placement survey by the service provider or contractor installing the cable. The staging area shall be safe and secure. It shall also provide convenient access to the right-of-way.
- The cable reel mechanical and thermal protection shall be left in place until the reel is going to be used. If access is to the cable end is required, the thermal wrap shall be replaced after the access has been completed.
- All Sterlite cables are shipped with loss information on each fibre. The information is provided electronically or as a hard copy attached to the cable reel.

All reels need to be inspected for damage as they are received. As a precaution and to avoid costly extra cable removal operations, all fibres should be measured on the reel in the "as received" state using an OTDR. Measurements on single-mode fibre cables should be made at 1550 nm and 1300 nm on multimode fibre cables. If discrepancies are found with respect to the factory "as shipped" test results on the cabled fibre, contact Sterlite directly.

## 3.2.2. Jetting

#### 3.2.2.1. Pre-Jetting Procedures

- The microduct system needs to be checked to be sure it is air tight between sections or between intermediate assist locations. If leaks are present they need to be fixed or else jetting distance will be sacrificed. The cable diameter needs to be measured at several locations along the cable length with sufficient accuracy and at enough locations to assure the size selected for the cable dies of the pusher/blower placing engine to properly fit the cable.
- The placing equipment shall be setup to provide direct and smooth passage of the cable into the microduct. All equipment shall be cleaned and adjusted to assure all parts are properly sized to grip and/or pass the cable that is being installed. Cable should be kept clean and as free from dust and/or other dirt as possible.
- Microducts, innerducts, and feed tubes shall be adjusted to keep bends in the cable from violating the cable minimum bend radius. If macroduct is being placed, care must be taken not to kink, distort, or crush the duct. The micro-duct manufacturer's recommended minimum diameter shall be maintained, if no diameter is recommended, use the minimum diameter recommended below.

Cable under no load, Minimum bend radius  $\ge$  15 × Cable Diameter Cable under load, Minimum bend radius  $\ge$  20 × Cable Diameter

- An air cooler should be considered to cool the compressed air between the compressor and the duct, especially if the ambient air temperature exceeds 25° C (80° F). It is possible on hot days for the compressed air to reach a temp of 200° C (390° F), if an air cooler is not used. The air in the microduct should never exceed the maximum cable installation temperature, typically 50° C (120° F). At temperatures above the cable's maximum installation temperature, the cable's outer jacket can soften causing an increase the coefficient of friction between cable and duct, resulting in an increase in placing force and limiting the placing distance.
- The placing operation requires good communications between all locations along the right-of-way. Radios are usually required to provide the level of communications required. Before placing is started, the communications system shall be tested.
- Remove 1 or 2 cm of the microduct cable's outer jacket. Use a 5 minute epoxy to seal off the cable end and also to mechanically bond all portions of the cable together, i.e., jacket, core, buffer tubes, fibre, and central strength member. Epoxy should be applied to cause a smooth blunt end without increasing the diameter of the cable.
- The cable jetting machine will have a pushing tread on it to provide a pushing force to the cable to assist it into the microduct as it is propelled forward with the air jetting. The pushing force could conceivably cause a buckling in the cable if the jetting fails or if the cable jams in the microduct. The bucking force of the cable should be determined before the placing operation begins. Install the cable in the placing engine. Block the forward motion of the end of the cable. Allow the placing engine to push the cable until it buckles or kinks. Record the force at which the action occurs. Set the push limiter on the

placing engine to 75% of the measured buckling load. This should keep the microduct cable from bucking if a jetting problem develops.

- Set the maximum tensile force exerted by the placing engine to 80% of the maximum placing load for the cable to assure that the cable's maximum pushing load will not be violated.
- Polywater offers the microduct cable placing lubrication estimate shown in Table 5 to place microduct cable in various size microducts. Pour approximately 75% of the lubricant indicated in Table 5 directly into the micro-duct ahead of the missile with the remainder of the lubricant being placed on the cable during the placing operation. Note, the actual quantity of lubrication used on any placing operation varies and is dependent upon the size, condition, and wall type of the microduct and the material in the duct and cable jacket.

Microduct Size (mm) (OD/ID)	Amount of Lubrication Required Per 30m/100 ft		
14/12 mm	0.30 fl. oz (9 ml)		
12/10 mm	0.25 fl. oz (7 ml)		
10/8 mm	0.20 fl. oz (5 ml)		
8/6 mm	0.15 fl. oz (4 ml)		
7/5 mm	0.13 fl. oz (4 ml)		
5/3.5 mm	0.09 fl. oz (3 ml)		
4/3 mm	0.08 fl. oz (2 ml)		

 
 Table 5 - Approximate Volume of Lubrication Required For Cable Jetting in Various Size Microducts

## 3.2.2.2. Microduct Cable Jetting

Before the cable placing operation begins, the microduct system should be checked to be assured the cable's minimum bend radius is not violated during handling, feeding, placing, and final positioning. The equipment and all pressure fittings should be checked. The placing engine should be checked to confirm that the tension and compression limits matching the cable being placed have been properly and accurately set. Radios should be checked to confirm that all manned positions along the right-of-way are in communications and prepared to start the placement. FIG7 shows a typical unassisted microduct cable jetting operation.





All transitions into and out of manholes shall be direct and smooth, not violating any of the cable's mechanical or geometrical limits. Air pressures and hydraulic pressures shall be set according to the placing engine manufacturer's instructions. The operation of the placing engine during placement shall follow its manufacturer's instructions.

The placing operation shall begin slowly and continue at the slow speed until it is clear that the placing operation is progressing smoothly. The placing speed can be increased gradually until the operation reaches a fast, but completely under control speed. Speeds from 30 to 60m/min (100-190 ft/min) or more can be reached depending upon the experience of the crew and the geometry of the placing route. Sterlite and the placing engine manufacturer recommend that the placing operation be performed at a safe and controllable speed. If the placing operation is too difficult to accomplish in a single, unassisted operation, two alternative methods can be considered:

Intermediate Assist
 Bidirectional Placement (Figure-Eight)

Individual conduit segments in both the intermediate assist and bidirectional placement methods need to be kept a bit shorter in length than the unassisted placement route. As a rule of thumb, placing runs in both assist procedures should be limited to 1.5 km or shorter. Since both intermediate assist methods have duct systems that are discontinuous at assist manholes, each of these discontinuous duct segments need to be lubricated independently, i.e., they need to have lubrication applied ahead of the cable, and then on the cable as it passes through the intermediate assist manhole or figure-eight manhole that leads into the next duct segment. Each placing engine in an intermediate assist procedure needs to be adjusted with the mechanical limitations determined for the cable being placed, i.e., maximum compression and tensile force.

## 3.2.2.3. Bidirectional Figure-8 Procedure

A placing plan listing the pulling locations, intermediate assist, and figure-8 locations should be developed during a pre-survey of the placing project. The placing plan will indicate the cable length to be coiled at the "figure-8" point.

For bidirectional placing operations a convenient intermediate point is selected for the figure-8 location. It should be near mid-span and, if possible, the duct section in both directions out from the figure-8 manhole should be placeable in a single operation.

Cable is jetted toward the intermediate figure-8 manhole following the jetting procedure outlined above. All cable is pulled off the reel with the excess cable figure eighted in a coil about 10 meters long at the intermediate figure-eight manhole. The figure-eighting of the cable shall be done carefully, in a safelocation free from access by the public.

Sufficient cable shall be left in the initial cable feed manhole to complete the splice to its neighboring cable and to provide cable slack for future maintenance operations.

After all cable has been pulled off reel and the excess cable figure eighted, the pulling engine shall be moved to the figure-8 manhole and set up to complete the cable jetting operation from the figure-8 coil at the intermediate figure-8 manhole. The figure -8 coil must be carefully turned over ("flipped") so that the cable that was on the bottom is now on top. This cable coil "flip" will enable cable to be fed off the top of the coil to the far manhole to complete the placing operation.

Also special accessories are available for Figure-Eight handling which could reduce the number of manpower and total installation time.

The final segment of microduct will be jetted from the figure-eight manhole to the far end manhole. The jetting operation shall be conducted as described above. As always, the encasing conduit, sub-duct, innerduct, or microduct must be lubricated prior to the start of any placing operation following the lubrication schedule in Table 5. Once the placing operation begins, lubrication must continue to be applied to the cable being jetted as it is placed.

#### 3.2.2.4. Intermediate Assist

A placing plan determining pulling locations, including the intermediate assist location should be developed during a pre-survey of the placing project. FIG8 shows a cable jetting operation with intermediate assist.



FIG6 - Cable Jetting Schematic Showing Placement With Intermediate Assist

For intermediate assist placing operations, a convenient intermediate point is selected as the intermediate location. It should be near mid-span and, if possible, the duct section in both directions out from the intermediate assist manhole should be placeable in a single operation. The area around the intermediate assist location should be capable of staging the ground support equipment (air compressor and hydraulic pump) for the placing engine. For an intermediate assist procedure to be successful, the placing engines (primary and assist engine) need to be coordinated, so compressive forces do not build up causing the cable to buckle or kink. The assist placing engine manufacturer's instructions to operate the engine as an assist engine in tandem with other placing engines should be followed. Once the cable has been placed, sufficient slack cable should be provided on each end of the cable route to enable the splice to be made to the adjoining cable and to store the standard amount of slack at each splice required by the end-user of the cable for maintenance operations. Also, sufficient slack must be provided in intermediate manholes to rack the micro-duct and cable along the sides of the manhole, out of the way from harm and still have sufficient slack stored to accommodate the end-users requirements. All ducts should be plugged at the conclusion of the placing operation. If a cable has been pulled into the duct, the duct plug should be sized for both the ID of the duct and the OD of the cable. The microduct shall be left intact through intermediate manholes during placing and racking, whenever possible unless the micro-duct was removed to enable intermediate assistance or a portion of the cable is branched off the cable route being placed. Typically, a cable coil will be placed in a manhole or hand-hole to provide extra cable in the event of network damage or extra cable for splicing fibres. In certain environments, it may be determined that cable protection for the coiled slack is required due to the threat of rodent damage. If possible, protect any slack coils with split flexible conduit and store the coil in a safe position in the manhole or hand hole.

## 3.2.3. Installation, Cable Termination and Splicing

The cable must be properly terminated in a splice closure. The proper clamping of the central strength member is necessary to provide a positive stop to prevent CSM pistoning. In addition, the jacket must be properly secured to prevent jacket retraction or cable slippage.

Expressing micro-duct cable buffer tubes through a splice closures is not permitted. The buffer tubes shall be opened and the express fibres shall be stored in the closure's splice trays or routed in furcation tubing through the closure. If the buffer tubes are expressed through the splice closure, an increase in attenuation may occur at colder temperatures.

#### 4. Safety issues

#### 6.1 Personal Protective Equipment

Jetting microduct cable is a cable placing procedure that uses sophisticated equipment that many placing crews may not be experienced with or in some cases be familiar with. As a result, Sterlite recommends using a placing crew that is familiar with and has experience jetting micro-duct and microduct cable. Approved personal safety equipment, such as hard hats, safety glasses, reflective traffic vests, and gloves shall be used for all outside cable construction activities.

## 6.2 Traffic Safety

All federal and state departments of transportation regulations and local traffic control codes and regulations shall be met including the use of safety equipment such as reflective safety vests, warning signs, barricades, lighting if work is being performed during non-daylight hours. All traffic control requirements shall be met.

#### 6.3 Microduct and Cable Placing Equipment

Most of the equipment used with the micro-duct system is more sophisticated than conventional placing equipment. High pressures are used to drive hydraulic motors as well as high pressure air. If a failure occurs to high pressure hoses or connections, it is potentially dangerous to those working around the equipment. Therefore, the placing crew needs to read, understand, and be familiar with the safety issues outlined by the placing equipment manufacturer as well all operating procedures.

#### 6.4 Cable Protection and Handling

- While loading or unloading cable reels, care must be taken to prevent collision with other reels, or damage to the reel itself.
- The reel should not be rolled a long distance. If it is necessary to roll the reel, it should be rolled in the direction indicated by the arrow on the flange.

- The reel should never be placed on its side.
- The reel should always be located on a flat surface and blocks placed to prevent it from rolling in either direction.
- The cable on the reel should be covered at the factory with a UV/thermal wrap until just prior to installation to protect the jacket from exposure to the sun and high temperatures.
- The reel should never be dropped (i.e. off of a flatbed truck).

#### 7. Conclusions

The Microduct System is a new concept of ducting and cable design that has been used in globally over the past several years. It was first developed for the inner city rings for its deployment versatility; its lower deployment cost has caused the concept to be used for long haul. One of the issues that make Sterlite microduct systems more economical to use than traditional systems is their ability to provide a complete series of the highest quality micro-duct cables that use the outside cable space available with the highest efficiency.

- 1. The initial investment is reduced and cash flow improved since microduct fibre cable installed closely matches the actual service demands, serving the customers providing the revenue stream at the time they were placed.
- 2. All of the fibre generates revenue.
- 3. Uses duct space more efficiently in underground and buried cable.
- 4. Greater cable lengths can be used with the cable jetting placing method.
- 5. There is a great deal more flexibility in providing new service as usage patterns change because the microduct system is so compact and can fit it to nearly any space available.
- 6. Cables can be installed without digging or blocking most of the right-of-way.
- 7. Because of the smaller cables and segregated cable system, maintenance operations can be done in a more expeditious manner than with traditional cable cable.
- 8. The multiple layers of ducting that houses the microduct cables provide robust protection to the cable.
- 9. The many low-cost microduct pathways that can fit into existing cable provide great flexibility and potential path diversity to the micro-duct cable cable.

#### 8. Pros and Cons

Pros	Cons			
<ul> <li>Long routes when Growth Trend is foreseen</li> </ul>	<ul> <li>Equipment Accessories Cost</li> </ul>			
• High Fibre Counts	• Long Routes may require additional Equipments, Accessories and Intermediate Assist Points			
• Where Right-of-Access is limited	<ul> <li>Cable Itself less Robust as compared to Traditional cabling</li> </ul>			
<ul> <li>Very Good Protection</li> </ul>	• Pricing of cable is at the same pricing level			
• Versatility, ease of handling				

# About STL

# STL is a data networks innovator, driving end-to-end hyper-scale data network solutions beyond tomorrow.

We drive innovation in network solutions for four key global customer segments: Telcos, Cloud Companies, Large Enterprises (such as the Defence) and Citizen Networks. We partner with eight of the top 10 telcos globally, two of the largest global Cloud companies, and defence and citizen networks of the world's second most populous country. In our home country, India, over 40% of all data travels on STL networks!

We partner with our customers for solutions for Mobility, Access Connectivity, Core Connectivity and Network Modernisation to bring 5G, FTTx, enterprise IoT and many more applications to urban and rural populations across the world.

#### We bring ultra-fast connectivity to all of us.

We are the only company in the world to have unique capabilities across all layers of the network: From photonics and material science-based precision manufacturing to algorithmic design, ultra-fast deployment, AI analytics and programmable networks.

We have four innovation centres for core research in optical fibre ultra-high speed connectivity and applied research on smarter networks. At last count, we had 273 patents to our credit – growing at a whopping 103% five year CAGR.

#### Innovation is at the core of everything we do.

We have a strong global presence, and have historically supplied to over a 100 countries! Today, we are a \$730 mn company, with almost 45% of our revenues being export driven.

On the supply side, we have next-gen optical preform, fibre and cable manufacturing facilities in India, Italy, China and Brazil and two software-development centres. Our manufacturing facilities are world-class, with our Silvassa plant being India's first zero waste to landfill optical fibre cable plant!

#### We are an India-headquartered MNC.

From frugal 5G and mini data centre kiosks to bring connectivity, apps and critical services to the remotest area to powering data-hungry applications for new tech such as augmented reality, enterprise IoT and autonomous cars, we are innovating to make digital ubiquitous.

Through our STL Academy, we are developing an ecosystem of highly skilled professionals in deploying and maintaining complex optical fibre networks. 1,500 professionals have been certified with us; and 15,000 are in the works.

#### We are transforming lives.

We believe the networks of tomorrow are fundamentally different from the traditional ones. These hyper-scale networks are denser, deeply fiberised and software-defined with computing at the edge.

With our unique silicon to software capability, we design, build and manage solutions for such hyper-scale networks.

#### We are leading the future of networks.

Over 3,000 people - we call ourselves STLers - from across 30 nationalities work with us. We are a Great Place To Work!

Together with our customers and partners, we STLers are taking data networks and humanity beyond tomorrow.

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