Chapter Four:
Passive Optical System Components for MDUs

Introduction

Once the key design choices have been mapped out, component selection can begin. The choices for components will be driven by two factors.

- The unique characteristics of the building being cabled will determine the amount of space available for hardware and cable placement, and thus the choice of products. Industry trends have clearly moved toward smaller, easier-to-deploy components, as exemplified in the ClearCurve™ Solution set detailed in this document.
- Total installed cost, which includes the net results of labor, materials and any secondary impacts such as building/homeowner acceptance and faster revenue generation through quicker deployment. These costs are directly influenced by the component and installation method choices discussed in detail in the paragraphs that follow.

The main objectives in component selection are:
- to deploy a reliable, robust network,
- with low optical attenuation,
- at the lowest possible cost ,
- in the least amount of time,
- with a minimum of interruption to tenants (for occupied MDUs).

To address these objectives, Corning's new ClearCurve Optical Fiber has been developed with very tight bend radius capabilities. This has enabled a revolutionary set of rugged, yet smaller, cable and hardware products that meet the specific needs of the MDU environment. This chapter of the Guide will step through the various component choices, comparing and contrasting the latest state-of-the-art products with traditional approaches. The discussion begins with the underpinning optical fiber technology and steps through cable types, cable protection, hardware and connectors.

Optical Fiber

The choice of optical fiber will determine the amount of bending that cables, especially living unit drop cables, can withstand. It also influences the size of the hardware needed to connect a given number of drop cables. ITU recommendations G.652 and G.657 define three levels

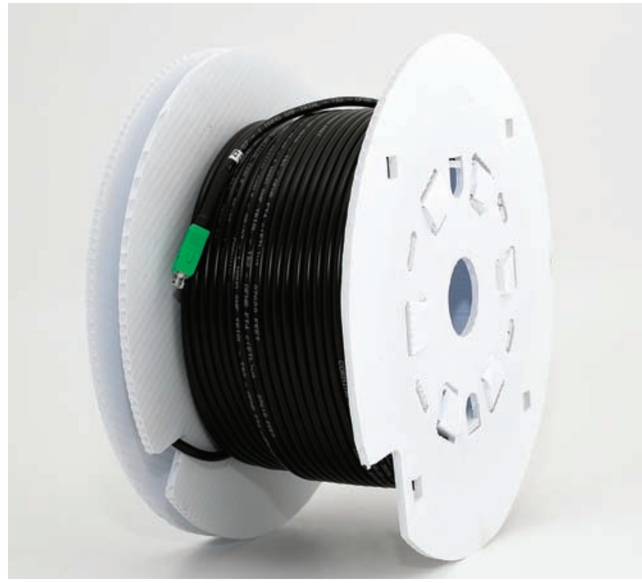

Figure 4.1 – ClearCurve Indoor/Outdoor Rugged Drop Cable | Photo NS165

of bending performance, described below. Corning Cable Systems' extensive customer and application research has defined a fourth, more stringent level of bending performance, as well.

Standard Single-Mode Fibers (ITU G.652.D)

ITU G.652.D recommendations cover standard, low-water-peak fibers used in FTTH feeder and distribution applications today. Corning's SMF-28e® Optical Fiber, which meets G.652.D requirements, will continue to be the workhorse for the feeder and distribution parts of the access network. However, with a minimum bend radius of 30 mm, it does not offer the bending capabilities required for MDU drop cable applications.

Bend-Improved Fibers (ITU G.657.A)

Bend-improved fibers are typically defined by the ITU-T recommendation G.657, type A (or simply "G.657.A"), which was published in late 2006. This ITU-T recommendation requires the fibers to be backwards compatible with standard low-water-peak single-mode fibers and defines the minimum bend radius to 10 mm. "Backwards compatible" means that the key fiber parameters as defined by ITU-T recommendation G.652.D are met, specifically optical transmission parameters such as mode-field diameter, cut-off wavelength, attenuation spectrum, chromatic dispersion, and polarization-mode dispersion, but also geometric parameters such as core-clad concentricity. This guarantees interoperability with an embedded base and with other network segments (e.g. feeder and distribution) that may use standard single-mode "G.652.D" fibers. The minimum bend radius of 10 mm comes with a penalty, however, as up to 0.75 dB of loss is permitted for one 360-degree turn at this radius. At smaller radii, the loss increases significantly. While these early bend-improved fibers have been used for MDU drop cable deployment, their greatest contribution has been to enable major density improvements for key FTTH hardware components. The benefits for fiber optic hardware, when combined with improved fiber management, can be significant. As an example, Corning® SMF-28e®XB fiber enabled a reduction in weight and size of local convergence cabinets by approximately 40 and 75 percent, respectively.

Bend-Tolerant Fibers (ITU G.657.B)

The ITU-T also recognized the challenges of fiber installation and defined a second class of bend-tolerant fibers in compliance with recommendation G.657, type B (or simply "G.657.B"). G.657.B fibers are not required to be backwards compatible, but are defined by a minimum bend radius reduction to 7.5 mm. However, as described earlier, evolving practices in MDU installations require an even further reduction in bend radius to bring fiber cable installation practices on par with copper installation in terms of speed, ruggedness and flexibility or to enable further density improvements for fiber hardware. Although these fibers are more tolerant of bending, they still are limited by an attenuation of up to 0.5 dB per 360-degree turn at this radius, which, with just a couple of turns, could exceed the normal loss of an MDU drop link. The resultant combination of significant bending loss and lack of a backward compatibility requirement places these fibers in a weak position for MDU applications.

Bend-Insensitive Fibers

The challenges of MDU applications call for a truly bend-insensitive optical fiber, yet one that remains compatible with ITU G.652.D fibers used in the feeder and distribution segments of the network. There are a variety of technologies for further improving bending performance in optical fibers. However, these are either limited in achieving performance to the bend-improved or bend-tolerant levels only, or suffer from strong incompatibility tradeoffs that render them incompatible with legacy fibers. Extensive customer and application research has shown that a functional radius of 5 mm with a maximum attenuation of 0.1 dB per 360-degree turn, while still maintaining backward compatibility, is the standard that fully addresses the "handle like copper" nature of MDU deployments. Corning's ClearCurve™ Optical Fiber meets all of these requirements and, when placed in a rugged, self bend-limiting cable sheath, creates an MDU drop cable that can be pulled through and stapled to building structures more quickly and at lower installed cost than conventional solutions.

Because of the extensive benefits of bend insensitive fibers, it is recommended that ClearCurve Optical Fiber be used for all drop cable segments in MDUs. These fibers may also be used in the riser segment, as hardware stub cables, to enable smaller hardware footprints. For feeder and distribution segments, standard single-mode (ITU G.652.D) fiber is recommended.

Rugged Drop Cables

Because the drop cable pathway is the most challenging part of MDU deployments, careful component choices must be made. Conventional practices make widespread use of microduct into which a single-fiber 2.9 mm interconnect cable is pulled. Greenfield deployments have been using microduct almost exclusively, and many brownfields use it as well, to protect cables in walls, ceilings, attics and through stacked closets. This approach is robust, but requires extra labor cost for the handling of the microduct followed by the pulling of the cable, as well as the extra material cost of the microduct itself. Microduct requires careful bend radius management to avoid kinking (which would prevent cable placement). In addition, its rigid nature and bulky shipping reels usually require multiple technicians during placement and may be difficult to handle in tight work spaces. Cable-in-conduit, where the microduct is extruded around the drop cable at the factory, reduces the labor needed to install the drop, but still requires the same handling cautions and added material costs as for empty microduct. Nonetheless, use of microduct and a small interconnect cable as the drop remains a viable technique for its one key benefit: it creates a reusable path, should the drop cable ever need to be replaced.

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A new approach which is fast gaining acceptance, taking lessons learned from copper cables, is to put a bend-insensitive fiber inside a rugged, self-bend-limiting sheath, to create an optical cable that can be handled and secured just like these competitive technologies. Corning Cable Systems' ClearCurve™ Rugged Drop Cable does just that. With this cable, the labor and material costs associated with microduct are completely eliminated. Cables can be pulled directly through holes drilled into studs, joists and masonry structures as well as through standard metal stud openings. Experience in actual field deployments is demonstrating that this method can achieve cable installation in as little as half the time compared to a microduct-based installation.

In most cases, a single technician can pull in a drop cable, whereas multiple technicians are required to manage and install microduct. The 4.8 mm diameter of this cable is smaller than typical microducts, allowing the use of smaller, faster-to-drill holes in structures. Where raceway or conduit is used to protect groups of drop cables, smaller raceway, conduit and core drills can be used at lower cost. The cable may also be stapled using conventional, off-the-shelf staplers. Wherever and however copper cables can be installed, ClearCurve Rugged Drop Cable can also be installed. Further savings are realized by eliminating the transition boxes and conduit often used to bring drop cables from microduct into the MDU terminal.

In Figure 4.2, ClearCurve Rugged Drop Cable is installed directly through a joist. The cables' self-limiting nature requires no bend radius management. In Figure 4.3, larger holes and large sweeping bends are required for these microducts.

Bends and stapling are routine practices for ClearCurve Rugged Drop Cable as seen in Figures 4.4a-c. Figure 4.4c demonstrates how the bend limiting sheath controls bending, even when stapled.

ClearCurve Rugged Drop Cables are available in an indoor riser-rated version in an appealing neutral off-white color or standard "single-mode yellow." An indoor/outdoor riser-rated version is also available in black. Tensile rating is 100 lbf., twice that of conventional interconnect cable used for drop, and similar to that of coaxial cable. The indoor/outdoor version is both water-blocked and UV-protected for exposure to the elements.

Figure 4.2 – ClearCurve Rugged Drop Cable Installed Through Joist | Photo NS159

Figure 4.3 – Sweeping Bends of Microduct in Joist | Photo NS157

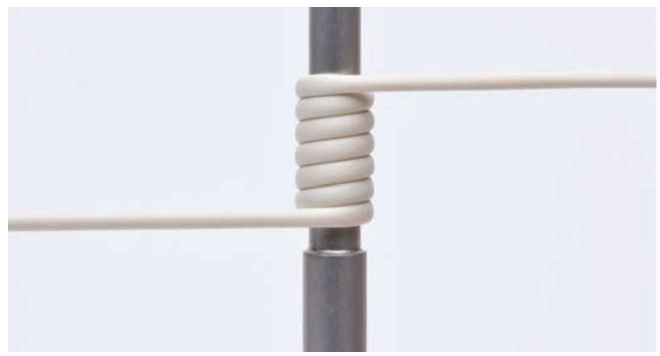

Figure 4.4a – ClearCurve Rugged Drop Cable Wrapped Around Mandrel | Photo CCV010

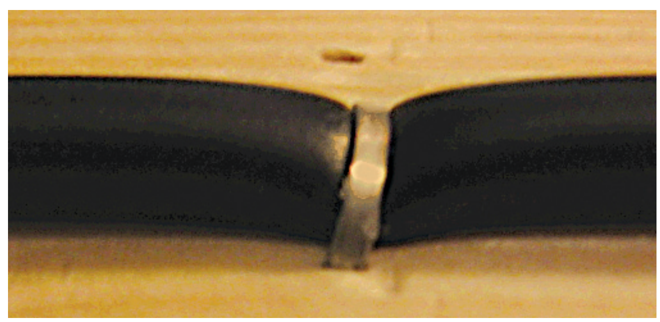

Figure 4.4b – ClearCurve Rugged Drop Cable Stapled to Joist | Photo NS162

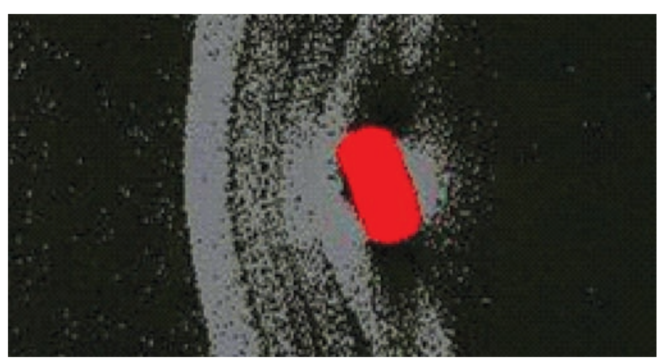

Figure 4.4c – X-Ray of Stapled ClearCurve Rugged Drop Cable | Photo NS156

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Compact Drop Cables

ClearCurve™ Compact Drop Cables utilize the same bend-insensitive fiber as rugged drop cable, but in a smaller 2.9 mm sheath. Compact drop cables are best where a smaller, more aesthetic appearance is desired, or where cables are run in raceway or microduct, and where the self-bend-limiting feature of the rugged drop cable is not needed. Compact drop cable is ideal for installers preferring the use of microduct, as it has the same diameter as the interconnect cables currently in use. However, it has the same tight bend capabilities as the ClearCurve Rugged Drop Cable, down to a 5 mm minimum bend radius.

Drop Cable Packaging – Bulk and Preconnectorized

ClearCurve Rugged and Compact Drop Cables are both available in bulk reels in various lengths. Standard reels can be placed on normal pay-off stands. Reel-in-a-box packaging, which requires no pay-off stand, is also available, making set up and tear down fast and easy when placing drop cables. Rugged drop and compact drop cables are available in 1500 and 4500 feet bulk reels, respectively. Bulk cables can be pulled in and conveniently cut to length, minimizing waste. Preconnectorized drops, with connectors on one or both ends, are also available to speed field deployments. The most popular preconnectorized option is a length of cable with a connector on one end that can be pulled from the living unit to the distribution terminal for field termination, leaving the preconnectorized end at the living unit for ONT connection. Preconnectorized drops are typically ordered and stocked in a variety of popularly used lengths and deployed as needed.

Figure 4.5 shows a reel-in-a-box with ClearCurve rugged indoor drop cable.

Figure 4.5 – Reel-in-a-box Rugged Indoor Drop Cable | Photo NS167

Cable Protection and Aesthetics

As noted earlier, ClearCurve Rugged Drop Cable precludes the need for microduct to protect MDU drop cables, resulting in greatly accelerated drop installation and elimination of microduct material costs. However, for purely aesthetic reasons, surface raceway is often used to hide network cabling. Conduit may also be used for vertical runs of riser and drop cable in riser pathways and outside wall of buildings. ClearCurve Indoor/Outdoor Rugged Drop Cable can be secured directly to exterior building surfaces or placed in outdoor raceway/conduit for added protection and visual appeal. Compared to traditional practices in which microducts are run in large exterior raceway/conduit to protect them from UV exposure, indoor/outdoor rugged drop cable is UV protected. Where raceway/conduit is deployed, a smaller size raceway/conduit can be used compared to that which is required for microduct.

Aesthetic Raceway and Moldings in Brownfield Deployments

Where walls and ceilings are already completely sealed and finished, cables can be run on the surface and covered with raceway.

Indoors, surface mounted raceways, such as decorative crown moldings or basic channels, are ideal for routing drop cables from the MDU terminal (at the riser) to the living unit. Multiple drops can be routed in one raceway and dropped at each living unit along the hallway. Raceway products include bend-management components to help prevent bend-induced attenuation in drop cabling, although these devices are not needed with ClearCurve drop cables. Decorative raceway hides and protects drop cables and can be re-entered to add or replace drops.

In Figure 4.6, raceway in the form of decorative crown molding hides and protects drop cables. The raceway can be re-entered to add or replace drops.

Outdoors, drop cables that originate outside and are routed to an indoor destination, or which must be routed entirely outdoors because there is no other available path, can be routed within outdoor surface raceway to provide aesthetically pleasing physical protection for cables. Cables which are not UV-protected must be run in raceway.

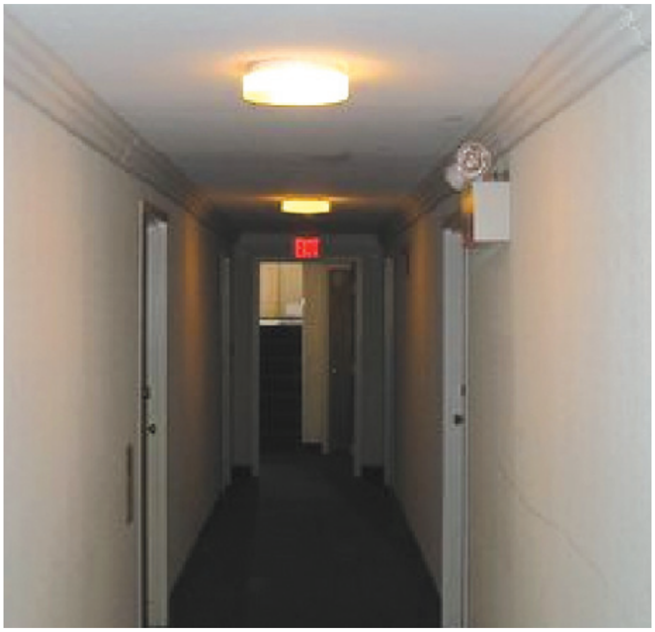

Figure 4.6 – Raceway in the Form of Decorative Crown Molding | Photo NS124

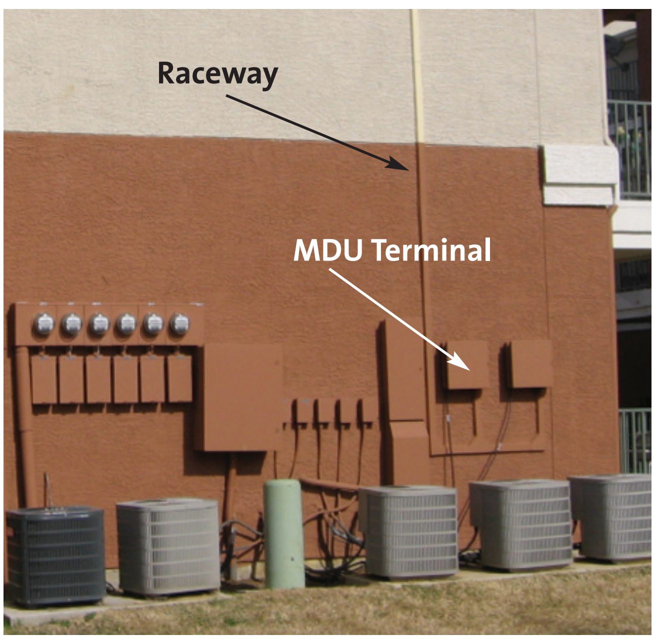

Figure 4.7 – Outdoor raceway | Photo NS125

In Figure 4.7, raceway can be run on the exterior surface of the MDU to the point of entry for the building – in this case extending up to an attic area. The raceway provides physical and UV protection for the drop cables. As seen here, it has been painted to blend into the color scheme of the building for an aesthetically pleasing installation.

Riser Cables

Riser cables within buildings should be protected by conduit. Because existing MDUs require placement of cable in spaces employed for other uses, such as stacked storage closets or disposal shafts, conduit should be used to protect the cables from physical harm. Cables run on exterior walls should also be protected, using a surface-mounted raceway designed for outdoor applications.

Standard riser cables, such as Corning Cable Systems MIC® and FREEDM® Cable products with Corning® SMF-28e® Optical Fiber, can be used for riser placement. In this case, splicing may be utilized every few floors to tie in MDU terminals. As an alternative, MDU terminals are often deployed with stub cables factory installed and ready for splicing on another floor, in a basement or exterior to the building. New reduced-footprint MDU terminals leverage riser-rated cables with ClearCurve™ Optical Fiber to achieve significantly smaller physical size.

Outside Plant

Just as with indoor riser and drop, outside plant distribution cables should be physically protected. Cables placed on the outside of buildings or placed underground should be run in conduit for optimal protection.

Terminal Distribution Systems for Outdoor and Riser Applications

Corning Cable Systems FlexNAP™ Terminal Distribution Systems are cable assemblies that offer consistent factory-built quality that increase network construction velocity and cost-effectiveness. Instead of building the cable and terminals on-site in the field, terminal access points (TAPs) are installed on the cable in the factory. The cable is installed like bulk cable, but the terminals are now in place. Applications include both outside plant, such as connecting multiple buildings in a garden-style complex, as well as inside plant, connecting terminals to a building riser cable. As a system, these assemblies reduce deployment time and cost by capturing the mid-span cable access and splicing that would otherwise be done in the field and performing it in a high-quality manufacturing setting. In the outside plant, distances between consecutive poles and/or handholes along the cable pathway are measured, slack locations and amounts are determined and the fiber count to be accessed at each location is specified. Once all measurements have been made and the exact fibers to be accessed at each terminal location have been determined, the specific requirements for the assembly are entered by the customer into a “configurator.” The configurator accepts the customer order and converts the requirements to a build order that can be executed by the factory to manufacture the assembly. When the custom assembly is built, the cable is accessed and terminal access points (TAPs) are placed on the cable. Each TAP has one or two short tethers with a multi-fiber connector for attaching a terminal stub cable. TAPs are sealed, low-profile moldings that can be pulled through duct and riser spaces just like any standard cable. The assembly is placed, just like a standard optical cable, and then the CO/HE end is spliced to either an LCP stub cable or a main distribution cable. Terminals are then connected in a plug-and-play fashion, making the network ready for subscriber drop cable connection. In riser applications, TAPs for terminals may be placed every floor, every other floor or every third floor, depending on available space and the number of units to be served on each floor.

The key components of the FlexNAP™ Terminal Distribution System (Figure 4.8) include:

- A cable assembly, having multiple TAPs at customer-defined locations, which can be placed in the same way as a standard cable.
- The terminal, which can be either an outdoor multiport terminal, OR an MDU terminal (indoor/outdoor use); in some cases, it is desirable to place the assembly, but defer the terminal until the first subscriber is to be connected, thus delaying the cost of the terminal until a future date.
- A hardened OptiTip™ Multi-Fiber Connector to join the terminal to the assembly in a matter of seconds.
- Optional loop-back caps placed on each OptiTip Connector to facilitate complete system testing from the LCP when terminals have not yet been connected.

To illustrate the advantages of the terminal distribution system compared to a system built with a conventional approach, Figure 4.9 breaks down the time required to build each system. The higher the labor rates where the system is being installed, the greater the dollar savings that can be realized.

Features and benefits important when selecting an outdoor terminal distribution system include:

- Wide range of fiber counts (12 to 288)

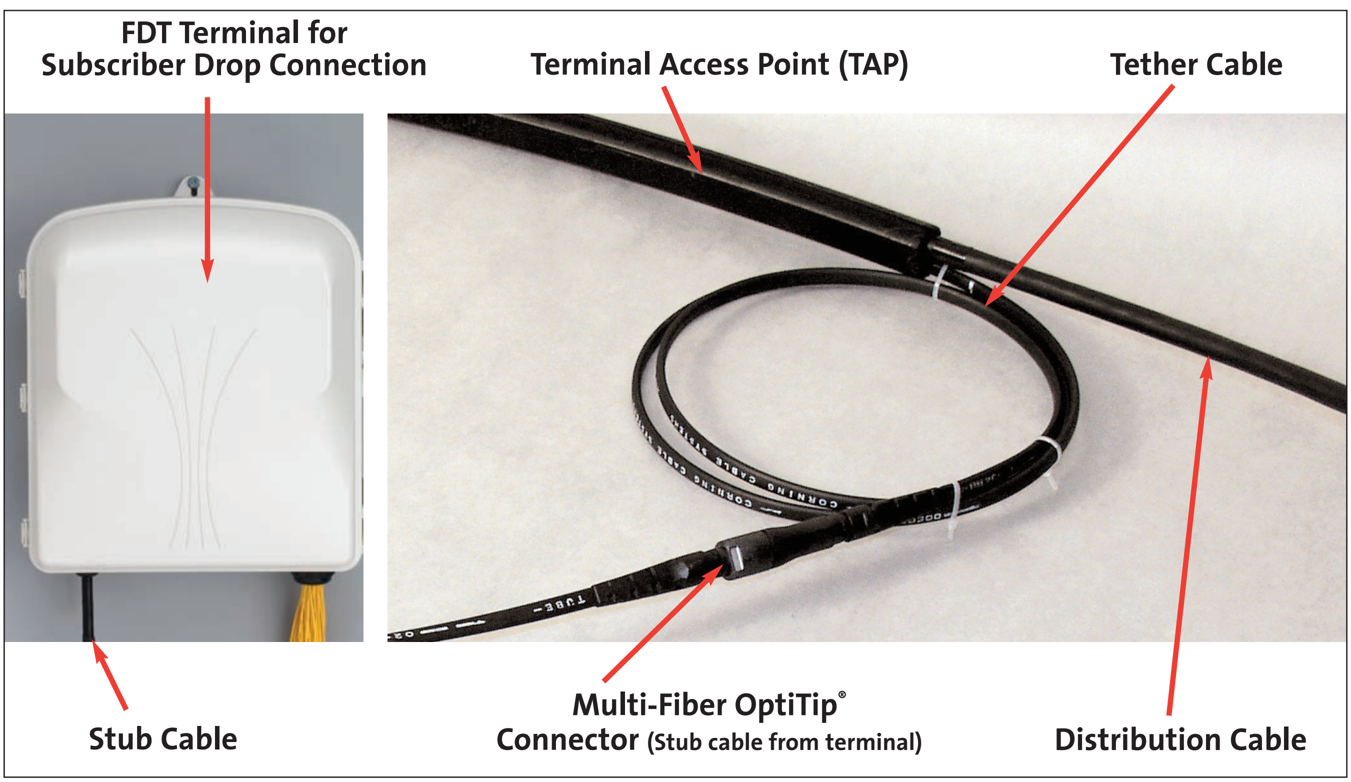

Figure 4.8 – FlexNAP® Terminal Distribution System Key Components | Photo SHD196, CCO124

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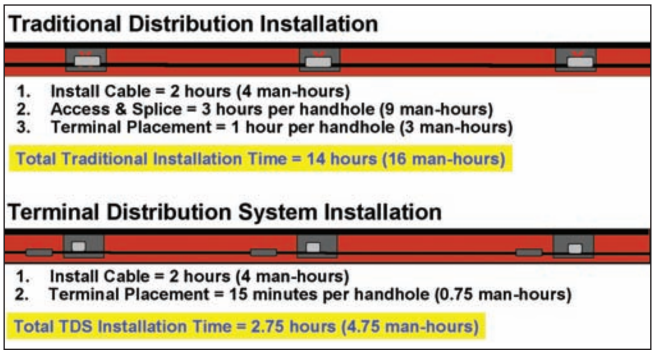

Figure 4.9 – Traditional vs. Terminal Distribution System Installation | Drawing ZA-3086

- Range of fiber counts available at each tap (4-12 per tether with one or two tethers possible)
- Up to 25 TAPs per cable assembly
- Assembly lengths up to 5,000 ft to minimize splicing and/or allow consolidation of several assemblies back to a common point
- Fits into conduit as small as 1.25 inches to maximize use of available conduits and minimize cost for new conduits
- Simple installation techniques – must pull like standard optical cable and provide easy position alignment markings on the assembly to match up to hand holes and/or poles.

FlexNAP ™ Terminal Distribution System – Riser Applications

Terminal distribution systems for riser applications (Figure 4.11) perform the same function as outside plant systems, except that they are placed vertically in the building riser.

The assembly is made using an indoor/outdoor riser-rated cable. TAPs are located at each floor, every other floor or every third floor. This approach is especially useful in medium and high-rise MDU applications. The cable is taken to the top floor and dropped down through the riser so that the taps are lined up with an opening or pull box in the riser conduit where the tether can be accessed. A terminal with a stub cable having a rugged multi-fiber connector is wall-mounted and connected to the multi-fiber connector on the tether. Because the TAP connector is ready for connection at any time, terminals can be deferred until the first subscriber is connected. Two tethers can be collocated, one for connection now and one for future use. Multiple assemblies can be used to serve very tall buildings or those with more than one riser. In brownfield installations, conduit as small as 1.25 inches can accommodate a terminal distribution system installation.

Since the FlexNAP Terminal Distribution System originated in outside plant applications, it is also possible to deploy it vertically and/or horizontally on the outside of an MDU and bring the tether inside to mate to the terminal when a riser pathway is not available.

FlexNAP Terminal Distribution Systems support the ready-to-connect philosophy in riser applications and offer extremely fast deployment of fiber to the home in MDUs. This makes it one of the quickest ways to pass and connect subscribers and rapidly capture market share. FlexNAP Terminal Distribution Systems can also be used in commercial buildings to provide services to business tenants.

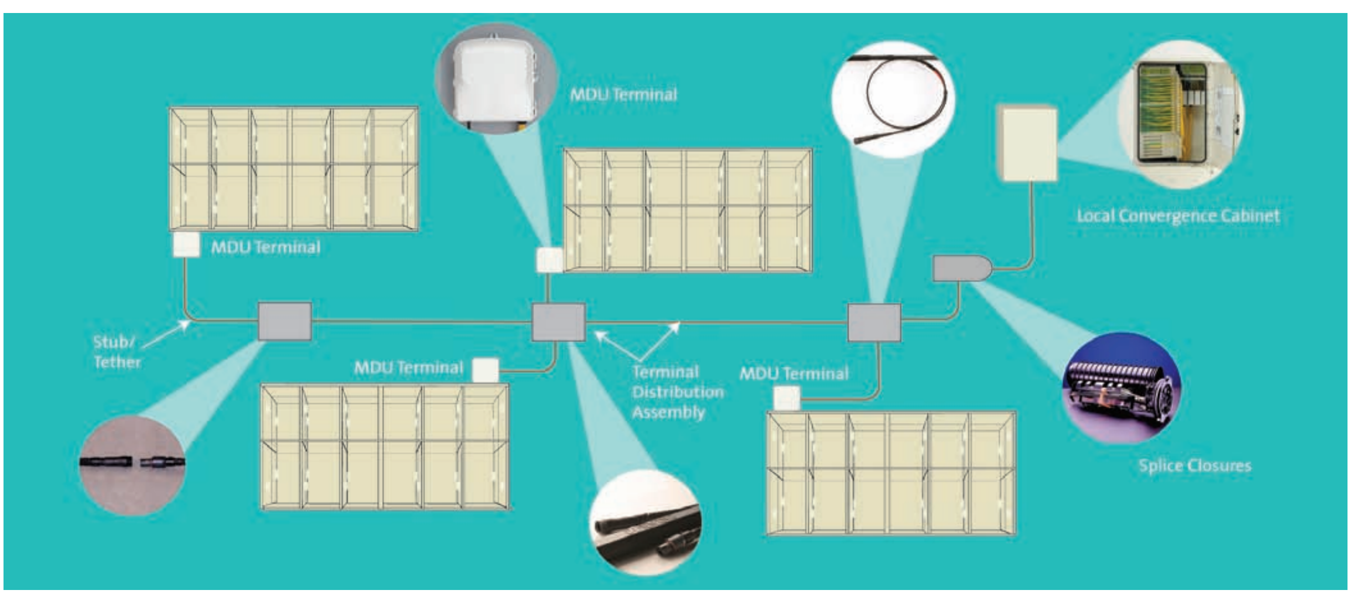

Figure 4.10 – FlexNAP Terminal Distribution System for MDU Complex | Drawing ZA-3208

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Features and benefits important when selecting a terminal distribution system for riser applications include:

- Riser-rated cabling
- Wide range of fiber counts (12 to 144)
- Range of fiber counts available at each tap (4-12 per tether with one or two tethers possible)
- Plenty of access points per cable (25)
- Lengths suitable for any building height, including cable to route horizontally or to adjacent buildings to reach the LCP
- Fits into conduit as small as 2.0 inches to maximize use of available riser space/ conduits and minimize cost for new conduits

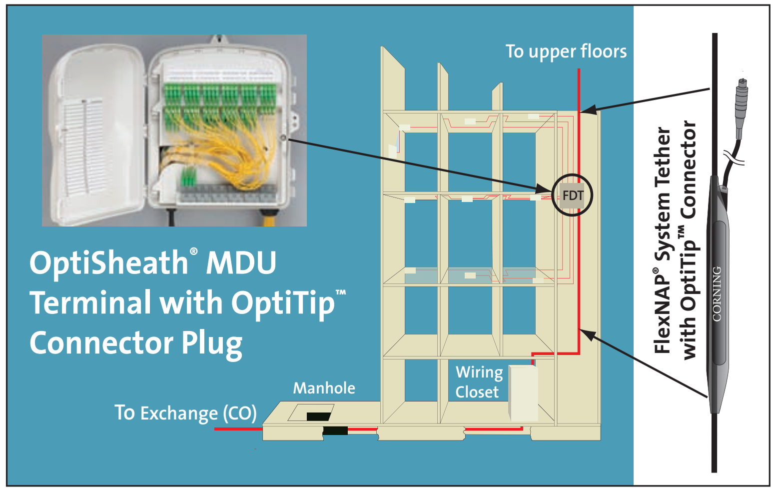

Figure 4.11 – FlexNAP Terminal Distribution System and Terminal | Drawing ZA-3083

Optical Hardware for MDUs

While cabling joins the various points in the network, optical hardware provides the connectivity, splitting and splicing needed to configure and manage the network. Many hardware products are available pre-stubbed, with a connectorized cable already in place and ready for splicing. This speeds deployment, cutting labor costs and enabling faster revenue generation. Cabinets, sometimes called "hubs," house splitters at the local convergence point and are available in indoor and outdoor versions. MDU terminals can be located on the outside or inside of buildings to connect smaller groups of subscribers. At the living unit, optical outlets can be used to connect to network electronics.

This section outlines the various hardware types used in MDU deployments as well as their respective applications. A reference table at the end of the section provides easy access to Corning Cable Systems product specifications for each type of hardware.

Local Convergence Points

Local convergence points (LCPs) serve as the splitter and connection point described earlier in the section on architectures. They provide individual subscriber connectivity to splitter outputs and serve as the demarcation between the feeder and distribution portions of the network. For the local convergence model, the most common architecture in use today, they contain all optical splitters. There are three common formats – outdoor cabinets, sealed outdoor closures (see Figure 4.15) and cabinets for indoor use (see Figure 4.13).

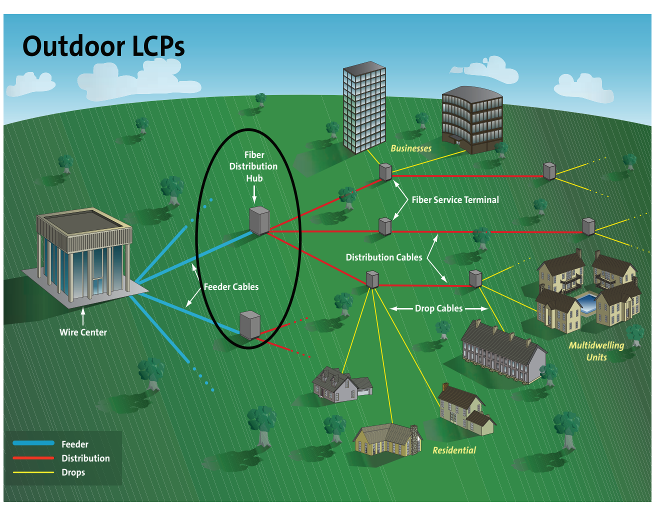

Figure 4.12 – Outdoor Fiber Distribution Hub | Drawing ZA-3085

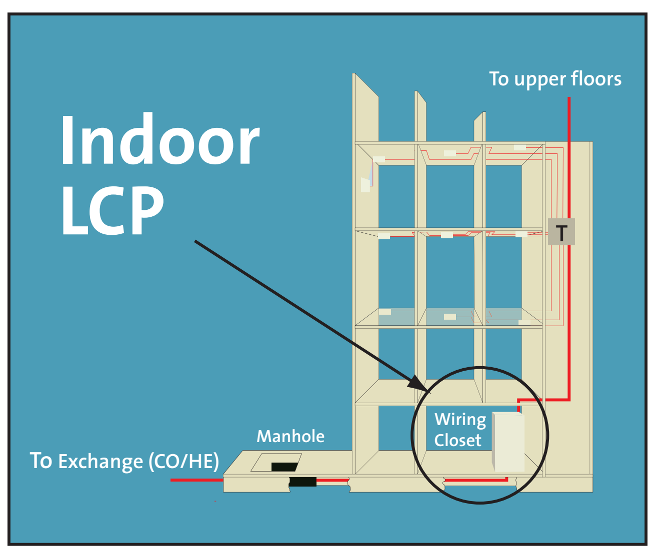

Figure 4.13 – Indoor Fiber Distribution Hub | Drawing ZA-3084

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Outdoor LCPs – Cabinets

Outdoor LCPs are used to serve single-family homes, groups of small to medium MDUs or a combination of both. They may also serve small- or medium-sized business accounts. Features and benefits important when choosing outdoor LCP cabinets (Figure 4.14) include:

- Wide range of capacities for design flexibility; 144 to 864 fibers
- Small footprint and compact design to minimize real estate used and optimize aesthetics
- Universal “one-size-fits-all” splitter modules across all cabinet sizes
- Factory preconnectorized stub cables to permit easy installation
- Pole, pad and wall mount capability
- Ample parking for unassigned splitter output legs
- Simple, intuitive fiber management
- Clear dust caps for easy VFL location in the distribution field
- Protective see-through cover for feeder inputs and modules
- ITL tested to applicable sections of GR-2898, GR-487, GR-63, GR-449-CORE, UL listed

Figure 4.14 – OptiTect™ Local Convergence Cabinet, LS Series | Photo HWPSS1794

Outdoor LCPs – Sealed Closures

Sealed LCPs (Figure 4.15) serve the same purpose as cabinet-based LCPs (to contain splitters and provide assignment of splitter outputs to subscribers), but are intended for underground use in handholes and vaults. Their primary use is where an “out of sight” network is desired. By placing the LCP below grade, there is usually no concern for additional permitting or real estate (right of way) needs. Sealed LCPs provide splitter connectivity management as well as parking for unused outputs. They are pre-stubbed for feeder and distribution sides, just like cabinets. Because they are sealed and more compact than cabinets, their subscriber capacity is smaller, too. Features and benefits important when choosing a sealed LCP include:

- Range of capacities for design flexibility; 72 to 144 fibers
- Simple, intuitive fiber management
- Buried (hand hole, vault), aerial, pole and pedestal mounting capability
- Pre-stubbed and preconnectorized
- Ample parking for unassigned splitter output legs

Indoor LCPs

Indoor LCPs (Figure 4.16) provide the same functionality as the outdoor units, but are intended for indoor use. They come with and without stub cables. They can contain space for splicing within the cabinet and offer the appropriate hardware for indoor mounting. Features and benefits important when choosing an indoor LCP include:

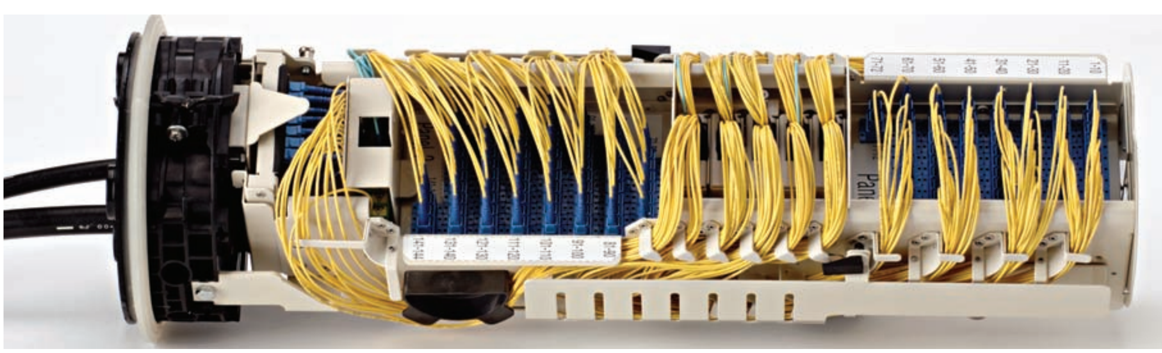

Figure 4.15 – OptiTect™ Sealed LCP Enclosure | Photo SHD186

- Wide range of capacities for design flexibility that includes medium to very large MDUs; 72 to 432 fibers
- Splicing options for feeder and distribution cables
- Small footprint and compact design to facilitate deployment in tight spaces
- Universal "one-size-fits-all" splitter modules for all cabinet sizes
- Factory preconnectorized stub cables to permit easy installation
- Wall- and rack-mountable capability
- Ample parking for unassigned splitter output legs
- Simple, intuitive fiber management
- Clear dust caps for easy VFL location in the distribution field
- Protective see-through cover for feeder inputs and modules

Figure 4.16 – OptiTect™ Indoor MDU Local Convergence Cabinet | Photo CCO119

OptiSheath® MDU Splitter Terminals

The OptiSheath® MDU Splitter Terminal is a rugged, low-cost, low-profile interconnect between the central office feed and the indoor/outdoor drop cables for multi-dwelling unit applications. It simplifies the MDU installation by reducing the installation materials, complexity and the space required to turn up service. A single housing combines the functionality of a local convergence cabinet with an MDU terminal.

Features and benefits important when selecting an MDU terminal (Figure 4.17 and 4.18) include:

- Indoor and outdoor rated
- Four to 32 ports in a single, low-profile footprint
- Available with 1x4, 1x8, and 1x32 splitters as well as dual 1x4, dual 1x8 and dual 1x16 splitters
- Factory-installed feeder (input) with the option to be direct spliced or connectorized to the splitter input
- 4-fiber input provides extra fibers to use as needed
- Preterminated pigtails simplify splicing of drop cables
- Fast, easy, reliable SC APC connector technology
- Integrated parking with splitter legs pre-routed and parked in place by the factory

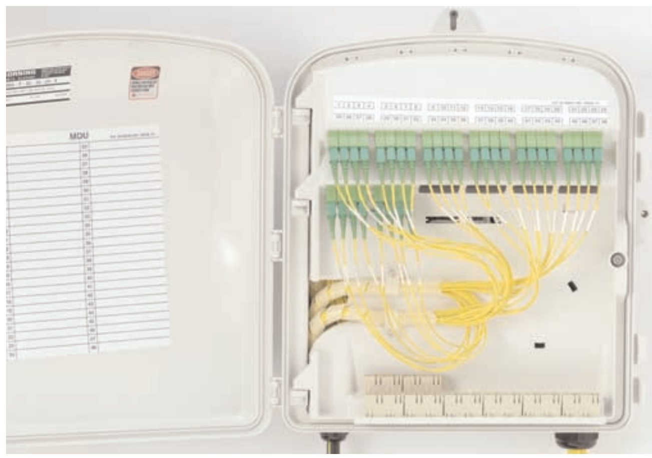

Figure 4.17 –OptiSheath MDU Splitter Terminal | Photo SHD213

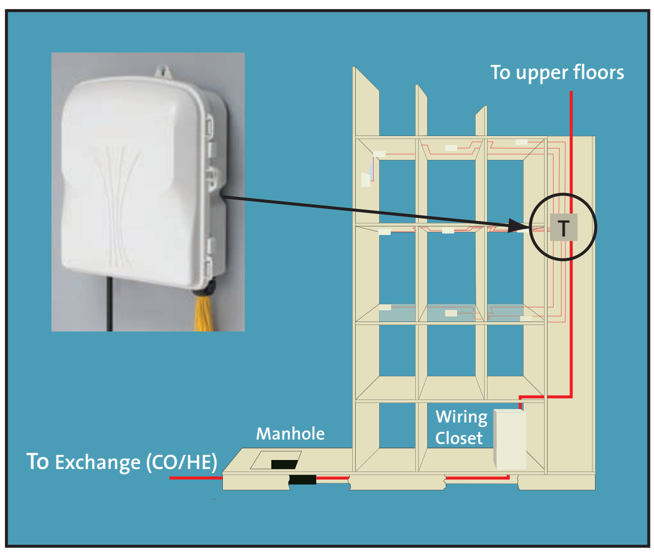

Figure 4.18 – –OptiSheath MDU Splitter Terminal | Drawing ZA-3095

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Passive Optical System Components for MDUs

Figure 4.19 – ClearCurve Fiber Distribution Terminals | Photos CCV004, 005

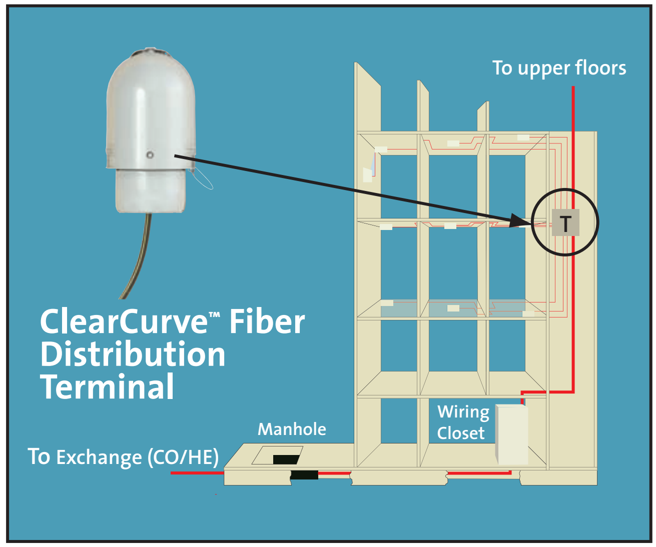


Figure 4.20 – ClearCurve Fiber Distribution Terminal | Drawing ZA-3204

ClearCurve™ Fiber Distribution Terminals

The ClearCurve™ Fiber Distribution Terminal (Figure 4.19) is a small, simple, rugged interconnect between the fiber optic distribution network and drop cables, ideally suited for MDU and FTTB applications.

The terminal can be mounted directly to any wall surface or pole in either indoor or outdoor applications, making it ideal for both high rise and garden-style apartment applications. The ClearCurve FDT is pre-terminated on the distribution side with outside plant or indoor/riser rated cable stubs enabling simple and quick connection to the fiber plant and maximum flexibility with a single product.

The ClearCurve FDT features a separate mounting plate which allows quick and easy mounting by one person without the risk of damaging factory-terminated cables. The terminal engages onto this plate and is locked into place when the cover is on. This unique feature also hides the mounting hardware, making the unit more attractive and preventing unauthorized removal of the terminal.

Features and benefits important when selecting a ClearCurve FDT terminal (Figure 4.20) include:

- 12 and 24 fiber capacity
- Minimal footprint/depth, making it easy to find a mounting location in space-constrained deployments
- Separate mounting plate and preterminated distribution stub allow easy, fast, risk-free installation
- Aesthetically superior and tamper-proof design with hidden mounting hardware
- Indoor and outdoor mounting capability
- Optional skirt provides up to 12 inches of coiled slack and eliminates extra hardware, conduit, and fittings for microduct transition or wall exits
- Individual drop entries allow the deferment of drops until subscriber turn-up
- Drop installation is quick and easy using entry grommets which double as the strain relief
- Engineering-grade thermoplastic housing is corrosion-resistant, impact-resistant and flame retardant
- Terminals are designed and tested to applicable sections of Telcordia GR-771

Optical Wall Plates

Drop cables may be routed directly to the ONT or to a wall plate to terminate it in the living unit. OptiWay® Wall Outlets isolate the drop cable with a jumper used

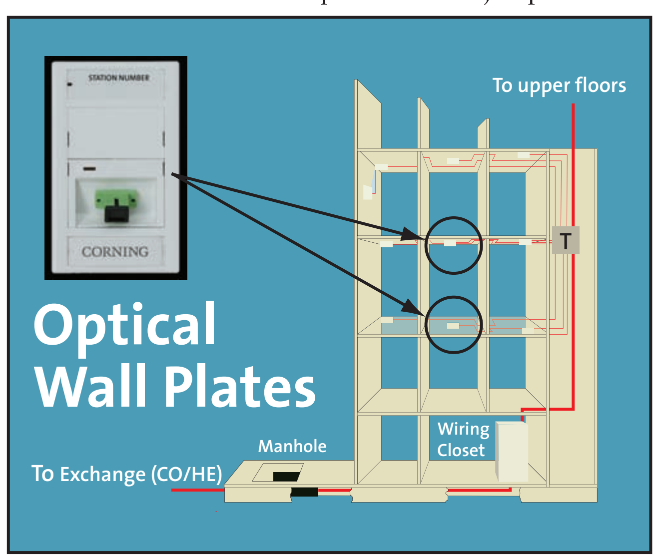


Figure 4.21 – OptiWay Wall Outlets | Drawing ZA-3096

Figure 4.22 – OptiWay Network Interface Device | Photo NID011

to connect to the ONT. Because the drop connector remains in the wall behind the wall plate, the chance for damage is minimized. If the jumper to the ONT is damaged, it can be easily replaced. Wall outlets can be attached to standard, deep single-gang electrical boxes or to low voltage outlet brackets.

Features and benefits important in selecting an optical wall outlet (Figure 4.21) include:

- Mounts to standard single-gang electrical box
- Utilizes modular panels
- Angled adapter increases connector and jumper protection and enhances eye safety
- Optional spring loaded dust cap
- Includes unit identification labels
- Optional copper connectors available upon request

Optical Network Interface Devices

OptiWay® Network Interface Devices (NIDs) provide a convenient optical interface for one or several distribution and/or drop connections. They can be used on the outside of small MDUs such as duplexes and quadplexes or on an interior surface, such as in a garage, basement or closet. In addition to a connector interface, they usually offer splicing capability, as well. ONT vendors use similar housings to contain their electronics boards and cable interfaces.

Features and benefits important in choosing an optical NID (Figure 4.22) include:

- Tamper-proof housing that can be padlocked
- Indoor and outdoor mounting capability
- Accepts fiber optic, coax, Ethernet and telephone cabling
- Accepts conduits and raceway
- Slack storage devices available to store up to 40 feet of drop cable
- Capability to perform and protect pigtail splicing
- UL certification

Figure 4.23 – OptiSnap™ Optical Fiber Cleaver | Photo LAN771

Figure 4.24 – OptiSnap Connector Installation Tool | Photo CCA206

Optical Connectors and Termination Methods

Optical Fiber Termination Methods

Optical fibers are terminated wherever they must make connections to electronic devices (CO/HE and subscriber ONTs) as well as anywhere it is necessary to mate, un-mate and re-mate to other fibers and photonics devices. Terminating a fiber requires that a connector be installed on it. Connectors provide a means for making easy connections and the ability to connect test equipment for performance verification and troubleshooting purposes, without the need to break and remake splices.

Termination in the outside plant (OSP) is generally done by fusion splicing a pigtail (fiber with a factory-installed connector) to the end of the fiber being terminated or by field installing a no-epoxy/no-polish connector directly on the fiber/cable. Both single-fiber and multi-fiber pigtails are available for terminating cables. Pigtails offer factory-polished and tested end-faces for top performance. For inside plant, such as in MDU terminals and indoor LCPs, pigtail splicing is also used.

Advances in no-epoxy/no-polish connectors are now making it possible to field install connectors directly on MDU drop cables without the use of a fusion splicing machine. Initial use of these connectors will be at the ONTs located inside living units and at MDU terminals. These connectors are available in both angled (APC) and non-angled (UPC) versions. Installation of these connectors takes the operator just a couple of minutes. The installation tool is easy to use and provides immediate "go/no-go" feedback on connection quality. It is now possible to deploy indoor drops using bulk cable reels, where the cable can be pulled and cut to length. Because set up time is minimal, the impact on tenants is minimized and overall deployment is accelerated. The OptiSnap™ Field-Installable Connector uses simple cleaving and installation tools (Figures 4.23 and 4.24).

The following features and benefits are important when selecting field-installable connectors and tools:

- Ergonomic craft-friendly designs for cleaver and installation tool
- Integrated, battery powered continuity test system
- Go/no-go analysis and instant feedback to know connector is good
- Cleaver with integrated fiber capture
- Correct cleave length every time
- Compatible with wide range of fiber coating and sheath sizes
- UPC and APC connectors available (Figure 4.25 and 4.26)

Optical Fiber Connection Performance

Optical connectors are characterized by two main properties: reflectance and insertion loss.

Reflectance

Reflectance is defined as the ratio of power reflected from an individual component, such as a connector, compared to the power being transmitted through (or incident upon) it. It is expressed as a negative value, and the lower (more negative) the value, the better the performance. For example, a value of -65 dB indicates that the reflection from the component is 65 dB below the incident signal being transmitted through the connector. Reflected optical power can decrease the received signal-to-noise ratio (SNR) and carrier-to-noise ratio (CNR) in video applications. For RF video overlays, this can mean degraded picture quality for television services. For data, it can increase the bit error rate (BER) leading to reduced transmission rates and poor network utilization. The higher the reflectance, the better the transmitted signal quality will be. The electronic system's connector reflectance specification is the parameter that should dictate component performance.

Insertion Loss

Insertion loss represents the amount of signal loss (attenuation) caused by inserting (or introducing) a component into a system. The smaller the insertion loss, the better the performance. This relative loss (dB), specifies optical performance. Lower insertion loss values are better, thus a maximum attenuation level is often

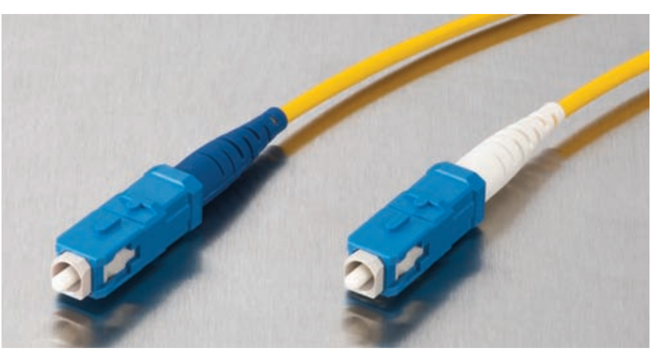


Figure 4.25 – UPC Connectors | Photo LAN620

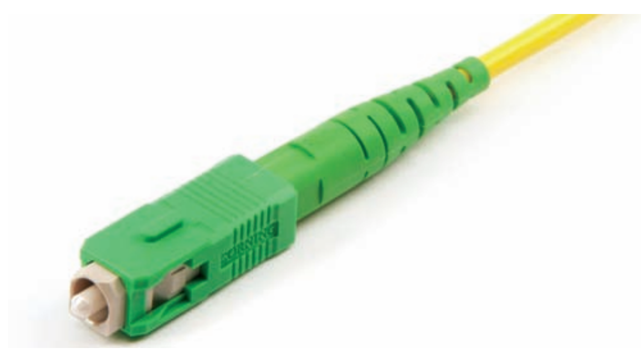


Figure 4.26 – APC Connector | Photo LAN807

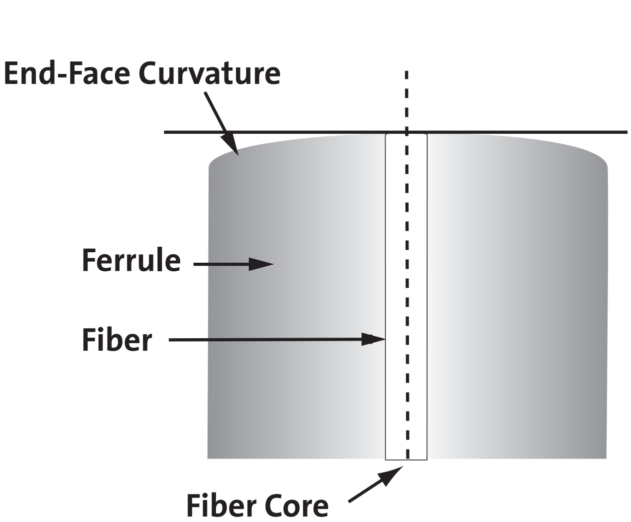


Figure 4.27 – UPC Connector End-Face | Drawing ZA-3128

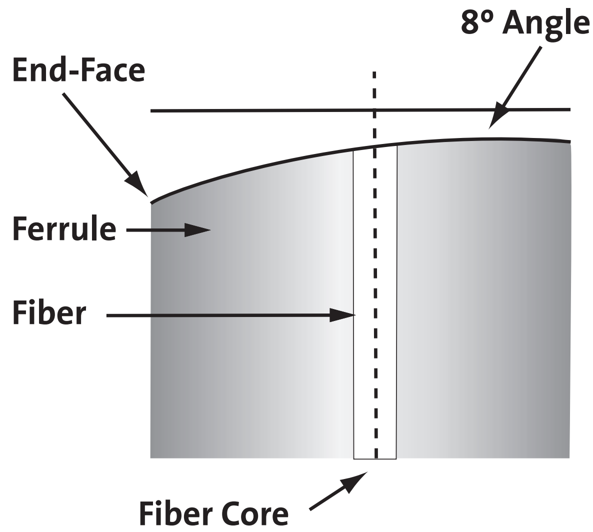


Figure 4.28 – APC Connector End-Face | Drawing ZA-3127

specified at 0.5 dB. Connectors that lower insertion loss enable more connections in the channel, all else being equal. Premium-performance connectors are available to help minimize system attenuation, potentially increasing network distance range.

Optical connectors are classified into two groups based on how the mating surface of the connector ferrule is polished:

Ultra physical contact (UPC) connectors

Ultra physical contact (UPC) connectors (Figure 4.27) have a basically "square" end-face, which is actually polished to have a slight radius (curvature) to it. These connectors offer reflectance of ≤ -55 dB. This performance is generally accepted for Ethernet, BPON and GPON connections and is often used on the output ports of OLTs in the CO/HE. These connectors and their interconnect adapters are easily identified by their industry-recognized blue color.

Angled physical contact (APC) connectors

Angled physical contact (APC) connectors (Figure 4.28) also have a radiused polish, but the mating surface of the connector ferrule is angled at 8 degrees to the passing light beam. This angled end-face minimizes reflections. This is required for systems using RF video overlay techniques, to avoid poor carrier-to-noise performance which can degrade picture quality. APCs are commonly used on CATV RF equipment such as EDFAs (erbium-doped fiber amplifiers). These connectors provide a reflectance performance of ≤ -65 dB. APCs and their interconnect adapters are easily identified by their industry-recognized green color. Even if a system will not be using RF video, it is recommended that APCs be used throughout the system for future-proofing purposes to ensure compatibility with present and future technologies.

A Note on Connector Cleanliness

Proper connector cleaning is critical for maximum system performance. Cleaning kits are available for all types of connectors and connector adapters. Both dry cleaning methods (used mainly in outside plant) and wet cleaning methods (used mainly indoors or when a stronger process is required) are available. Cleaning maximizes connector reflectance, minimizes attenuation and ensures the longest possible life for connectors. As a rule, connectors should be cleaned before each mating. Where high power is present (> 15 dBm), as in RF overlay systems, proper cleaning minimizes the chance of connector damage due to high system power. When cleaning connectors, the power should be reduced, or ideally, turned off during cleaning. Proper eye safety procedures must always be used.

Fiber Splicing

There are three methods used for splicing in fiber optic systems. Single-fiber and mass fusion splicing methods provide the lowest possible attenuation with zero reflectance. In fusion splicing, the glass fibers are fused (welded) using a high-temperature electric arc and computer-controlled mechanism to optimize the joint. The third form of splicing, mechanical splicing, holds the fibers in permanent contact and alignment using a physical device. Because the glass is not actually fused, there may be some non-zero reflectance observed.

Single-fiber fusion splicing involves stripping, cleaning, cleaving (for a clean cut) and splicing two fibers to each other. Several different types of alignment mechanisms are available, from low-cost "V-groove" technology to more sophisticated methods that identify the fiber claddings and/or the fiber cores and use these images for computer-guided alignment.

Mass splicing is used to join fiber ribbons of four to 12 fibers together all at once. The ribbon is stripped, cleaned, cleaved and spliced much the same as for single-fiber splicing, but can achieve much higher productivity where ribbon cables and/or high fiber counts are involved. The attenuation for mass spliced fibers may be slightly higher than for single-fiber splicing, but the productivity gains far outweigh the differences.

Mechanical splicing involves much the same preparation as for fusion splicing: stripping cleaning and cleaving the fiber. Because mechanical splicing may contribute some reflectance to the system, it is not commonly used for permanent splicing applications. However, for temporary use, such as a fiber cable restoration, a mechanical splice can be used to get the system up and running quickly, followed by a permanent fusion-spliced solution.

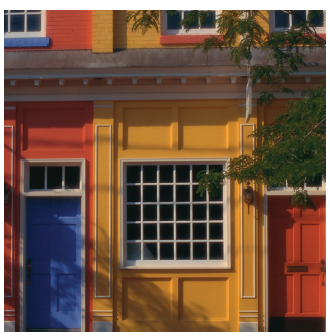
Splitters

Splitters (also called couplers) are photonic devices that split a single optical signal into two or more outputs. PON systems use splitters to divide the downstream signal power from the CO/HE into multiple outputs, typically 16 or 32 outputs, for delivery to subscriber ONTs. The ONTs in turn send signals upstream, which are combined onto one single fiber back toward the CO/HE. The OLT/ONT electronics manages communications between the CO/HE and the 16 or 32 subscribers connected over the fiber and splitter.

Standard Performance Splitter Specifications	Typical IL	Maximum IL
1 x 2 Coupler/Splitter	3.1	3.90
1 x 4 Coupler/Splitter	6.3	7.70
1 x 8 Coupler/Splitter	9.7	10.75
1 x 16 Coupler/Splitter	12.7	14.00
1 x 32 Coupler/Splitter	15.8	17.10
1 x 64 Coupler/Splitter	18.9	20.50
2 x 2 Coupler/Splitter	3.1	3.90
2 x 4 Coupler/Splitter	6.3	7.80
2 x 8 Coupler/Splitter	10.0	11.20
2 x 16 Coupler/Splitter	13.0	14.80
2 x 32 Coupler/Splitter	16.0	18.00

Figure 4.29 – Standard Performance Splitter Specifications | Drawing ZA-3124

Because the splitter divides the optical power of the signal, it has an important impact on the system loss budget. Each time the signal is divided in two, it represents a 3 dB attenuation, plus a small allowance for inherent losses in the device itself. Therefore 1x16 and 1x32 splitters used in typical PON systems have considerable alteration. Figure 4.29 relates various split ratios and their typical insertion loss performance. Splitters with two inputs and 16 or 32 outputs are also available and can be used in applications where signals from two sources must be combined and then shared among the outputs.

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