AN OFS **WHITE PAPER**

NEW TECHNOLOGIES ENABLE FASTER, EASIER FIBER INSTALLATION INTO HOMES AND MDUs

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Executive Summary

Driven by unprecedented demand for Gigabit and fast-emerging 10 Gigabit Broadband, Fiber to the Home (FTTH) deployment is expected to reach record numbers in the coming years. According to iDate, FTTH connections will more than double in Europe over the next six years, while RVA forecasts that FTTH investment in North America will double in the next five years compared to the previous five. In addition to homes, service providers are bringing fiber to the living unit in multiple dwelling units (MDUs) and into commercial and institutional buildings.

In all these scenarios, a cost-effective and compact optical network terminal (ONT) is typically placed inside each living unit or office to enable Gigabit or even 10 Gigabit connectivity. However, there are aesthetic and cost challenges to placing fiber inside residences or buildings. While service providers typically prefer to deploy ONTs deep within subscribers' units with co-located Wi-Fi:

- there may be no existing fiber ducts or pathways to the ONT location.
- installing new ducts or cutting and patching walls can be very expensive and disruptive.
- surface mounting conventional fiber cables can be unsightly and result in optical signal loss when the cables are bent around the many sharp corners on the pathway to the ONT.
- wire molding or tape systems to house fiber are typically cost prohibitive, visible. and very slow to install.

To overcome these challenges, OFS has developed two new fiber solutions - EZ-Bend® cabling and InvisiLight® Solutions - that are virtually invisible and faster and easier to deploy. This paper explains these new enabling technologies that are being widely adopted by communications service providers (CSP).

EZ-Bend Fibers and Cables Enable Worry-Free Bending

The first FTTH systems took one of two installation approaches: deployment of outdoor ONTs either connected to existing indoor copper wiring, or the placement of new copper cables from the outdoor ONT to reach a gateway inside. In the past 10 - 15 years, new fiber deployments have transitioned to less-expensive indoor ONTs in each living unit or office, first in MDUs and later in single-family homes.

In early MDU fiber deployments, CSPs discovered that, while 7.5-millimeter (mm) bend radius fiber met the ITU-T G.657. A2 recommendation, it was not practical due to the high bend losses resulting from routing and stapling the fiber cables around the many sharp corners along pathways in existing buildings. In response, the ITU developed a recommendation for 5 mm bend radius fiber. Called ITU G.657.B3, it improves bending performance but still falls short of supporting the tight bends that are often required in these applications.

To meet the challenges of indoor fiber deployments, OFS developed EZ-Bend fiber, a G.657.B3-compliant fiber which uses OFS Labs' patented resonance assisted waveguide design to allow 2.5 mm bends, twice as tight as the 5 mm specified for ordinary G.657.B3 fibers. EZ-Bend cables containing EZ-Bend fibers reliably support stapling and tight bends without fiber breakage or signal loss concerns. EZ-Bend cables are engineered with extra strength elements enabling a 45 kilogram (100 lb.) tensile rating, double that of other G.657.B3 cables.

TPR-9424, an MDU simulation test developed by Verizon in 2008, replicates the bending and stresses possible in MDU fiber deployments. As shown in Figure 1, this test demonstrates the insufficiency of G.657.A2 fiber cables for these applications, while proving the capability of OFS EZ-Bend Cables. OFS analyzed the failure probability from fiber breakage (assuming each installed drop cable is subjected to the full stress of the TPR-9424 MDU simulation) and predicted a failure probability of less than one in five million subscribers per year.

EZ-Bend cables have withstood the test of time in real deployments, with no reported issues with fiber bending loss or breakage in more than five million cables installed from 2009 to 2021 in multiple Tier 1 networks and dozens of others. In a "box

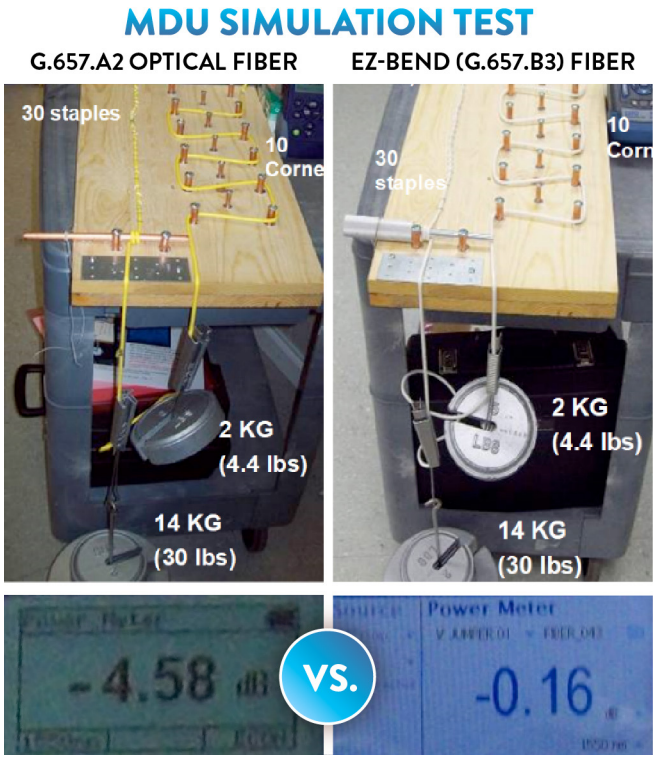


FIGURE 1: An MDU simulation test demonstrates the insufficiency of G.657A2 fiber cables, while proving the capability of OFS EZ-Bend cables.

test" (Figure 2) created by a Tier 1 service provider to simulate real-world conditions, EZ-Bend 3 mm cables experienced bend losses three to five times lower than ordinary G.657.B3 cables (Figure 3).

Most FTTH networks deployed today will need to support XGS-PON or NG-PON-2 systems, which utilize bend-sensitive wavelengths of 1580 nanometers (nm) and 1625 nm downstream, respectively. The box tests were performed using widely available test wavelengths of 1550 nm and 1625 nm. OFS added an estimate for the loss at 1580 nm to represent XGS-PON downstream, by interpolating between the values measured at 1550 nm and 1625 nm. The results show clearly that EZ-Bend cables exhibit up to 3 (decibels) dB lower bend loss compared to ordinary G.657.B3 cables, and more than 18 dB lower bend loss compared to G.657.A2 cables.

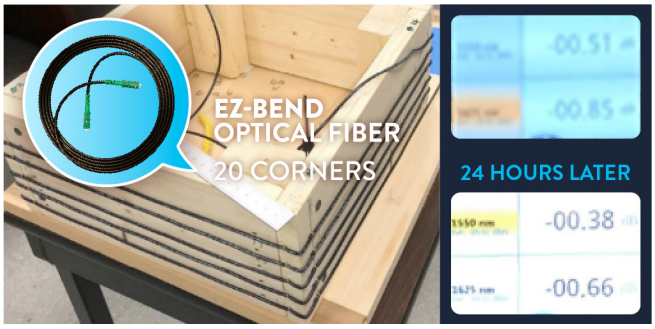


FIGURE 2: Box test with 20 corners.

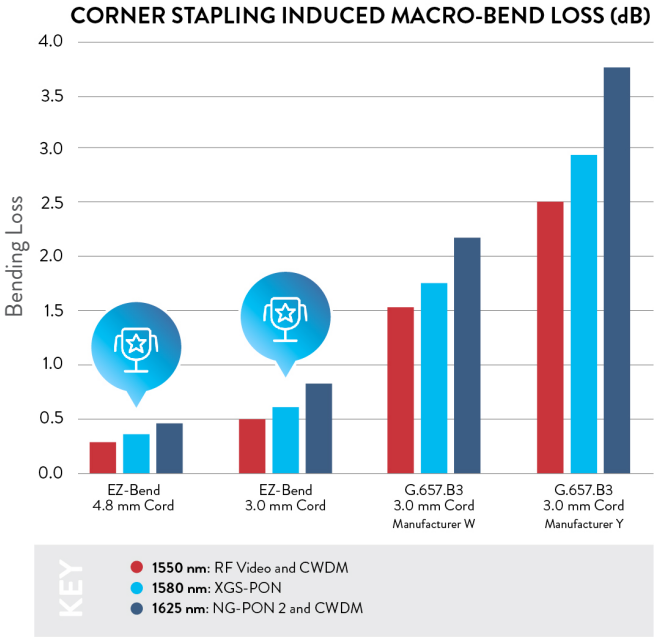


FIGURE 3: Box test performance comparison.

NOTE: The losses of G.657.A2 fiber in a 3 mm cord in the box test were 12 dB at 1550 nm and 19 dB at 1625 nm, thus "off the chart" and not shown.

InvisiLight Solutions Solve the Challenge of Customer Acceptance

EZ-Bend cabling enables easy, faster installations inside MDUs and single-family homes using conventional stapling around sharp corners and allows for no-worry slack storage in tight compact bundles. However, service providers discovered that some subscribers would not accept the appearance of 4.8 mm or even 3 mm outer diameter cables along their baseboards or moldings. In response, OFS developed the InvisiLight Solution in 2012. EZ-Bend fiber buffered in a 0.9 mm outside diameter

(OD) is adhered in the creases between walls and ceilings or between moldings and walls, using a few simple tools and a process that can be learned in minutes. InvisiLight Solutions use OFS EZ-Bend fiber to handle the 2.5 mm bend radius corners encountered in real deployments. Since 2012, more than 800,000 subscribers have been connected using this solution by multiple Tier 1 service providers with no reports of fiber breakage or fiber falling off the wall as has been reported for other low-visibility systems.

FIGURE 4: InvisiLight Solution enables virtually invisible fiber in living units or offices in different module types.

Fiber pathways inside living units, offices and buildings can be full of corners; it is not unusual to see 20 corners in a large deployment. The photo on the right in Figure 5 shows 10 corners over only 10 feet (3 meters). Hallways may have even more corners.

Corners in buildings require the very lowest bend loss performance, down to 2.5 mm bend radius. While it is possible to use bend management devices to navigate corners at larger bend radii, such devices slow installation time and increase visibility. InvisiLight 900-micron fiber can be bent around sharp corners without the use of bend management devices. The product has been installed in this way to connect hundreds of thousands of subscribers without fiber bend loss or breakage.

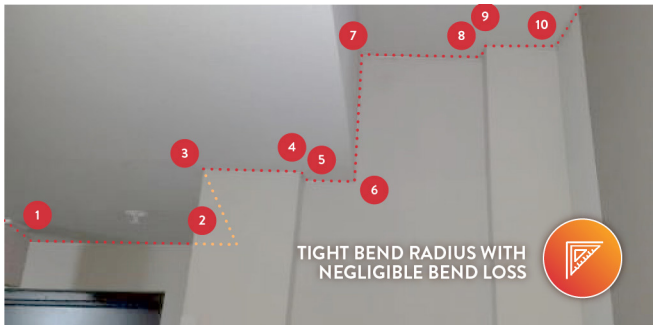
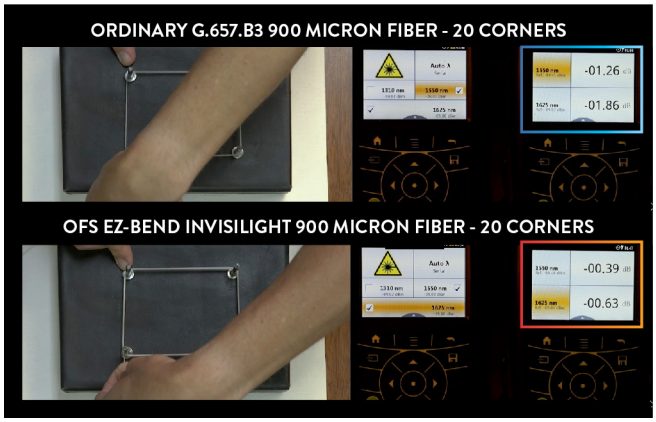


FIGURE 5: Corners in real-world applications.

After observing hundreds of indoor installations with fiber bends down to 2.5 mm bend radius, OFS developed a test that bends the buffered fiber around 20 corners, resulting in a fiber bend radius of 2.5 mm (Figure 6). The test clearly demonstrates the InvisiLight ILU 900-micron cord with EZ-Bend fiber inside enables three times lower bend loss than 900-micron cords using ordinary G.657.B3 fiber.



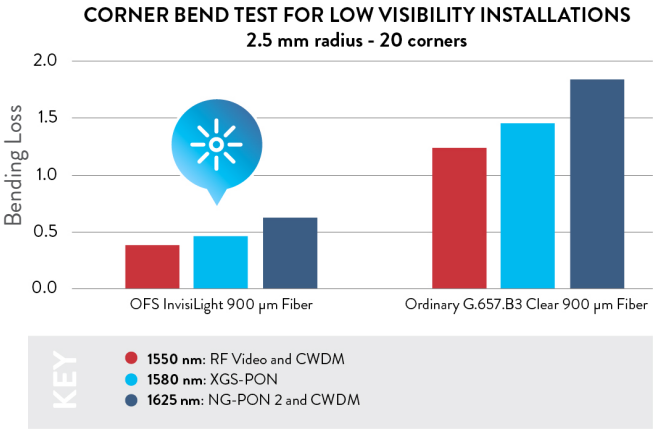


FIGURE 6: This performance is magnified further in next generation PON networks, which operate at longer wavelengths. InvisiLight ILU fiber exhibits three times lower bend loss than ordinary G.657.B3 fiber.

In addition to the In Living Unit Solution, OFS has expanded InvisiLight Solutions to enable faster, easier, cost-effective and virtually invisible fiber deployment throughout and on buildings, homes and offices (Figure 7).

Summary

EZ-Bend Cabling and InvisiLight Solutions enable fast, easy and accepted fiber deployments to and into MDUs, homes and offices. The combination of EZ-Bend Fiber's 2.5 mm bend radius performance in a total system of fiber, cable and connectivity designed and engineered to work together has provided reliable optical fiber connections to millions of subscribers thus far and can be expected to connect millions more in the years ahead.

FIGURE 7: InvisiLight Solutions cover multiple applications. OFS has been developing these solutions for over 12 years, providing solutions that consumers have not yet seen.

Ask About Our
INVISILIGHT® EZ-CONNECT MODULE

- Easy, quick install
- Integrated jumper option
- Blends into decor
- Protected in crevices
- Most indoor surfaces
- Paintable
- 50 Corners