# Putting Drop and Indoor FTTH Cables to the Test

The demand for smaller and more bend-tolerant drop and indoor fiber optic cables is on the rise; Draka Comteq has responded to the need and the competition with new, carefully tested configurations.

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Fiber-to-the-home installations require a variety of optical cable designs, including in-duct, direct-buried, and indoor/outdoor. Most cable is too large for use as small subscriber drop or indoor FTTH cables. This has created a rising market demand for small drop cables.

For European applications, and for MDUs and many single-family installations in North America as well, the selection of suitable halogen-free flame-retardant (HFFR) materials has also been an issue for meeting relevant fire codes and standards.

The task for cable manufacturers, therefore, is to design fiber optic drop cables with superior mechanical strength that are still small and flexible enough for indoor installations.

These fibers require lower fiber counts (with the exception of riser cable) and little or no gel. This article will describe several new fiber cables designed especially with FTTH architectures in mind – and show how they stand up to various mechanical, environmental and installation tests.

## FTTH CABLE REQUIREMENTS

Because FTTH architectures extend to both indoor and outdoor environments, they require many different kinds of cables. They also require ways to transition from one to the other. This means that we need indoor, indoor/outdoor, and outdoor cable designs that can accommodate the huge variety of installation techniques being used today.

On the outdoor side, system architects are installing aerial or direct-buried fiber, or else running fiber through ducts and microducts. Indoors, fiber is installed along walls, behind moldings, around corners, through ceilings, and with a variety of other installation techniques. The local environment – building styles, existing ducts, regulations, owner requirements, life safety codes and more – typically dictates what methods are used.

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The need for today's fiber to have both mechanical strength and flexible installation capability is most evident in small subscriber drop and indoor cable products. The new bend-optimized fiber products are especially important in FTTH deployments, particularly for indoor use.

The best bend performance is attained by using fibers that meet the specifications of ITU-T G.657 class B. These fibers withstand bends of exceptionally low radius without increasing attenuation. This provides huge advantages for single-mode fibers used indoors, because installations typically require routing around sharp edges and corners.

Small-bend-radius fibers also allow a reduction in the physical size of connection equipment such as splice closures and termination boxes.

Let's look at several types of fiber cable designs for use as drop cables and indoor cabling.

## DROP AND INDOOR CABLE DESIGNS

As mentioned earlier, no particular fiber drop or indoor cable is suitable for all FTTH architectures – there is no "one size fits all" design. Each deployment has its own set of unique circumstances that will dictate which cable design will work best.

Thus, the following designs – dry central tube drop cable, semi-tight buff-

| TEST | RESULT | COMMENTS | |
|---|---|---|---|
| | | BBXS Fibers | ESMF Fibers |
| **Crush Test**<br>2000 newtons;<br>plate-plate,<br>100 mm, 15 min | Pass | 0.04 dB<br>No damage | 0.02 dB<br>No damage |
| **Impact Test**<br>10 newton-meters,<br>three impacts,<br>r=300 mm | Pass | 0.00 dB<br>No damage | 0.00 dB<br>No damage |
| **Temperature Cycle Test**<br>-5 to +70 degrees C | Pass | 0.05 dB/km<br>average | 0.08 dB/km<br>average |
| **Bend Test (RT)**<br>6 turns, 10 cycles | Pass | R=10 mm<br>0.09 dB max | R=20 mm<br>0.08 dB max |

**Table 1. Type test results. Attenuation was measured at 1550 nm. These fibers withstand temperature cycling, moderate bending radii and severe crushing and impact forces well.**

Both cables are based on 900 µm semi-tight buffered fibers. In these designs, the fiber is decoupled from the 900 µm buffer tube. This semi-tight construction guarantees easy end-access of the optical fibers – over 1 meter in less than a minute. Both of the cables tested were made with bend-optimized Bend-BrightXS fibers (see Table 2). In each case, a highly flame-retardant HFFR was also used.

The two-fiber dry semi-tight subscriber cable was subjected to stapling installation testing. The cable was stapled against a wall and around a doorframe, using a stapling gun with rounded staples.

Figure 1 shows the installation path, which included fifteen 90-degree bends

ered cable, riser cable, zipcord cable and composite cable – each have their own benefits in specific deployment scenarios. Each design has been subjected to crush, impact, temperature and bend testing – all with FTTH applications in mind.

***Central tube drop cable*** – The central tube drop cable consists of a HFFR tube and sheath. The tube housing the optical fibers is completely dry, without gels or compressible yarns. The outer diameter is just 4 mm (1/6 inch) and aramid yarns are embedded as strength elements. These drop cables are specifically designed to have extremely high crush and impact resistance.

This makes these drop cables particularly effective for on-wall installations using staples. Although these fiber cables are absolutely free of gels, swelling materials can be added to achieve a watertight design. Both enhanced standard single-mode fiber (ESMF) and bend-optimized fiber designs were tested for their various attributes. The most noticeable difference was in bend radius (see Table 1).

While standard ESMFs only allowed a minimum bend radius of 20 mm in the tests, the bend-optimized fiber could bend to a radius of 10 mm – half the bending radius. This is a significant difference when the application calls for frequent small bends. It offers an extra margin of safety for FTTH installations.

> ***Small-bend-radius fibers also allow reducing the physical size of connection equipment such as splice closures and termination boxes.***

***Dry semi-tight design*** – Dry semi-tight designs typically are one- or two-fiber cables used for branching inside the subscriber premises. They are usually installed on-wall by stapling or gluing. The single-fiber cable has a 2.8 mm diameter while the two-fiber cable has a diameter of 4.2 mm.

using 89 staples. During the installation, the attenuation was measured at 1550 nm, and the attenuation change for the test was only 0.05 dB.

***Riser cable*** – When there is a need to get many fibers to several distribution points or separate apartments on multiple floors of a building, a riser de-

| TEST | RESULT | COMMENTS | |
|---|---|---|---|
| | | Single-Fiber Design | Dual-Fiber Design |
| **Crush Test**<br>1000 newtons;<br>plate-plate,<br>100 mm, 15 min | Pass | 0.03 dB<br>No damage | 0.00 dB<br>No damage |
| **Impact Test (RT and -5°C)**<br>3 newton-meters,<br>three impacts, r=300 mm | Pass | <0.01 dB<br>No damage | 0.03 dB<br>No damage |
| **Temperature Cycle Test**<br>-5 to +60 degrees C | Pass | <0.01 dB/km | <0.01 dB/km |
| **Bend Test (RT)**<br>6 turns, 10 cycles | Pass | R=10 mm<br>0.13 dB | R=10 mm<br>0.04 dB |

**Table 2. Test results using installation path shown in Figure 1 on next page. Attenuation was measured at 1550 nm.**

sign is necessary for the vertical installation. Riser cables should be very low in weight and size. However, the main requirement is the cable's ability to segregate one or more bundles of fibers per apartment, typically achieved by opening small windows approximately 5 cm (2 inches) long in the outer jacket. This also allows easy termination of several fibers in a distribution box on a particular building floor.

The riser cable carries a maximum of 48 optical fibers in an 8x6 configuration, with several small semi-tight buffer tubes made of a soft material. These modules are loosely placed into the cable center, surrounded by several aramid yarns as strength elements and an HFFR jacket. The overall outer cable diameter is approximately 7.6 mm and weighs about 50 grams (3 ounces) per meter.

The riser cables were mechanically and thermally tested in two versions – ESMF and bend-resistant fiber (specifically BendBrightXS). The test results indicated that the bend-resistant variety was a slight favorite, although both passed the target requirements (see Table 3).

The most amazing difference was in the bend test, where the bend-optimized fibers reached a maximum attenuation loss of just 0.02 dB for a mandrel of 10 mm radius. The test was performed on each module within the 48-fiber cable, because the complete cable could not easily be bent to such a small radius, making the test even more impressive.

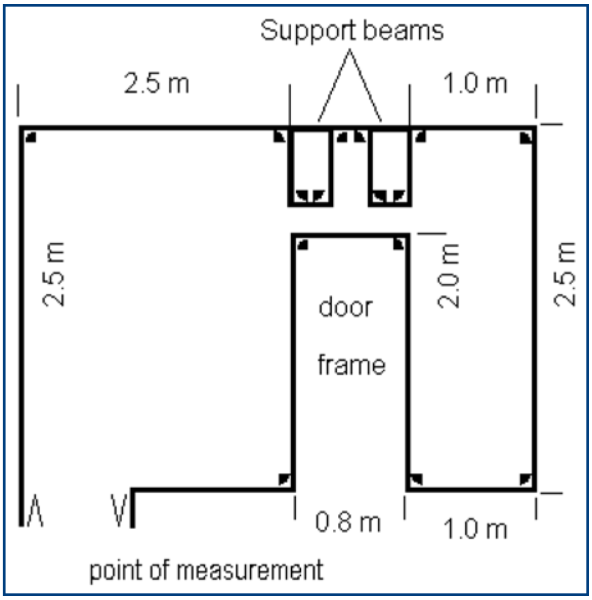


**Figure 1. The installation path tested as in Table 2, which included fifteen 90-degree bends using 89 staples.**

*Tests have shown that service providers can reduce safety risks and increase installation flexibility by using products containing bend-optimized fibers.*

| TEST | RESULT | COMMENTS | |
|---|---|---|---|
| | | BBXS Fibers | ESMF Fibers |
| **Crush Test**<br>2000 newtons; plate-plate, 100 mm, 15 min | Pass | 0.04 dB<br>No damage (reversible) | 1.5 dB (informational only; the specification requests 1400 N load); No damage (reversible) |
| **Impact Test**<br>5 newton-meters, three impacts, r=300 mm | Pass | 0.00 dB<br>No damage | 0.01 dB<br>No damage |
| **Temperature Cycle Test**<br>-5 to +60 degrees C | Pass | 0.05 dB/km | 0.10 dB/km average |
| **Bend Test (RT)**<br>6 turns, 10 cycles (on modules) | Pass | R=10 mm<br>0.02 dB max | R=20 mm<br>1.0 dB max |

**Table 3. Riser test results. Attenuation was measured at 1550 nm. These fibers withstand temperature cycling, moderate bending radii and severe crushing and impact forces well; BBXS does much better than ESMF, especially (as expected) when bent.**

The attenuation increase through various processes during cable manufacturing showed a slight difference, depending on the fiber type. The maximum attenuation change (at both 1550 nm and 1625 nm) for the bend-optimized fibers was 0.01 dB/km, and 0.02 dB/km for the ESMF fibers. It does, however, confirm that bend-optimized fibers can withstand higher stress on fibers during the cabling process as compared with standard ESMF fibers.

For vertical installations in buildings, the fiber units of the riser cable would be individually segregated to each subscriber. The use of bend-optimized fiber will enable significantly smaller bends in the installation route, such as around the 90-degree corners in Figure 2.

***Zipcord cable*** – The zipcord cable consists of two 2.8 mm outside diameter patchcords. Each comprises a 900 µm tight-buffered tube surrounded by aramid yarns and an HFFR jacket. The zipcord can be split into the two single-fiber patchcords.

To compare the behaviors of a bend-optimized fiber and a standard ESMF, a zipcord was assembled using each type for a separate branch. It was then bent around a single sharp bend (see Figure 3). The measured loss was 5.45 dB for

**Bend-optimized fibers can withstand higher stress on fibers during the cabling process as compared with ESMF fibers.**

| TEST | RESULT | COMMENTS |
|---|---|---|
| **Crush Test** 3000 newtons; plate-plate, 100 mm, 5 min | Pass | 0.00 dB |
| **Temperature Cycle Test** -30 to +70 degrees C | Pass | 0.00dB; 1550 and 1625 nm |
| **Bend Test (RT)** 2 turns; 5 cycles; r=10 mm | Pass | 0.01 dB max |
| **Bend Test (RT)** 90-degree turn, r=5 mm | Pass | 0.01 dB max |

**Table 4. Composite 5.5 mm cable with two bend-optimized fibers and two insulated copper conductors, wrapped with a polyester nonwoven tape, aramid yarns and an HFFR sheath. It connects an optical-electrical converter and its power source. Attenuation was measured at 1550 nm unless noted otherwise.**

the ESMF fiber and only 0.01 dB for the bend-optimized fiber at 1550 nm.

***Composite cable*** – The composite cable consists of four transmission elements – two tight-buffered bend-optimized fibers and two insulated copper conductors – wrapped with a polyester nonwoven tape, aramid yarns and an HFFR sheath. The cable has an outer diameter of 5.5 mm. This single cable, designed for indoor use, connects an optical-electrical converter and its power source.

During testing, the composite cable was installed on top of baseboard using cable clips, bending around four 90-degree corners. The resulting attenuation increase was only 0.01 dB at 1550 nm – well within the measurement accuracy of 0.05 dB. Test results are shown in Table 4.

## CONCLUSIONS

Different types of FTTH subscriber drop, indoor and riser cables are being developed for different customer applications. These cables can be constructed using standard ESMF fibers as well as bend-optimized fibers, such as BendBrightXS.

Tests have shown that service providers can reduce safety risks and increase installation flexibility by using products containing bend-optimized fibers. These fiber cables boast increased robustness that allows on-wall stapling with very low risk of damage to the fibers.

Bend-optimized fibers offer additional advantages, but no constraints in comparison with standard ESMF fibers. By allowing a minimum bend radius of about 10 mm, these fibers present less possibility of kinking or damaging the glass core when installing in tighter FTTH environments. **BBP**


### About the Authors

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**Figure 2. Path around corner; note the slight groove in the wall at corner bend.**

**Figure 3. A for-test-only zipcord with a bend-optimized fiber and a standard ESMF fiber, bent around a single sharp corner. The measured loss was 5.45 dB for the ESMF fiber and only 0.01 dB for the bend-optimized fiber at 1550 nm.**