One fibre everywhere?

Vanesa Diaz, market development engineer at Corning Optical Fiber, describes the benefits of a bend-improved optical fibre featuring full compatibility with legacy deployments

Network owners have much to consider when designing access networks. The network has to be able to support high-data rates and to maximise coverage area from the central office. Ideally, it should take advantage of low cost installation techniques and hardware miniaturisation. Once deployed, the network may have a lifespan of 15 to 20 years so upgrades to higher data rates must be supported. Finally, but not least, backwards compatibility is essential to ensure that new installations can be connected to equipment that has been already installed.

Although designing the network to meet all these conflicting considerations at once might seem difficult, the fibre selected can actually make a positive difference.

Fibre choices for access networks

There are currently three fibre types used extensively in access networks:

- Traditional G.652.D fibres are highly backwards compatible as they have been used in all networks for many years. However, advanced cable design and installation options that require higher bend resistance may be limited with these fibres. Higher attenuation might also limit coverage area and disallow some upgrade paths that low-loss G.652 fibres support;
- Low-loss G.652.D fibres are also fully backwards-compatible and their lower attenuation allows for extended network coverage and extra margin to allow future upgrades and accommodate repairs. However, lacking additional bend resilience, they are also limited for allowing cable and hardware miniaturisation and low cost deployment techniques; and
- Macrobend improved G.657 fibres have become popular in outside plant (OSP) installations in recent years as their bend resistance enables smaller cable designs (aka mini-cables) and low costs installations techniques. These fibres however tend to be designed with smaller mode field diameter (MFD) and may feature a lower refractive index 'trench' region around the core to assist in bend resistance which can cause difficulties during installation.

Why are G.657 standard fibres so popular in the access?

There are three grades of macrobend performance defined in the ITU-T G.657 recommendation. G.657.A1 fibres are primarily intended for use in OSP and have been enthusiastically adopted by network owners[1] while G.657.A2 and G.657.B3 compliant fibres are more commonly used inside the building.

In general, G.657 standard fibres have proved to be very attractive in the access because the improved macrobending and microbending performance allows for tighter packing in smaller cable designs. For example, the Japanese NTT organisation reduced the diameter of their OSP ribbon cable by 30 per cent by employing a G.657.A1 fibre instead of G.652.D fibres[2]. The smaller and lighter design of minicables, installed within

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microducts, improves product handleability and deployment speed. Operators can also reutilise duct space that otherwise would be deemed full for larger cables, avoiding the expense of new trenching. Also, a cable that can cope with smaller bend diameter radius (G.657.A1 fibres allow bends down to 10mm radius) can be more tightly coiled to allow housing in smaller cabinets and closures.

Where a network operator does not own the duct infrastructure and seeks to rent space in the incumbent infrastructure, mini-cables also derive cost advantage. In Portugal and France, for example, where duct rental is charged based on cross sectional area of duct filled[3], minicables can deliver proportionate cost savings through the network's lifetime.

Finally, subscriber demand for content means network operators must be well placed to deliver higher data capacity in the future. To allow upgrade to higher capacities, standards organisations are allocating new transmission windows at longer wavelengths where fibre is more susceptible to bend loss. The use of bend-improved fibres better positions the network for future upgrade. But, despite their obvious benefits, the glass design of G.657 fibres can create difficulties during the installation process that might lead operators to reject the use of these products.

Deploying G.657 fibres in legacy G.652 networks

In access networks can be necessary to connect new fibre to existing plant. When established G.657 fibres are connected to G.652.D fibres differences between these two designs can lead to problems:

- **Splices:** the improved macrobend performance of G.657 fibres is often achieved by reducing the mode field diameter and lowering the refractive index in a so-called 'trench' around the core. Because of this design, some splicing machines can struggle to identify G.657 fibres and fail to identify the right splicing program, causing delays in installation.
- **OTDR:** this test is used to measure attenuation through the link by launching a pulse of light and measuring the amount of light that it is returned through backscattering. With a typically smaller MFD, G.657 fibres tend to backscatter a larger

fraction of light than G.652.D fibres (MFD typical of 9.2μm). This difference results in the OTDR measurement as an 'exaggerated loss' at the splicing point when transitioning from a G.657 fibre to a G.652 type. That would be a concern for the installer who to confirm the splice quality must then repeat the OTDR test from the other end of the link (the measurement will now result in a 'gainer'). This phenomenon has been addressed by the standard organisations that recommend determining the splice loss by calculating the average of both OTDR measurements from each end[4], but this procedure increases installation time and costs.

The value of low loss in OSP access networks

A fibre with low attenuation can bring additional benefits to operators so it is worthwhile considering these fibres for new deployments. In access networks, fibre attenuation limits the maximum reach that can be achieved from any given central office.

Some incumbent operators are seeking to reduce the number of central offices to rationalise access network equipment and real estate in order to reduce costs. As central office consolidation naturally increases the required reach to connect all subscribers, low-loss G.652 fibres are recommended to maximise coverage, maximising the opportunity for creating redundant central offices that may be closed.

Is it possible to have it all?

G.657.A1 type fibres have proved their value in OSP plant applications but might present potential compatibility problems. On the other hand, low attenuation fibres are 100 per cent compatible but do not have the bend resistance to allow for miniaturisation or to protect the network from occasional bends. Fortunately, technology advances have now removed the need to trade-off between desirable properties.

In March 2013, Corning became the first manufacturer to introduce an innovative fibre (Corning SMF-28 Ultra fibre) that delivers low attenuation and improved macrobend performance while maintaining the 9.2μm MFD diameter of legacy G.652.D fibres for seamless integration into the pre-existing networks. Suitable also for use in metro and long-haul networks, where lower attenuation can be exploited even further, these versatile fibres can reduce costs associated with inventory complexity providing one robust solution across all network applications.

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