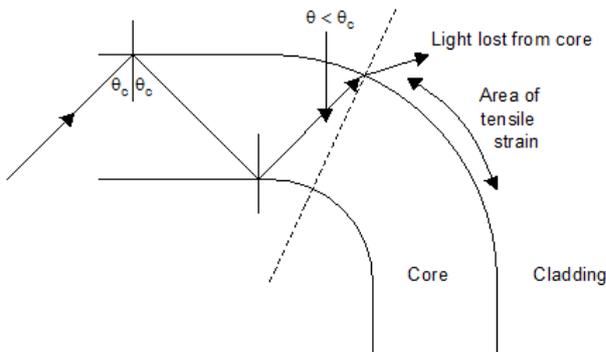


## MICRO-BENDING, MACRO-BENDING AND LESS BEND SENSITIVE OPTICAL FIBRES

by  
Mike Gilmore, Technical Director

This White Paper seeks to clarify the difference between micro-bends and macro-bends and also to explain the impact of optical fibres described as “less bend sensitive” or, more inaccurately, as “bend insensitive”.

Macro-bends can be most easily classified as being optical fibres, or cables containing optical fibres, that are subjected to bend radii below the manufacturers recommended values to such an extent that the light cannot be guided along the core of optical fibre – thereby resulting in attenuation i.e. a localised loss.

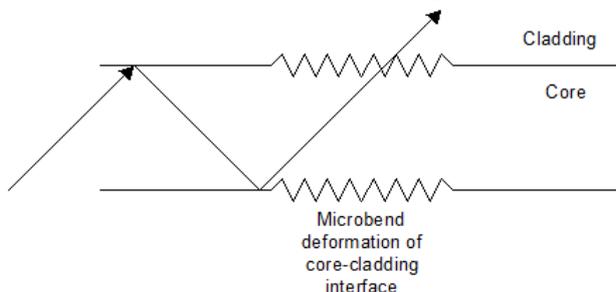


The figure on the left shows the problem to a purposely extreme and unrealistic degree in order to simplify the concept. Light is shown travelling in a step index optical fibre and enters the bend with the ray already at the critical angle (below which total internal reflection cannot take place). As it enters the bend the angle of incidence of the light on the outside of the bend falls below that of the critical angle and the light is lost from the core.

In reality, the bends are substantially less than shown and the amount of light lost will also

depend upon the modal distribution of optical power within the optical fibre - and will only be a fraction of the total light transmitted (although more severe for singlemode than multimode optical fibres). Macro-bends may be identified by such losses when measured by an OTDR, but the losses may be quite small (< 1 dB) and may not be discovered by other test methods, e.g. light source/power meter measurements, which tend to mask localised loss events. Of greater concern is the fact that macro-bends indicate points at which the optical fibre is under tensile strain, generating stresses that can result in catastrophic failure via crack propagation. In essence, the localised loss created by the macro-bend is actually only a symptom a more fundamental, longer term, problem.

The term “macro-“ is intended to convey the idea that the effect occurs at a macroscopic level and can be corrected at that level e.g. by removing the bend, recovering the loss and removing the stress. By comparison, micro-bends tend to be associated with deformations of the refractive index profile and/or the core-cladding interface inside the optical fibre and can occur in macroscopically unbent and apparently unstressed optical fibre or cable. This is shown, to an extreme degree, in the schematic below.



Such deformations have a wide range of potential causes. They can be caused by faulty processes during the manufacture of the optical fibre or when the various coatings are applied to it during the cabling process. Similarly, they can be caused by radial compression i.e. pinching of the optical fibre. This is sometimes seen in badly reeled cables - and may be resolved by re-reeling.

It can also result from axial forces – perhaps where the optical fibre wants to move but the cable construction prevents that movement. It can also occur if the optical fibre is subjected to low temperatures or high pressures.

Clearly some of these causes are localised - producing a localised loss - whereas others may affect a long length of cable. The losses can be progressive (such as exhibited in a badly reeled cable) where the additional loss per metre is quite small but cumulatively produces a large loss. Alternatively the micro-bends may be very localised, affecting only millimetres of optical fibre length, but producing very large losses (losses of 40 dB have been seen where optical fibres are subject to axial compression).

Recently, optical fibres have been introduced to the market that are termed "less bend sensitive" i.e. they do not lose as much light when subjected to bends which would, historically, be considered to be severe. The initial product launches were focussed on singlemode technology as cables were expected to be installed into difficult routes in building within fibre-to-the-home implementations. These optical fibres are designated by ITU-T as G.657 (currently in four variants) and by BS EN 60793-2-50 as Category B.6.

The migration of less bend sensitive optical fibres into the multimode environment has been less straightforward and is not universally accepted and no standards for these optical fibres have yet materialised.

However, for both singlemode and multimode solutions, it must not be forgotten that although the losses may be reduced, the stresses on the surface of the optical fibres have not. In truth these optical fibres disguise the presence of cable bends which, although in line with cable suppliers recommendations, infrastructure owners might actually want to be made aware of.

Produced 21<sup>st</sup> April 2012