

# Coating geometry parameters of silica optical fiber - An Appraisal

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## Issued

April 2013

## Abstract

This white paper outlines the primary functions and specified values across various international standards for optical fiber coating geometry parameters. The role of coating geometry parameters in optical fiber cabling operation is explained.

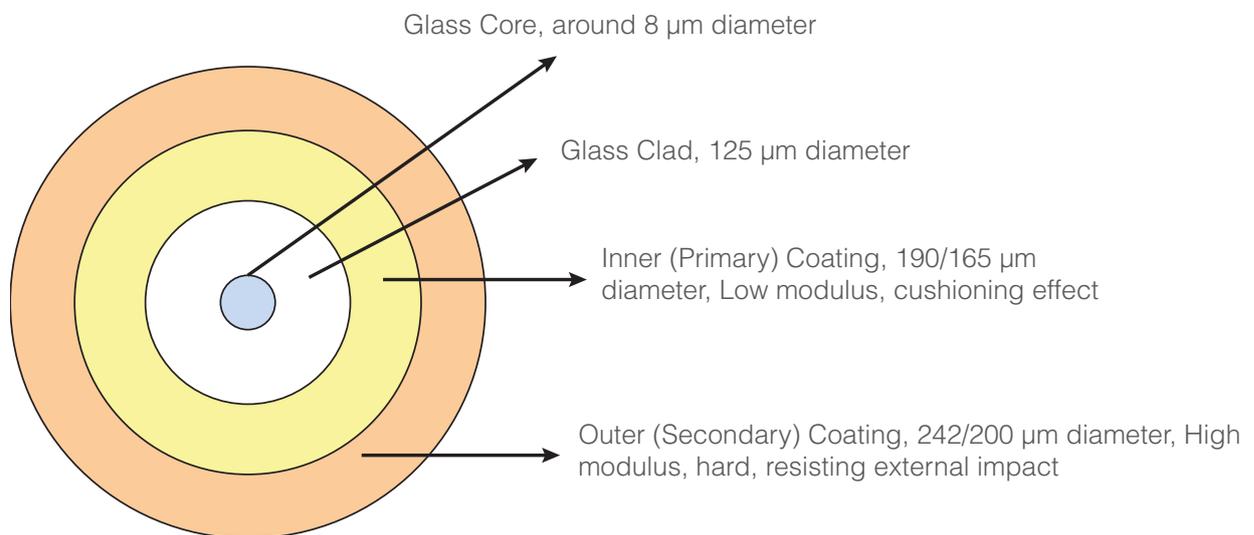
## Keywords

Optical fiber, Coating diameter, Coat- Clad Concentricity Error, Coating non-circularity



## Introduction

Silica optical fiber is used in all modern optical communications including long-haul, regional, access, and FTTx/Premises networks. The silica optical fiber is made up of three layers, the core, cladding, and the coating. The core is the center of the fiber, which is made of doped glass. This is the region in which information bearing laser light (i.e voice, video, data) is confined. The cladding is also made up of pure silica glass, which keeps the light trapped in the core due to the principle of ‘total internal reflection’ and allows it to ‘bend’ around curves in the fiber. The coating is made of a UV curable polymer called acrylate, which acts to protect the inner glass fiber. Dual layered coating structures are generally applied, which use a low-modulus inner or buffer layer to cushion the fiber surrounded by a high-modulus outer coating to increase the flexural rigidity and distribute the lateral external forces.



**Figure 1: Schematic cross-sectional view of dual coated optical fiber**

## Primary functions of coating

Primary functions of coating are to:

1. Protect the glass fiber from external sources of abrasion and contamination

2. Increase mechanical strength: Coating materials bear approximately 3 to 10% of the strength of coated optical fiber. The fraction of tensile load carried by a uniformly thick, linear elastic coating is given by:

$$\frac{E_c A_c}{E_c A_c + E_g A_g} \text{---Eq (1)}$$



Where,  $E$  is the elastic modulus,  $A$  is the cross-sectional area, and subscripts  $g$  and  $c$  represent glass and coating respectively.

3. Suppress ingress of moisture: As water molecules accelerate the stress corrosion of silica glass, the coating layers resist moisture from penetrating through the coating layers and reach surface of the glass fiber.

4. Reduce micro-bending loss: Soft/low modulus primary coating provides cushioning and reduce optical power loss due to the phenomenon of micro-bending.

5. Provide long-term reliability: As a result of the above functions, the coating improves the long term reliability and controls lifetime of silica optical fiber.

Coating materials should be easily processable; hence it must be applied concentrically and be of sufficient thickness without damaging the surface of the glass fiber. It should also be cured rapidly before the fiber reaches capstan of fiber drawing tower.

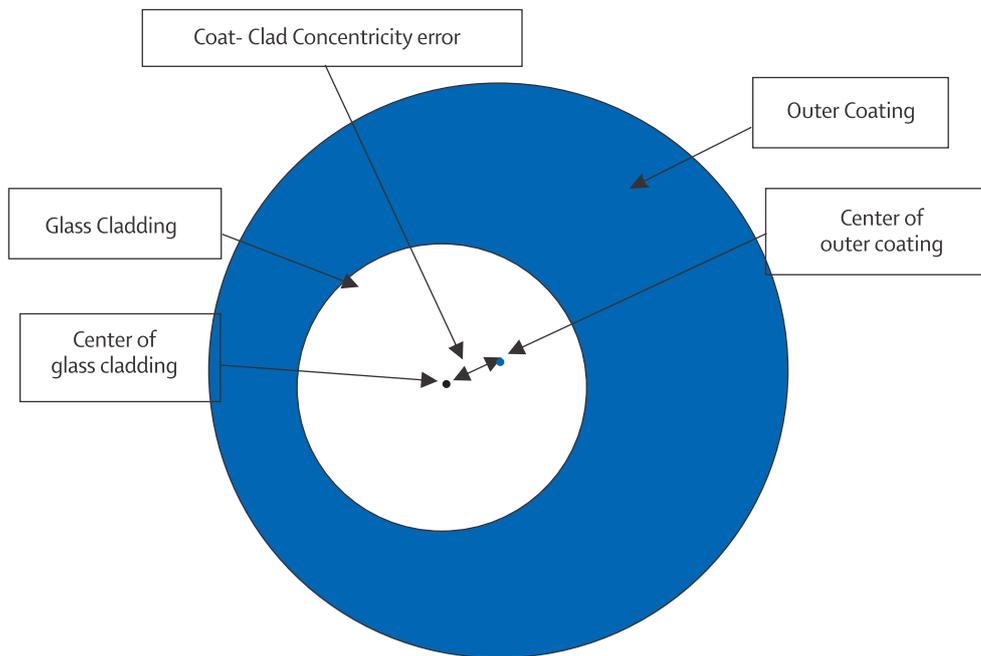
Coating materials are chosen to fulfill these primary functions. Important coating performance attributes are curing rate, glass transition temperature, modulus of elasticity, abrasion resistance, good bonding to glass, moisture resistance, proper index of refraction, gel fraction and volatile matters, among others.



## Coating geometry parameters

In addition to the coating performance attributes, optimum coating geometry parameters are required to meet primary functions effectively. The different coating geometry parameters are

1. Diameter of outer coating
2. Coat-Clad Concentricity error: The variation in space between the respective centers of the outer coating and the glass cladding



3. Non - circularity of coating (Coat ovality) : The percentage by which the shape of the layer deviates from a circle.

The following tables (Table 1, 2 & 3) show specified values of the coating geometry parameters mentioned in the international standards & industry typical values. Coating geometry parameters of Sterlite's optical fibers are typically more stringent than the values required by the international standards.

**Table 1: Outer coating diameter (Un-colored)**

Standard	Nominal Diameter	Tolerance
GR-20-CORE (Telcordia), 2008	245 $\mu\text{m}$	$\pm 10 \mu\text{m}$
ITU-T G.652 , G.655, G.657	Not Specified	Not Specified
IEC 60793 -2 - 50 (Ed 4)	235 - 245 $\mu\text{m}$ (Limits) 200 $\mu\text{m}$ (Nominal)	No tolerance $\pm 10 \mu\text{m}$
Industry Typical Values	240 - 245 $\mu\text{m}$	$\pm 5$ or $7 \mu\text{m}$



**Table 2: Coat-clad concentricity error**

Standard	Value
GR-20-CORE (Telcordia), 2008	$\leq 12.5 \mu\text{m}$
ITU-T G.652, G.655, G.657	Not Specified
IEC 60793 -2 - 50 (Ed 4)	$\leq 12.5 \mu\text{m}$ ( $\leq 10 \mu\text{m}$ for 200 $\mu\text{m}$ )
Industry Typical Values	$\leq 10\text{-}12 \mu\text{m}$

**Table 3: Coat non-circularity (Ovality)**

Standard	Value
GR-20-CORE (Telcordia), 2008	Not Specified
ITU-T G.652, G.655, G.657	Not Specified
IEC 60793-2-50 (Ed. 4)	Not Specified
Industry Typical Values	$\leq 4\text{-}6\%$

### Role of coating geometry parameters

#### 1. Diameter of outer coating

- Coating diameter affects strength of the optical fiber according to Equation 1.
- Optical fibers are colored for identification during the cabling process. The diameter of the coloring die is dependent on the outer diameter of uncolored fiber and desired thickness of color ink layer. So a tighter outer diameter tolerance specification helps to reduce frequency of the changing of the coloring die to maintain uniform thickness of color ink layer. This tighter tolerance adds together to provide significant savings in coloring time and cost.
- In field use, a small section of the coating has to be stripped before splicing or connectorization. Maximum coating strip force is the force at which the craftsman can strip a fiber with the occurrence of minimal problems (e.g. fiber breakage, multiple stripping passes, excessive coating residue, etc.). On the other hand, easily strippable fiber can potentially experience a loss of adhesion of the coating to the glass, resulting in de-lamination on aging and exposure of the glass to the environment. Therefore, an optimum value of coating strip force is required. The outer coating diameter plays a very important role to control the strip force and performance of optical fiber on aging and hence provides long-time reliability <sup>1,2,3</sup>.



- Splicing and connectorization systems use strain-relief mechanisms that grip directly onto the fiber's coating. So for easy and perfect gripping, a higher degree of outer diameter control is required.
  - Fiber ribbon products require a lower tolerance level of outer diameter so that the fibers maintain their relative position in the ribbon for mass splicing.
2. Coat-Clad Concentricity
- Coating concentricity of an optical fiber affects both transmission and strength. Poor coating concentricity influences fiber losses by producing non-uniformly distributed stresses on the fiber as a result of density changes on curing and thermal expansion mismatch'.
3. Non-circularity of coating (Coat ovality)
- Coat non-circularity also affects both transmission and strength owing to a build-up of non-uniformly distributed stresses on the glass fiber.

### Conclusion

To fulfill the primary functions of coating effectively, geometrically perfect coatings should be applied on glass fiber. Coating geometry parameters play an important role during cabling and splicing in terms of easy processing and saving of time & cost.

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