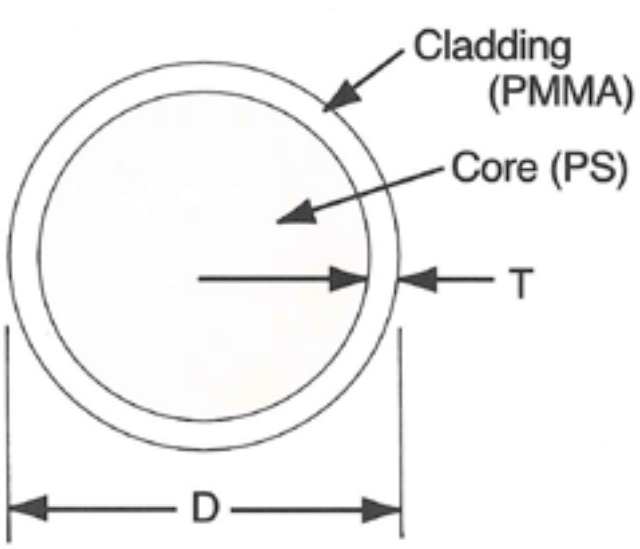
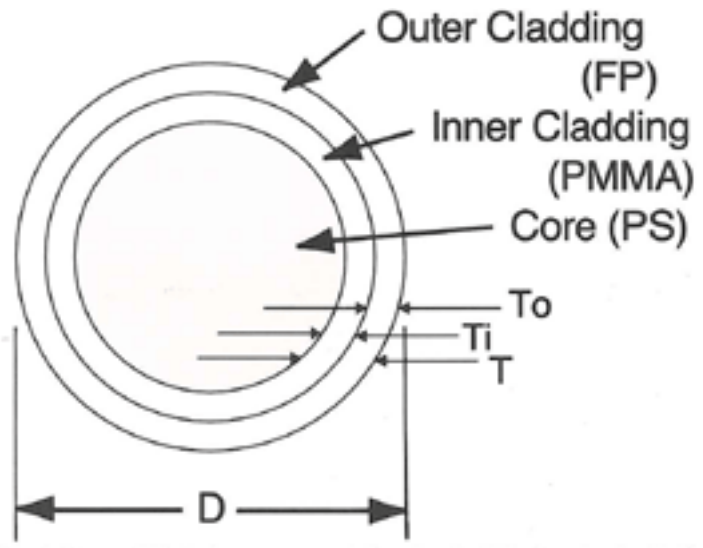
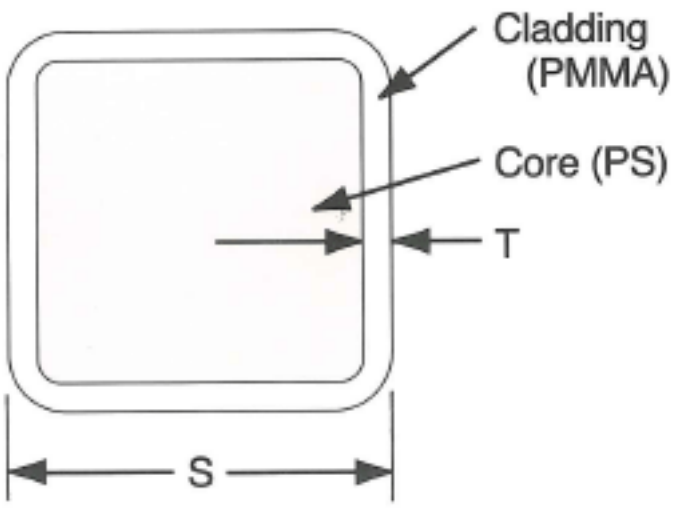
Plastic Scintillating Fibers (Materials and Structures)

Materials

		Material	Refractive index	Density (g/cm^3)	No. of atom per cm^3
Core		Polystyrene (PS)	n_D=1.59	1.05	C:4.9x10^{22} H:4.9x10^{22}
Cladding	**for single cladding inner for multi cladding**	Polymethylmethacrylate (PMMA)	n_D=1.49	1.19	C:3.6x10^{22} H:5.7x10^{22} O:1.4x10^{22}
	outer for multi cladding	Fluorinated polymer (FP)	n_D=1.42	1.43	

Cross-section and Cladding Thickness

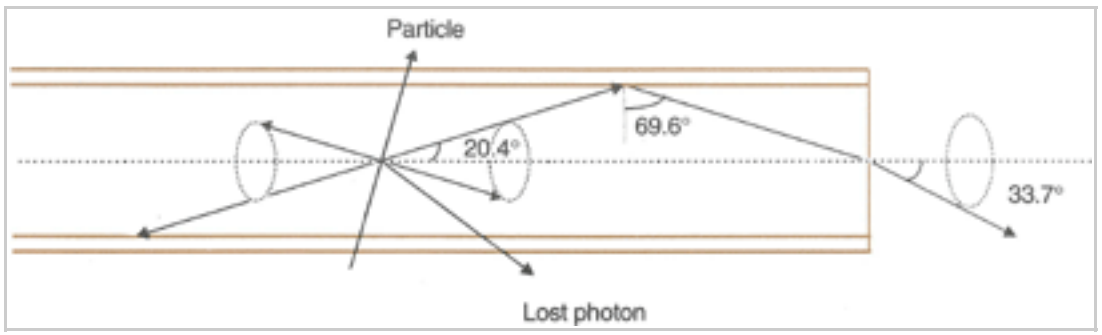
	Single Cladding	Multi Cladding (M)
Round Fiber (D)	 Cladding Thickness : T=3% of D Numerical Aperture : NA=0.55 Trapping Efficiency : 3.1%	 Cladding Thickness : T =3% (To)+3% (Ti) =6% of D Numerical Aperture : NA=0.72 Trapping Efficiency : 5.4%
Square Fiber (SQ)	 Cladding Thickness : T=2% of S	Not available

Numerical Aperture : NA=0.55
Trapping Efficiency : 4.2%

Cladding and Transmission mechanism

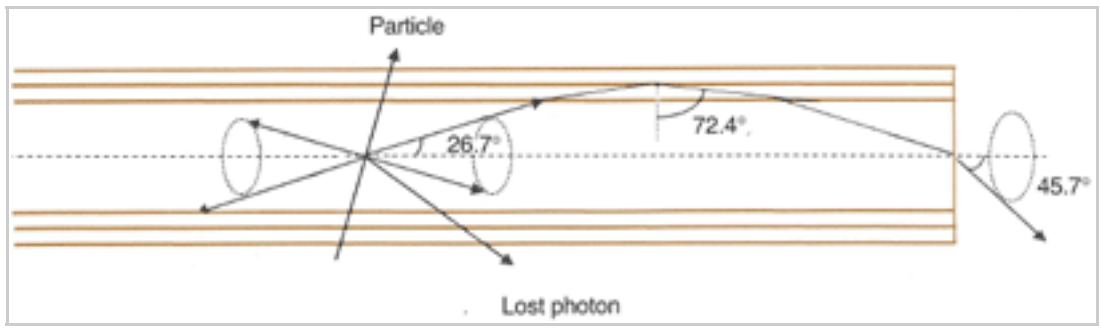
Single Cladding

Single cladding is standard type of cladding.



Multi Cladding

Multi cladding fiber(M) 50% has higher light yield than single cladding fiber because of large trapping efficiency.
Clear-PS fiber of this cladding has extremely higher NA than conventional PMMA or PS fiber, and very useful as light guide fiber.
Multicladding fiber has long attenuation length equal to single cladding fiber.



Type of Polymer Orientation of PS Core

Standard type (Non-S type)

PS core is of almost no oriented polystyrene chain and is optically isotropic and very transparent.
This conventional standard type has good attenuation length, but it showed weakness against cracking caused by bending or handling during assembling.

S type (S)

Core has molecular orientation along drawing direction. This fiber is mechanically stronger against cracking at the cost of transparency.
The attenuation length of this type is nearly 10% shorter than standard type.

Dimensions and Tolerance

Cross-sectional Dimension

Minimum : 0.2mm, Maximum : 2.0mm, typically as follows.
Round (Single and Multi Cladding) : 0.2, 0.5, 1.0, 1.5, 2.0mm dia.
Square (Single Cladding) : 0.2x0.2, 0.5x0.5, 1.0x1.0, 2.0x2.0mm side

Tolerance of Diameter

- **Cut Fiber (1-5m long) :**

$\left|\frac{\Delta D}{\overline{D}}\right|$ < 2.0% for round fiber

$\left|\frac{\Delta S}{\overline{S}}\right|$ < 3.0% for square fiber

- **Endless Spool Fiber :**

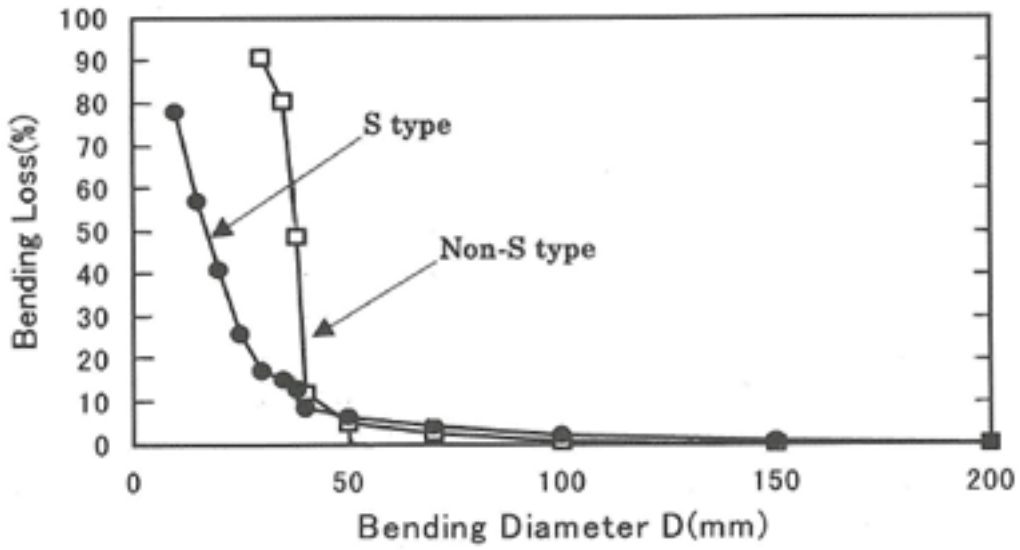
$\frac{3\sigma}{\overline{D}}$ < 2.5% (σ : rms, Spool Dia. : 300mm or 900mm.)

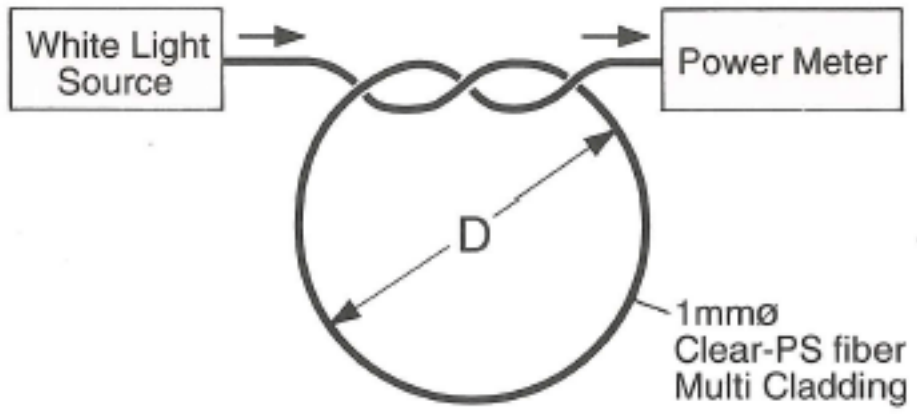
Bending Loss and Minimum Bending Diameter

Bending Loss

The following figure shows bending loss of Clear-PSM and Clear PSMS.
S type is better than Non-S type.
The rapid increase of bending loss of non-S type is due to cracking of core.
S type does not show such cracking.

Measurement Method





Minimum Bending Diameter

We recommend minimum bending diameter as the following table on safety side and long term reliability.

Type	2mmΦFiber	1mmΦFiber	0.5mmΦFiber
S type	200mm	100mm	50mm
Non-S type	400mm	200mm	100mm

→ Plastic Scintillating Fibers
→ Wavelength Shifting Fibers
→ Clear Fibers