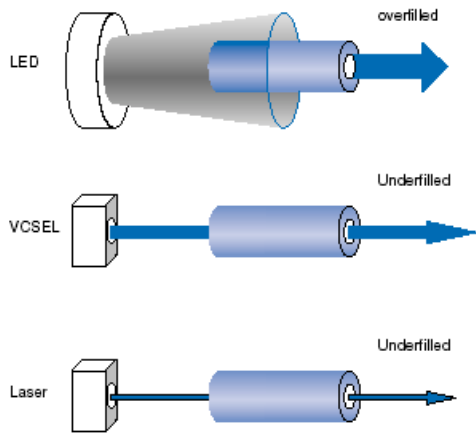


# Launch Condition Analysis

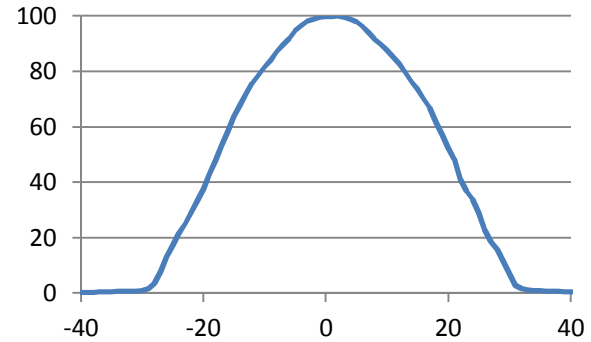


# Fill Conditions

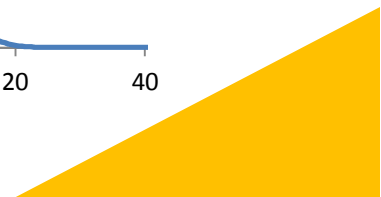
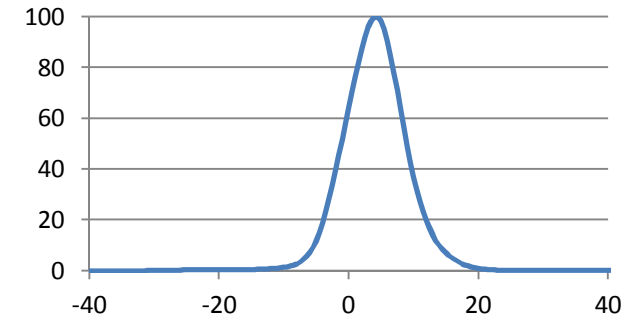
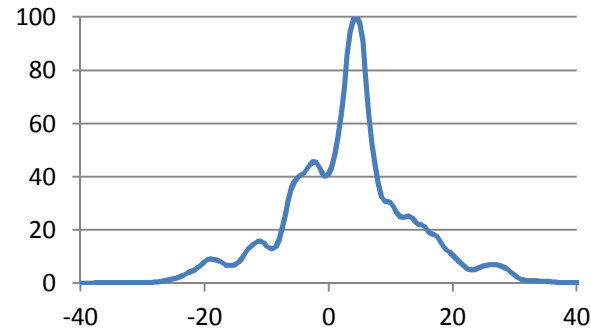
A multimode fiber can be filled anywhere from highly underfilled, where only one mode is excited (single mode), to overfilled, where all possible modes are excited.



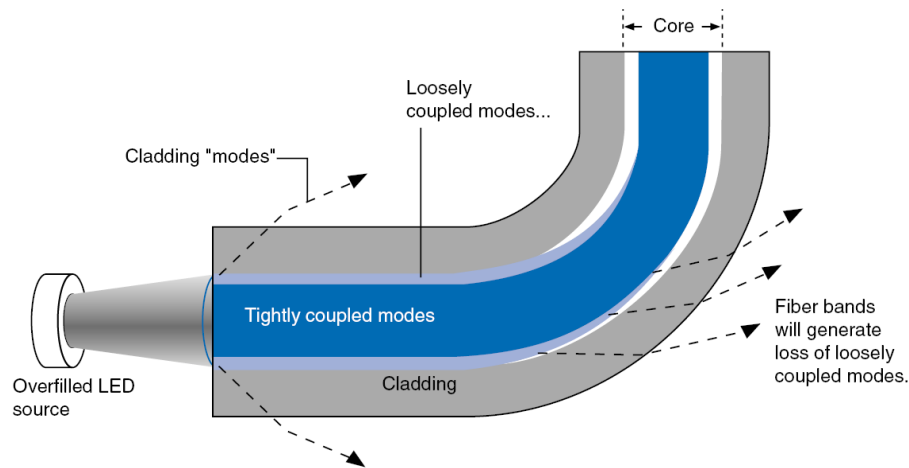
**Overfilled**



**Underfilled**



# Mandrel Wrapping



In a multimode fiber, there are many possible optical path for the light to travel through:

## → Different Modes:

“The **lower order modes** are excited by light launched near the center of the core.

“The **higher order modes** travel at the outer diameter of the core.

**Higher order modes or Cladding modes** are attenuated by bending the fiber, for example with a mandrel wrap.

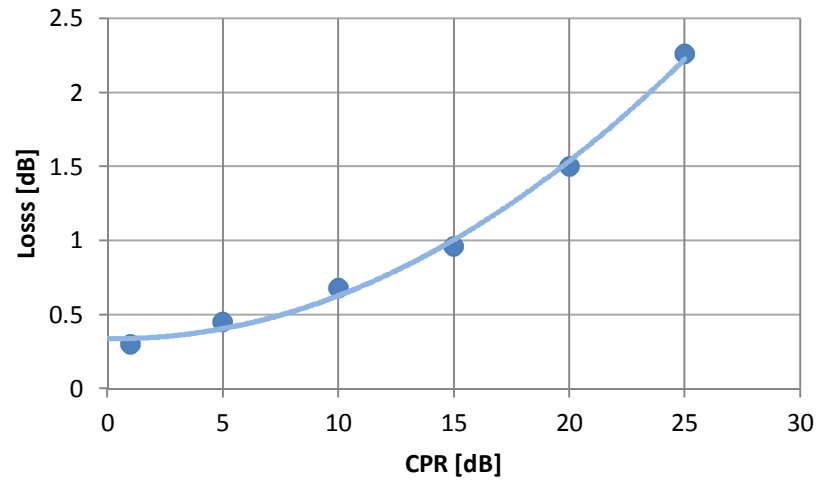
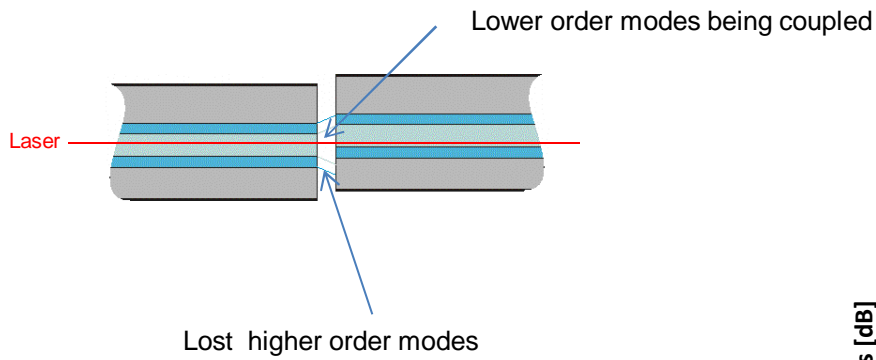
Lower order modes → center → tightly coupled

Higher order modes → loosely coupled



## Effect of Launch Condition

Depending on which modes, higher order or lower order, are being launched from one fiber into the next fiber, the measured insertion loss of a non-ideal connector varies.



# Coupling Power Ratio

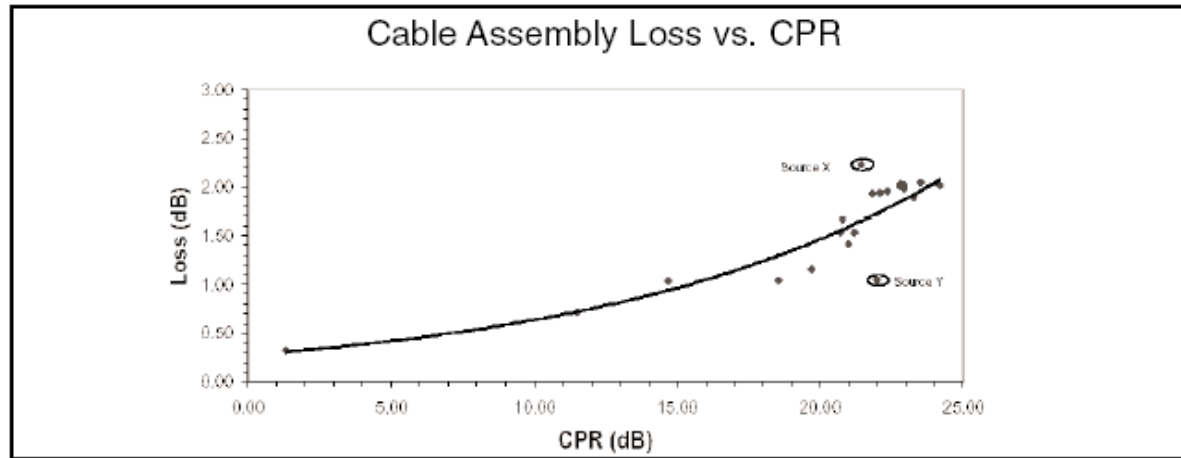
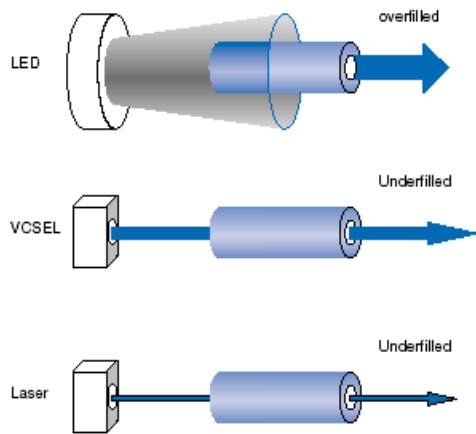


Figure 6 (courtesy of Gair Brown, NAVSEA) - Cable assembly loss (nominal 1 dB) vs. different light-source CPRs.

## Measuring Coupling Power Ratio

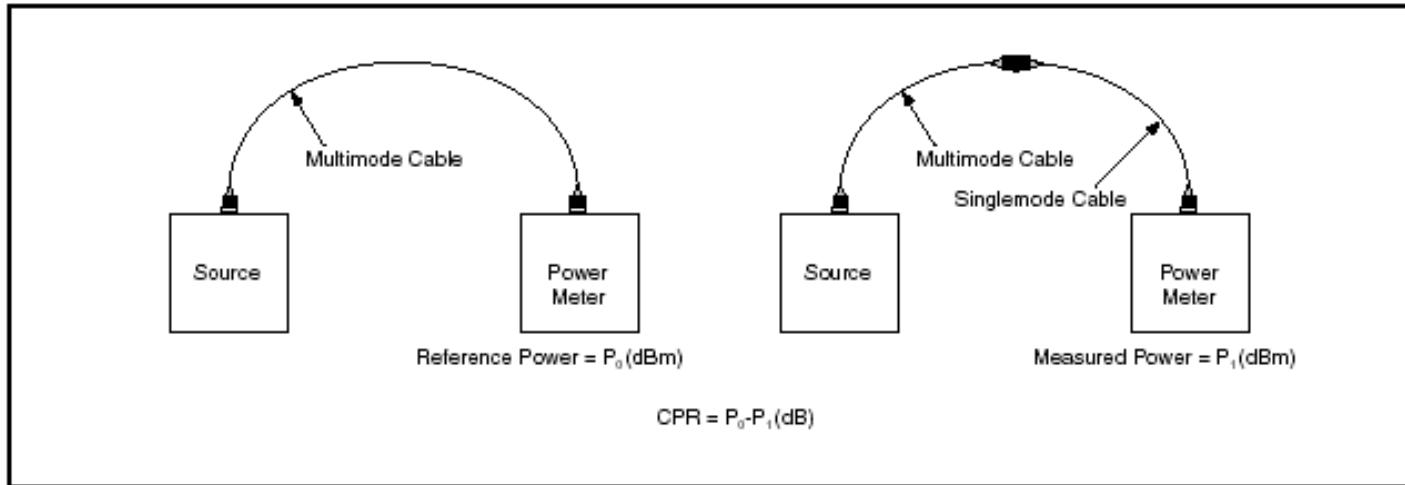


Figure 3 – Setup for measuring coupled-power ratio (CPR).

Fiber Size	Categories 1 to 3 (CPR)	Categories 4 and 5 (CPR)
50/125	11-24	0-10.9
62.5/125	14-29	0-13.9

Table 1. Light source CPR values (in dB) for 850 nm.

Fiber Size	Categories 1 to 3 (CPR)	Categories 4 and 5 (CPR)
50/125	8-20	0-7.9
62.5/125	12-25	0-11.9

Table 2. Light source CPR values (in dB) for 1300 nm.

## Measuring High-Order Mode Power

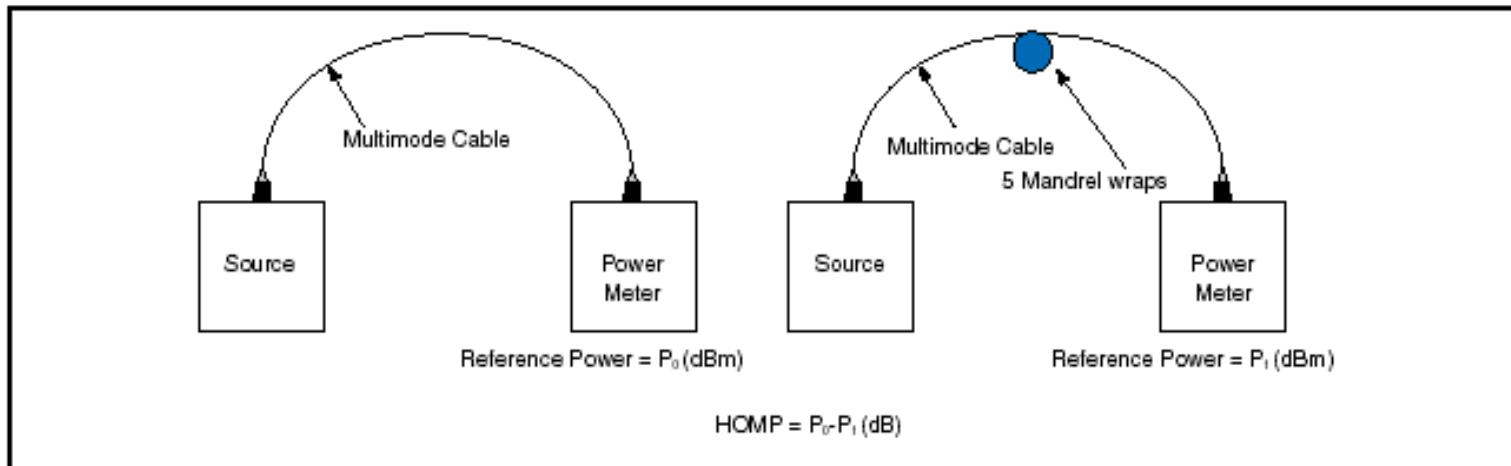


Figure 7 – Setup for measuring high-order mode power (HOMP).

## Standards

**TIA 526-14A**  
**IEC 61280-4**

Fiber optic communications subsystems test procedures . Part 1-4:  
General communications subsystems . CPR Measurement

**FOTP-43 TIA/EAI-455-43A**

Output Near-Field Radiation Pattern Measurement of Optical  
Waveguide Fibers

**FOTP-177 TIA-455-177B**  
**IEC-60793-1-43**

Optical Fibers . Measurement Methods and Test Procedures .  
Numerical Aperture

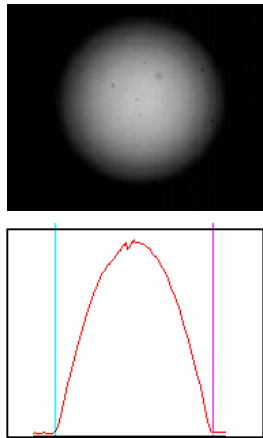
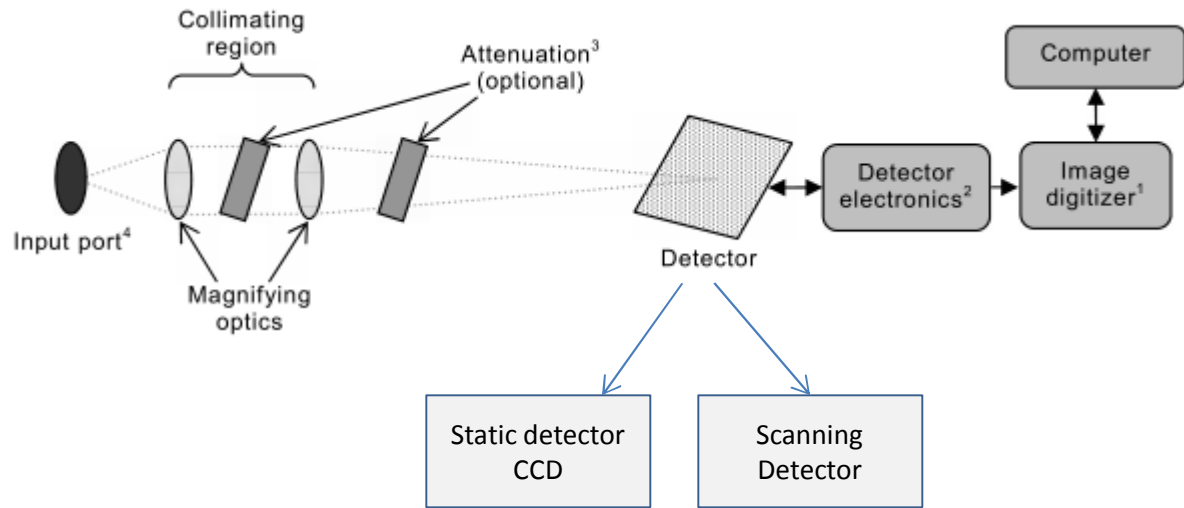
**IEC 61280 1-4**

Fiber optic communications subsystems test procedures . Part 1-4:  
General communications subsystems . Light source encircled flux  
measurement methods

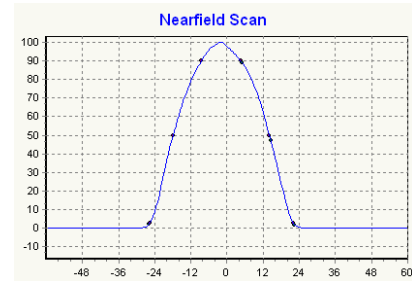




## Measurement Principles - Nearfield

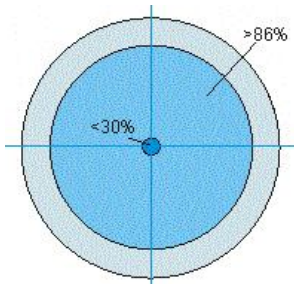


Intensity Profile



## Encircled Flux EF

$$EF(r) = \frac{\int_0^r xI(x)dx}{\int_0^R xI(x)dx}$$

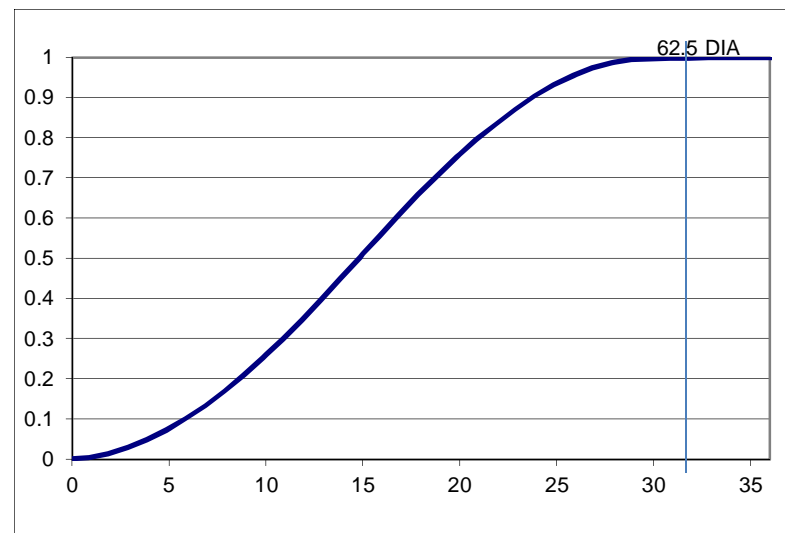


Typical power distribution

Encircled flux describes the measurement of light power distribution from the center of the core to the cladding with respect to the radial distance. The fraction of cumulative near field power to total output power as a function of radial distance from the centre of the core.

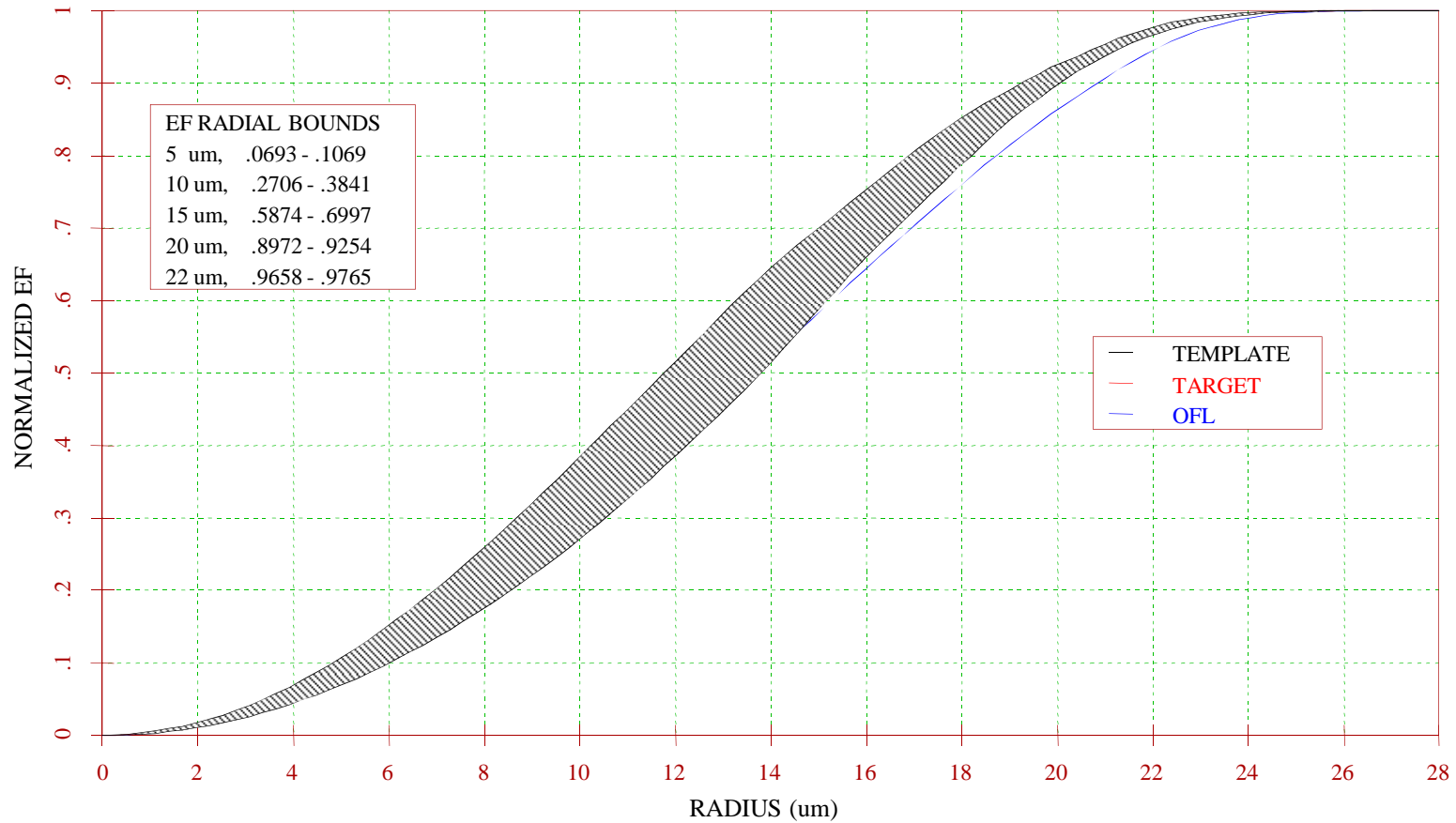
It is often quantified as the radius from the center of the fiber required to encircle 25% and 75% of the light energy through the fiber.

This value is a crucial factor in ensuring the required data transmission rate in Gigabit Ethernet systems.



# EF Template

8 ATTENUATION DEVIATION CONSTRAINTS, 850 nm, 50  $\mu\text{m}$   
75% SHAPE TOL, LINK CONSTRAINTS ( $\mu\text{m}$  SHIFT x #CMPTS, dB Tol) =  
(2.0 x 2, .07 dB), (3.0 x 2, .07 dB), (4.0 x 2, .07 dB), (5.0 x 2, 10%), (2.0 x 5, .07 dB), (3.0 x 5, 10%), (4.0 x 5, 10%), (5.0 x 5, 10%)



## EF Requirements per IEC 61280-4-1

**Table E1 – EF requirements for 50 µm core fibre cabling at 850 nm**

EF Tolerance Range . 50µm, 850 nm, 2X+5X, .07 dB Threshold			
Radial Offset (µm)	EF Lower Bound	Target	EF Upper Bound
5	0.0693	0.0880	0.1069
10	0.2706	0.3271	0.3841
15	0.5874	0.6428	0.6997
20	0.8972	0.9112	0.9254
22	0.9658	0.9711	0.9765

**Table E2 – EF requirements for 50 µm core fibre cabling at 1300 nm**

EF Tolerance Range . 50µm, 1300 nm, 2X+5X, .07 dB Threshold			
Radial Offset (µm)	EF Lower Bound	Target	EF Upper Bound
5	0.0700	0.0894	0.1089
10	0.2756	0.3320	0.3889
15	0.5969	0.6507	0.7059
20	0.9094	0.9178	0.9263
22	0.9694	0.9733	0.9772

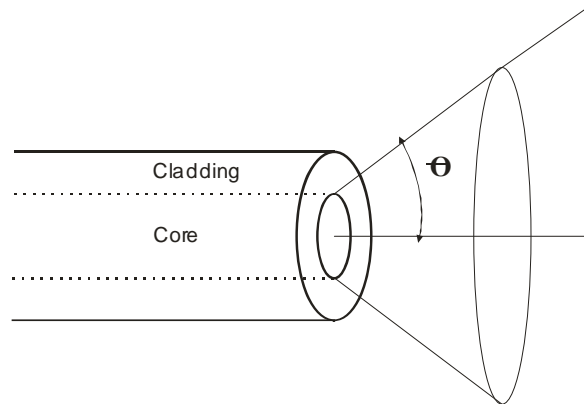
**Table E3 – EF requirements for 62.5 µm fibre cabling at 850 nm**

EF Tolerance Range . 62.5µm, 850 nm, 2X+5X, .07 dB Threshold			
Radial Offset (µm)	EF Lower Bound	Target	EF Upper Bound
5	0.0425	0.0547	0.0671
10	0.1677	0.2096	0.2517
15	0.3684	0.4366	0.5052
20	0.6333	0.6892	0.7460
26	0.9202	0.9328	0.9455
28	0.9716	0.9770	0.9824

**Table E4 - EF requirements for 62.5 µm fibre cabling at 1300 nm**

EF Tolerance Range . 62.5µm, 1300 nm, 2X+5X, .07 dB Threshold			
Radial Offset (µm)	EF Lower Bound	Target	EF Upper Bound
5	0.0425	0.0548	0.0672
10	0.1677	0.2100	0.2525
15	0.3690	0.4374	0.5062
20	0.6355	0.6902	0.7457
26	0.9236	0.9335	0.9435
28	0.9734	0.9774	0.9815

## Numerical Aperture

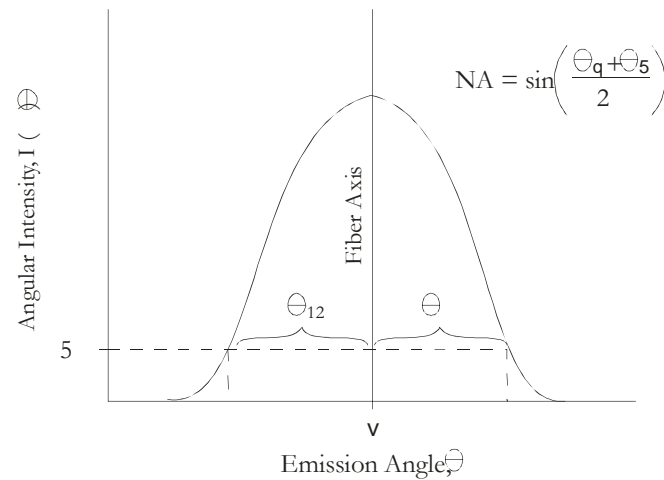


The Numerical Aperture NA is the sine of the half angle of a fiber's light acceptance cone. All modes of light entering the fiber at angles less than the NA will be confined to the core of the fiber.

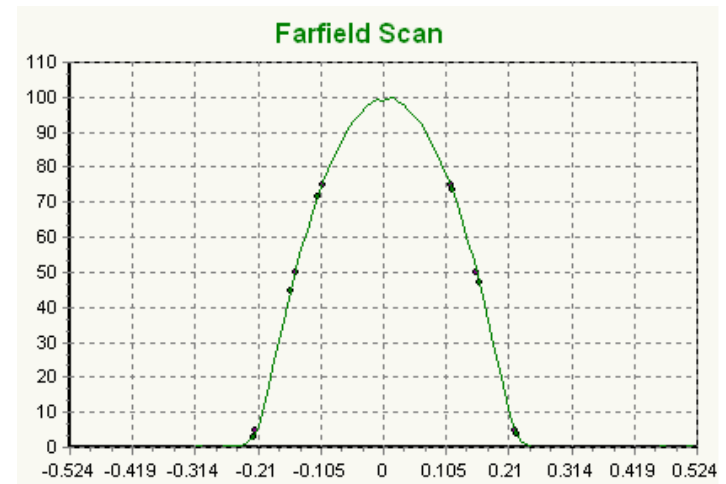
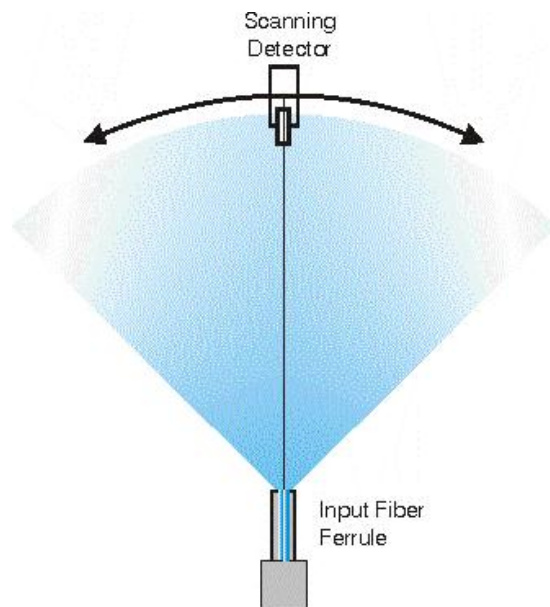
NA is determined from the measurement of the far-field optical power distribution exiting from a two meter length of fiber.

Larger NA  $\rightarrow$  larger light acceptance cone

## Farfield Measurement



## Launch Condition Measurement



## OP1021 Launch Condition Analyzer



Adapters for  
Ferrules: 1.25, 1.6, 2, 2.5mm



The OP1021 Launch Condition Analyzer is a convenient and compact benchtop nearfield and farfield scanner for optical fibers. Coupled with the software package, OPL-LCA, the user can scan and easily plot both the nearfield and farfield patterns of almost any fiber.

The OP1021 comes with 2 internal sources. These are usually one 850nm LED and one 1300nm LED. Both sources are coupled into a 105/125um step index fiber to provide an overfilled launch condition into both 50um and 62.5um fibers.

### Farfield Measurement

- " +/- 0.5 radians scan angle
- " 0.1um step size
- " measure numerical aperture NA

### Nearfield Measurement

- " +/- 250  $\mu\text{m}$  scan range
- " 0.1  $\mu\text{m}$  step size
- " Meets IEC Standards to measure Encircled Flux
- " Auto-align feature to center and focus NearField scanner

### Overall Features

- " Wavelength Independent: measures 850nm to 1625nm
- " Farfield and Nearfield analysis in one instrument
- " Integrated OPL LCA software
- " Directly links to Excel spreadsheet . quick print