FIBER OPTICS

CALCULATING NUMERICAL APERTURES

The two different optically conductive materials which compose most fiber optics determines the advantages and disadvantages of any configuration. Eighty-five percent of the total fiber forms the Core and has a higher refractive index because it carries the light. The Cladding, which contains the Core, creates the reflecting interface. Optical fibers are usually made from glass, plastic, or a synthetic fused silica, which is referred to as "quartz". The properties of these materials determine their use. Silica fibers are most often used for data communications. Illumination and sensing applications generally require glass. Plastic fibers are reserved for assemblies not exposed to heat above 175°F. Also, because plastic fibers are not as fine as glass fibers they are not as flexible and of limited use when the bend radius is tight.

In order for light to be transmitted along a fiber optic it must enter within an acceptance angle. Light attempting to enter outside the acceptance angle will spill out of the sides of the fiber and there will be little or no light transmission. The angle beyond the acceptance angle is called the critical angle. The refractive index of the core material (N_1) and the refractive index of the cladding material (N_2) are used to determine these angles. Using these indices, the Numerical Aperture (N.A.) can be calculated by the following formula.

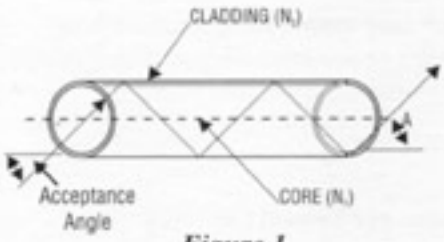

Figure 1

$$\text{N.A.} = \sqrt{(N_1)^2 - (N_2)^2} \qquad f\# = 1/(2\ \text{N.A.})$$

Example: If N_1 is 1.62 and N_2 is 1.52, the N.A. will be .56 which equals the Critical Angle of 34° and an Acceptance Angle of 68°.

The f number/equivalent will be f/0.89.

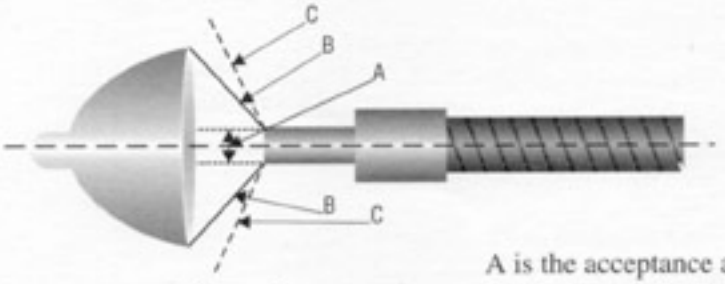

Figure 2

A = Acceptance Angle of a .25 NA fiber
B = Incident Angle
C = Acceptance Angle of a .66 NA fiber

Optical fiber tends to preserve the Angle of Incidence during light transmission. In Figure 1 angle A is shown both at the entrance and exit ends of the fiber. Figure 2 shows a typical projecting lamp illuminating a fiber bundle. Angle A is the acceptance angle of a .25 N.A. fiber (29°). Angle B is the incident angle from the lamp and Angle C is the acceptance angle of a .66 N.A. fiber (83°).

In calculating the minimum N.A. required for the 45° Angle of Incidence, the N.A. is found to be .38. Therefore, the fiber with an N.A. of .66 will accept *all* of the light from the lamp, but the output angle will only be 45° *and not* the 83° which might be expected. However, the .25 N.A. fiber which cannot accept all of the light, will have an output angle of 20°. Using a low N.A. fiber will ***not focus*** the light from the lamp because it can't receive any light beyond its critical angle and therefore has a narrow output cone.