

# What is Encircled Flux and Other Related Questions

## AEN 129, Revision 1

As higher data rate transmissions (1Gb/s and higher) and more demanding system requirements have increased over time, more consistent and reproducible attenuation test results in the field has arisen. Consistency across a variety of field test instruments is currently not possible due to different launch conditions from source to source (ex. LED vs. VCSEL) and due to the different procedures for mandrel wrapping and referencing for each unit. In an effort to eliminate the discrepancies between test instruments, the telecommunications industry is going to implement a new testing standard involving the use of Encircled Flux. To help us understand Encircled Flux, the following document discusses the use of Encircled Flux, what Encircled Flux is, how Encircled Flux will affect testing, and CCS' position on Encircled Flux.

### What is Encircled Flux?

In general, an optical source's near-field (power distribution across the cross-sectional area along short distances) is measured using a camera equipped with optical detectors and the ability to produce a two dimensional grayscale profile of the optical intensity of the near-field. The data from the grayscale profile is normalized into three functions that are derived from the radial distance from the optical fiber's center. These functions are Intensity, Incremental Flux, and Encircled Flux (EF). The units for each of the functions are optical power per area, dimension power per differential of radius, and dimension total optical power respectively.

As defined in TIA TSB-178, the equation for Encircled Flux is:

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

where EF(r) is the Encircled Flux vector

r is the radial position on the near field

I(x) is the near-field intensity matrix

R or R<sub>max</sub> is 1.15 times the nominal core of the fiber being tested

EF: The fraction of cumulative near-field power to the total output power as a function of radial distance from the optical center of the core. See TIA-455-203.

Using this equation, one can mathematically define the optical source's near-field output profile including an upper and lower limit to meet the +/- 10% variability between test sets. An example from TIA TSB-178 of an EF template using a 50 µm fiber at 850nm is shown in Figure 1 on the next page. The target EF along with the EF that would be obtained with an Overfilled Launch (OFL) is also shown.

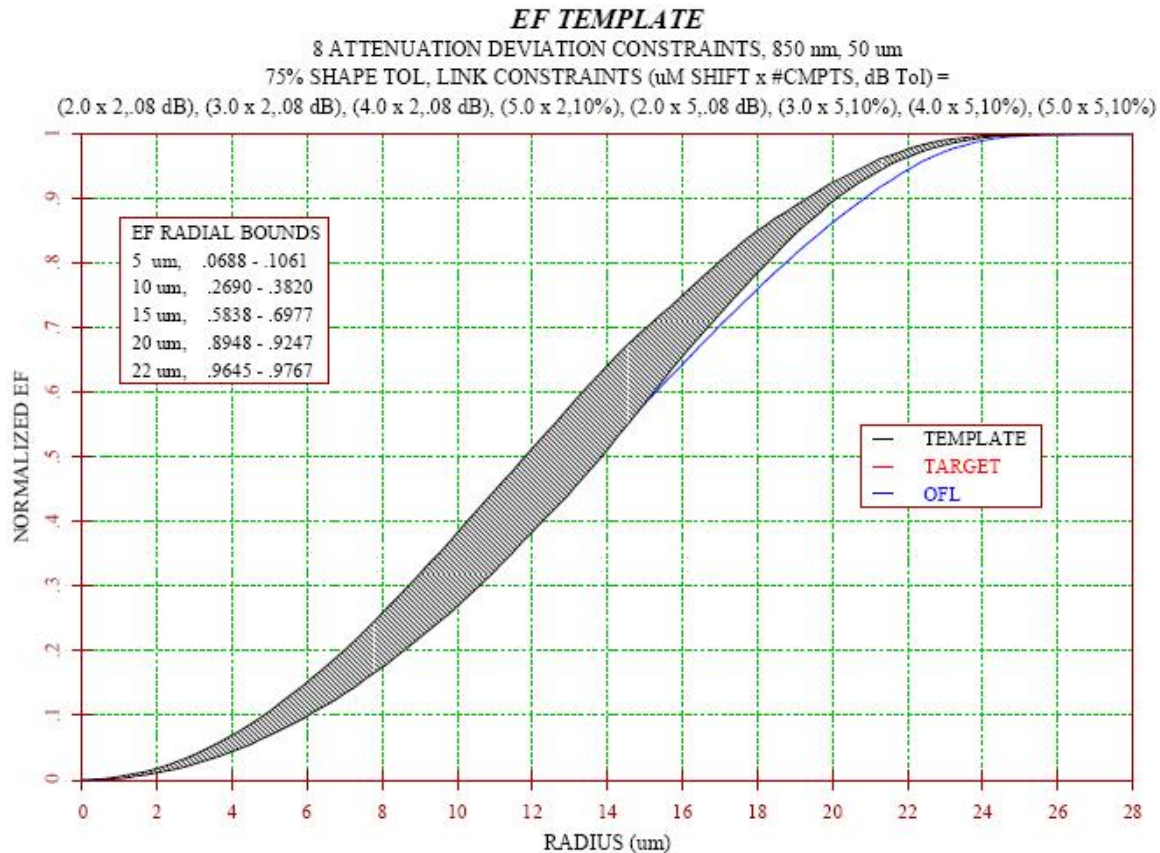


Figure 1 – Encircled Flux Template Example

### Boundary Conditions on Encircled Flux

Although Encircled Flux does achieve the goal for more consistent test results, there are thresholds or limits in which the  $\pm 10\%$  variability attained with Encircled Flux ceases to apply. Through several experiments and model simulations, these thresholds have been determined for each multimode fiber type and for each wavelength. For example, the threshold limit for 50  $\mu\text{m}$  fiber at 850 nm is 0.08dB. Therefore, the  $\pm 10\%$  variability among test sets applies for systems that have a total attenuation  $\geq 0.8$  dB. For systems that have an attenuation  $< 0.8$  dB, the variability is  $\pm 0.08$  dB. See attached table A from TIA TSB-178 for more information on EF boundary conditions.

Table A – EF boundary conditions for 50  $\mu\text{m}$  and 62.5 $\mu\text{m}$  core fibers

| Core size( $\mu\text{m}$ ) | Threshold @ 850nm(dB) | Threshold @1300nm(dB) |
|----------------------------|-----------------------|-----------------------|
| 50                         | 0.08                  | 0.12                  |
| 62.5                       | 0.10                  | 0.15                  |

## Corning's Position on Encircled Flux?

Encircled Flux, defined in TIA-455-203, is a mathematically defined cross-sectional area of a power source's laser profile that is derived from the cumulative near-field power. More intuitively, it is effectively a launch condition that is in between an OFL (Over-filled Launch, LED's) and RML (Restricted Mode Launch, VCSEL's), and since EF is mathematically defined it forces a consistent launch condition across all scenarios and test instruments. EF affects all types of multimode at all operating wavelengths.

Because of the current trend in LAN's for tighter link-loss budgets to meet increasingly higher data transmission rates (100 megabit → 1 gigabit → 10 gigabit → 100 gigabit), a more consistent launch condition is required to ensure accurate and consistent testing for all parts of a system. The goal of using EF is to approach +/- 10% variability among sources whereas the sources today have +20 /-40% variability as compared to the target attenuation.

If you require more technical information regarding EF, please reference TIA-455-203 or TIA TSB-178.

### References:

TIA TSB-178, *Launch Condition Guidelines for Measuring Attenuation of Installed Multimode Cabling*

TIA-455-203, *Launched power distribution measurement procedure for graded-index multimode fiber transmitters*