Engineering Standards and Technology

End-Face

CLEARFIELD

What is IL?

Insertion loss (IL) is the loss of signal power resulting from the insertion of a device in a transmission line or optical fiber. Usually expressed as a ratio in dB relative to the transmitted signal power, it can also be referred to as attenuation.

What is RL?

Return loss or reflection loss (RL) is the reflection of signal power resulting from the insertion of a device in a transmission line or optical fiber. It is usually expressed as a ratio in dB relative to the transmitted signal power.

Test and Measurement

Your minimum requirements should include data that meets insertion loss and return loss (reflectance). Insertion loss should meet the 326-Core minimum of 0.4 dB, with reflectance meeting 55 dB for UPC connectors and 65 dB for APC. Asking the typical performance measures of a manufacturer's process can save you on link loss budgets over a long fiber run through a FTTH network.

Apex offset, the measurement for how well the center core of the fiber is centered in relationship to the spherical apex of the polished tip, minimizes lateral offset between two fibers and maintains a better physical contact. Apex offset describes a physical condition of the polished fiber, rather than a performance parameter. It is also an acceptance criteria for Telcordia. An excessive apex offset contributes to high insertion loss and high back reflection readings.

Fiber undercut or protrusion affects the physical contact zone. This metric measures, in nanometers, the height of the fiber under or below the ceramic end-face. Too much undercut minimizes the chance of a good physical contact, while too much protrusion causes excessive fiber deformation when mating occurs resulting in degradation of signal. When two connectors are mated, the ceramic compresses around the fiber core which allows the fibers to squeeze up and make good contact with each other. When they do not touch (because of too much undercut), an air gap is created and loss happens. If the fiber is protruding too far (beyond 50nm), chipping and cracking can occur during the mate.

Radius of curvature is the measurement of the connector end-face spherical condition. The radius generated affects the performance because the radius, when mated with another connector, should be compressing most of the material surrounding the core (ceramic ferrule). A proper radius, 5 to 12 micron, allows for the right compression and max performance. Too tight of a radius will put too much compression on the glass and too loose will put too much on the surrounding ferrule with not enough glass compression. Too much or too little radius can cause light scatter or inadequate physical contact for optimal signal transfer.

Apex offset, fiber undercut/protrusion, and radius of curvature are the main ingredients that work in concert to deliver good IL and RL performance. Processes that drift out of this geometry range can still yield acceptable IL/RL, but sensitive traffic will be affected (such as video) and long term performance of the connector will be compromised.

Your vendor should be able to provide these geometry test reports with on-hand interferometer testing. While you may not require this data for each and every connector, you should require that random testing is being performed to ensure the process is capable and not drifting out of spec. "Garage shops" will not be able to deliver this test data on demand.

Your test reports should account for each connector independently and not a total report that summarizes both ends.

End-face Quality & Cleanliness

Currently, there is not an industry standard for this topic. To be sure, end-face and cleanliness has a direct impact on the performance of the connector.

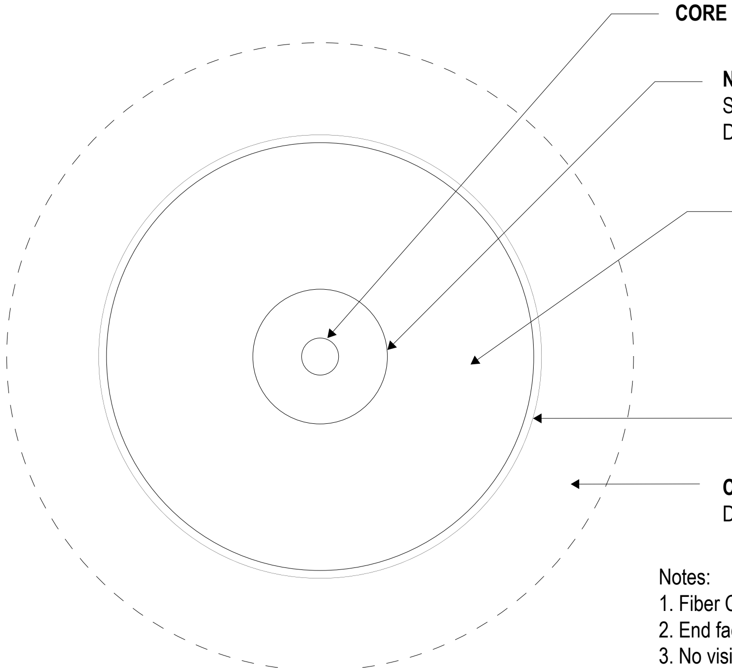
Several organizations (most notably, NEMI) have studied the impact of end-face defects and cleanliness. The influence of the contamination/scratches becomes more evident if they are located in the core/cladding areas. Particle contamination can cause a significant increase in IL (up to 10 times) and decrease in RL (up to three times). Scratches applied to the fiber contact zones 1a and 1b, which is an area from the core out to the cladding (125 μm), decreased RL by up to 25%. On the other hand, scratches located in the cladding layer showed little effect on IL and RL. Multiple heavy scratches passing through the core caused severe performance degradation in IL/RL and can be catastrophic.

Connectors with particle contamination will pass on contamination to mated connectors. Contaminant can prevent direct physical contact, creating an air gap. Multiply this by the number of re-mates over time and the problem spreads. Pits and scratches, in the critical contact zone 1a, will collect particulates over time and the same contamination-spread occurs. Long term reliability in dynamic circuits is severely reduced as opposed to those that are static. Scratches and polishing marks outside of critical contact areas are acceptable and do not have any impact on signal performance.

The quality fiber assembly manufacturers and OEMs will have their own inspection criteria. However, these specifications differ from company to company and the differences can cause materials to be "non-conforming" at user/customer sites.

Singlemode

Acceptable Fiber End Face



CORE (9 µm shown)

NO DEFECT ZONE (0-25 µm)
Scratches: Fails if there are any scratches at all
Defects: Fails if there are any defects at all

CLADDING (25-115 µm)
Scratches: Fails if any width is more than 3 µm
Defects: Fails if any diameter is more than 5 µm
Fails if there are more than five defects
Exclude if the diameter is less than 2 µm

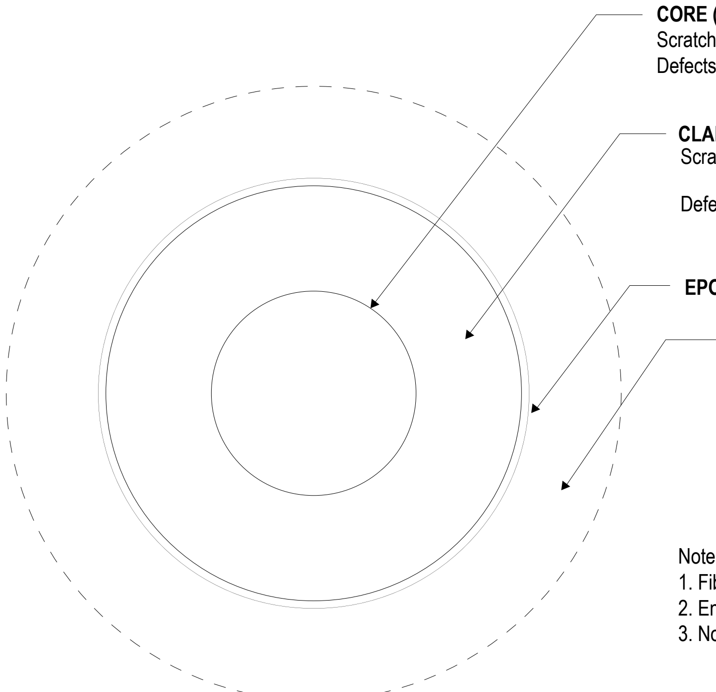
EPOXY RING (115-135 µm)

CONTACT ZONE (135-250 µm)
Defects: Fails if any diameter is more than 10 µm

Notes:
1. Fiber Core: 9 µm diameter
2. End face viewed at a minimum of 400x magnification
3. No visible contamination

Multimode

Acceptable Fiber End Face



CORE (0-65 µm shown)
Scratches: Fails if any width is more than 3 µm
Defects: Fails if any diameter is more than 5 µm
Fails if there are more than four defects

CLADDING (65-115 µm)
Scratches: No limit ≤ 5 µm
None > 5 µm
Defects: No limit < 5 µm
5 from 5 µm to 10 µm
None > 10 µm

EPOXY RING (115-135 µm)

CONTACT ZONE (135-250 µm)
Scratches: No limit
Defects: No limit < 20 µm
5 from 20 µm to 30 µm
None > 30 µm

Notes:
1. Fiber Core: 50 µm or 62.5 µm
2. End face viewed at a minimum of 400x magnification
3. No visible contamination