Impact on End-Face Defects and Cleanliness on the Performance of Optical Connector

End-face termination defects and cleanliness has a direct impact on the performance of the connector, which end up affect the entire network performance.

Scratches/particles/oil contamination on end-face creates blockage and air gaps that prevent direct physical contact during mating, as a result, optical performance such as **Insertion Loss (IL) and Return Loss (RL) are degraded**.

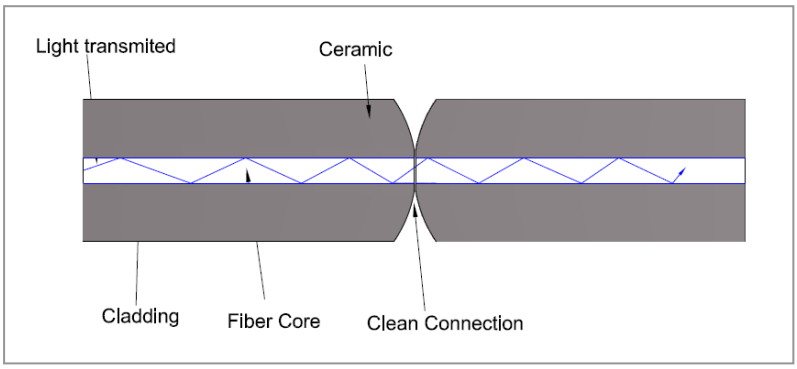


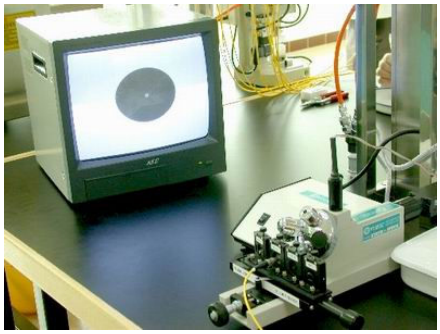
Diagram-1: Clean and defect free end-face achieve perfect core alignment and physical contact

The International Electronics Manufacturing Initiative (iNEMI) has studied the impact of end-face defects and cleanliness on IL and RL.

- Particle contamination can cause a significant increase in IL (up to 10 times), and decrease in RL (up to 3 times)
- Scratches located at the fiber contact zone (0 to 125µm), will decrease RL by 25%

PARAMETERS ON END-FACE TERMINATION WORKMANSHIP

Visual inspection by microscope can examine fiber optic connector end-face workmanship and cleanliness.



Video Microscope (200x / 400x)

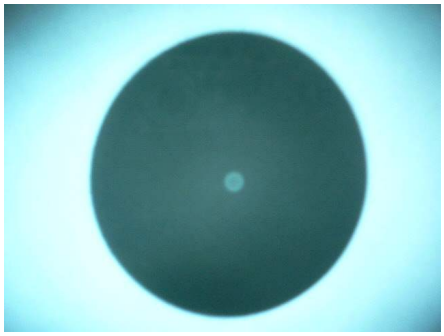


Diagram-2: Clean and defect free end-face inspection under 400x microscope

Defects are defined into the following categories:

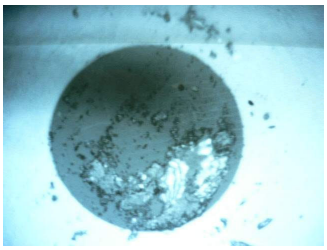
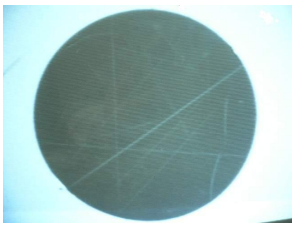
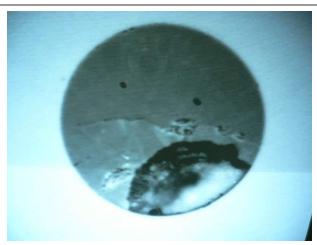
 **Loose contamination or dirt:** Loose debris such as dust, streaks, grease that can be removed with proper cleaning. Effect of loose contaminates varies depending on type, size, and location.	 **Oil contamination (finger print):** Loose oil contaminations that can be removed with proper cleaning. Oil contaminations cause no IL increase, but will cause a large decrease in RL.
 **Scratches:** Permanent linear features that are usually caused by cleaning or polishing process, which can be cured by re-polishing. Depending on scratches size and location, they affect IL and RL performance in different level.	 **Pits, chips and other defects:** Permanent defects that including pits, chips, voids, and fixed contamination, which may caused by improper fiber cleaving, polishing, etc.

Diagram-3: Categories and definitions of end-face defects

MEASURING CRITERIA AND RELATED INDUSTRIAL STANDARD

IEC 61300-3-35: 2009(E) describes methods for quantitatively assessing the end-face quality of a polished fiber optic connector. The information is intended for use with other standards which set requirements for allowable surface defects such as scratches, pits and debris which may affect optical performance.

There are 3 basic measurements on assessing defects:

(i) defect's **location** (distance the defect/particle from the core)

(ii) defect's **size**

(iii) defect's **quantity**

When the scratches or contamination located in the fiber core, the influence of degradation of optical performance becomes more significant. The fiber core guides the light in the fiber, any defects located in this area can directly affect the amount of light transmitted and reflected. Defects are also assessed by size and quantity. Assessment of defects' size and quantity is performed for each defined end-face location, with allowable limits of size and quantity specified for each location and defect type, below tables and diagram list the acceptance criteria standardized by the IEC 61300-3-35.

End-face zones definition:

Zones are a series of concentric circles that identify areas of interest on the connector end-face. The inner-most zones are more sensitive to contamination and defects.

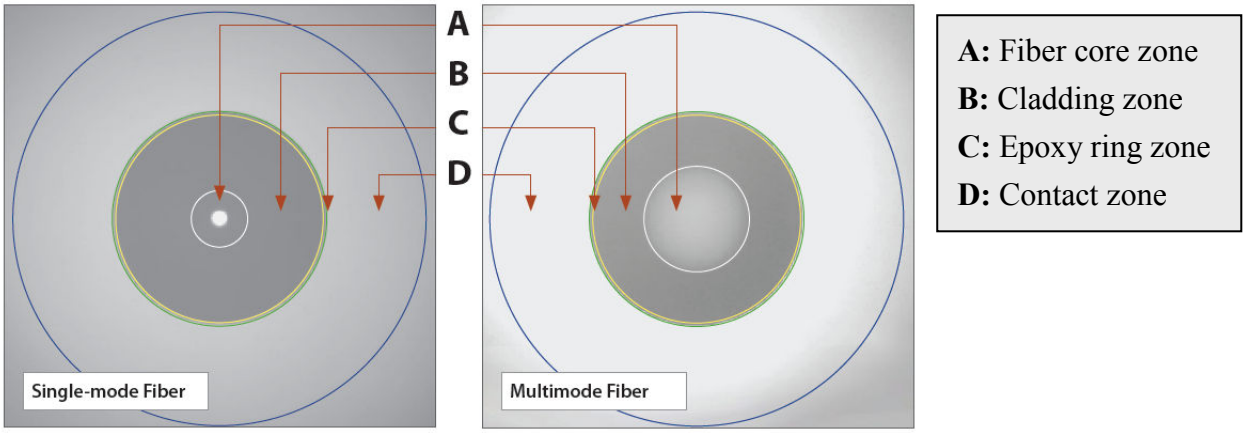


Diagram-4: End-face zone definition

Singlemode Connectors

Zone	Region	Allowable defects	Scratches
A: Fiber core zone	0 – 25 µm	None	None
B: Cladding zone	25 – 120 µm	No limit < 2 µm 5 from 2 – 5 µm None > 5 µm	No limit ≤ 3 µm None > 3 µm
C: Epoxy ring zone	120 – 130 µm	No limit	No limit
D: Contact zone	130 – 250 µm	Non ≥ 10 µm	No limit

Table-1: Acceptance criteria by IEC for Singlemode connector

Multimode Connectors

Zone	Region	Allowable defects	Scratches
A: Fiber core zone	0 – 65 µm	4 ≤ 5 µm None > 5	No limit ≤ 5 µm None > 5 µm
B: Cladding zone	65 – 120 µm	No limit < 2 µm 5 from 2 – 5 µm None > 5 µm	No limit ≤ 5 µm None > 5 µm
C: Epoxy ring zone	120 – 130 µm	No limit	No limit
D: Contact zone	130 – 250 µm	None ≥ 10 µm	No limit

Table-2: Acceptance criteria by IEC for Multimode connector

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