

**Statement of Work
iNEMI Optoelectronic Technology Integration Group (TIG) Fiber Connector End-
Face Inspection Phase II**

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Purpose:

The Fiber Connector End-Face Inspection Specifications is a follow-on initiative to the NEMI Fiber Optics Signal Performance Project. The project will develop visual inspection criteria for polished connector for singlemode, multimode fiber and receptacle-type connectors, including requirements for allowable surface defects, such as scratches, pits and contamination. Based on experimental data and mathematical modeling, zone criteria and pass/fail visual requirements will be defined. The criteria will focus on singlemode and multimode polished connectors as well as receptacle-type connectors. Specifications for dust cap cleanliness including requirements for the mechanical design, material type, and test methods, will also be developed. This project will collaborate with the International Electrotechnical Committee (IEC), Telecommunications Industry Association (TIA) and IPC to develop a cleanliness standard. The project will also focus on improving the cleaning process and prevention of fiber endface contamination

The Fiber Connector End-Face Inspection Specifications will be open to non-members of NEMI. Potential participants include, but are not limited to, OEM(outside equipment manufacturers), EMS() providers, previous members of the NEMI Fiber Optic Signal Performance Project, suppliers of fiber optic cables and receptacle modules, inspection equipment suppliers and fiber optic connector cleaning solution suppliers.

Objective:

This new initiative proposes development of requirements for an industry-wide fiber optic connector cleanliness standard. It builds on experimental data assembled by the NEMI Fiber Optics Signal Performance Project. This effort will develop requirements for allowable surface defects, such as scratches, pits and contamination. The intent of this project is to develop fiber optic connector inspection criteria, which may be comprised of different requirements based on the application (i.e. transmission speed, SM, MM, receptacle devices etc.). The test results will provide feedback to OEM incoming quality and component engineering groups as well as optic suppliers on specific cleanliness requirements with supporting data. Potentially, the inspection criteria could be used as an enhancement to existing TIA, IPC and IEC standards bodies. The broader objectives of the project are prevention of contamination and improvement in the cleaning process resulting in cost reduction.

Background

The Fiber Optic Signal Performance Project investigated the influence of scratches, particles and oil contamination on insertion loss (IL) and return loss (RL) of single-mode SC connectors. It was found that:

- Scratches (2um or less), within MFD, have no impact on IL but can degrade RL.
- Polishing scratches outside the fiber MFD have no impact on IL or RL.
- Application of oil contamination results in significant degradation of RL (10-12 dB) and do not result in any significant changes of IL.

- The contamination of the core zone, which has a diameter of 25 um from the core, with Arizona dust particles increased IL (changes up to 1.8 dB).
- The contamination of the core zone combined with the presence of clusters of particles with a diameter of >30um in the cladding layer may result in catastrophic changes of the RL (changes of 10-40 dB).
- Arizona road dust particles on the cladding layer (outside of the 25 um core zone) and ferrule do not significantly impact performance.
- Contamination particles can prevent direct physical contact, creating an air gap between two endfaces.

Based on experimental data for scratches, Arizona road dust, and carbon particles, the team proposed inspection criteria for SMF pigtailed and patchcord connectors. Project results were reported at the OMI conference (2003), IEC meeting (Montreal, 2003), APEX 2004, IEC meeting (Locarno, 2004) and IEC meeting (Warsaw, 2004). Four papers have been published based on project research, and another has been accepted for APEX 2005.

Further investigation of the influence of particle size on IL and RL contamination is needed. Additional research will focus on finalizing visual inspection criteria for SMF pigtail and patchcord connectors as well as on development of visual inspection criteria for receptacle-type connectors and multimode fiber. Based on our knowledge, there is no data available on the influence of scratches and particle contamination on the optical performance of receptacle-type connectors.

Further investigation of the influence of the particle thickness on RL, is required. Development of a cleanliness specification for multimode (MM) fiber, MTP connectors and receptacle type of devices is needed. Measure the particle thickness of SM connectors in order to correlate the RL changes with the size of the air gap. Correlate the changes of IL & RL of contaminated connectors with the signal integrity (Bit Error Rate)

Scope of Work:

A phase approach will be used to breakdown the workload into manageable stages.

PHASE 1

Fiber Optic Connector End-face Anomaly Assessment for MT Connectors

- The losses, (IL and RL), which occurs on MT connectors due to contamination with Arizona road dust and polishing scratches will be examined.
- The DOE (Design of experiment) that was used in the Fiber Optic Signal Performance Project for singlemode SC connectors will be used for this phase of the project. (Ref: Avanex experiments, Optical Signal Performance project)
- Statistical data analysis will be performed.

- Results for the influence of scratches and Arizona road dust for MT connectors will be compared with the results from the other types of connectors (SM, ST, FC, LC, MU)
- Mathematical modeling for the IL results will be provided (Gaussian Weighted Percentage Occluded Area).
- Inspection criteria for MT connectors will be finalized.
- Investigation on correlation between RL changes and particle size.

PHASE 2

Fiber Optic Connector End-face Anomaly Assessment for SM and MM fiber

- The loss (IL, RL) realized by MM applications due to fiber optic connector end-face anomalies (polishing scratches and Arizona dust contamination) will be assessed.
- The DOE (Design of experiment) that was used in the Fiber Optic Signal Performance Project for singlemode SC connectors will be used for this phase of the project. (Ref: Avanex experiments, Optical Signal Performance project)
- Statistical data analysis will be performed.
- Investigate correlation between IL changes and Gaussian Weighted Percentage Occluded Area.
- Inspection criteria for MM connectors will be developed.
- Investigation on correlation between RL changes and particle size on SM and MM fibers.

PHASE 3

Fiber Optic Connector End-face Anomaly Assessment for Receptacle Modules

- The different technologies for the receptacle modules to be studied will be identified (fiber stub, lenses, contact, non-contact, etc.)
- Data rates to be studied will be chosen (OC-48, OC-192, etc.)
- Critical parameters sensitive to scratches and/or contamination will be identified
- The DOE will be performed (based on Sumitomo/ExceLight initiatives)
- Provide Gage R & R study for test and measurement equipment
- Relevant types of anomalies will be identified (e.g. Arizona road dust, typical work-bench surface contamination (dust), scratches, pits)
- A method for application of anomalies will be developed
- The influence of the Arizona road dust and scratches on the optical performance of receptacle modules will be investigated
- Statistical data analysis will be performed (Minitab software can be used for this)
- Critical factors such as particle size, distance from the core, type of particles, will be identified
- The correlation between measurements, (RL, BERT and other tests yet to be determined), and images of the connector end-face will be calculated.
- Criteria for cleanliness of receptacle modules will be developed

PHASE 4

Collaboration with standards bodies

- A roadmap for the collaboration with the TIA, IPC, IEC will be developed.
 - Collaboration with the IPC will be on standard IPC-8794-01: "Cleaning methods and contamination assessment for optical assembly." (Amendment for MM, MT and receptacle devices).
 - A recommendation to update the IEC doc "61300-3-35: Basic test and measurement procedures" based on quantitative data will be put forth.
- Recommendations will be harmonized across all vendors, EMS providers, and OEMs to achieve a true international standard.

PHASE 5

Improving the cleaning process and prevention of contamination

Investigate the potential solutions to prevent electrostatic charge effect during the cleaning process of fiber optic connectors in order to prevent a risk of optical degradation as particles have been shown to migrate on multiple connections over time.

Project Expected Results:

- Identify the effects of contamination / scratches etc. on fiber optic signal performance with quantitative evidence for MT, MM fiber and receptacle modules
- Collaboration with IPC on standard IPC-8794-01: "Cleaning methods and contamination assessment for optical assembly."
- Update the criteria in IEC doc "61300-3-35: Basic test and measurement procedures" based on quantitative data.
- Development of a fiber connector endface inspection criteria specification for receptacle devices
- Identify recommended cleaning procedures and contamination prevention guidelines

Schedules:

From project start date:

- | | | |
|---|----------|-----------------|
| • Discovery phase | 2 months | |
| • Phase 1 | 4 month | |
| • Development of Phase 2/3 DOEs | 4 months | |
| • Phase 2/3 sample preparation, testing and evaluation of results | 6 months | <i>parallel</i> |
| • Phase 3 testing and evaluation | 3 months | <i>parallel</i> |

