

Optical Connector Contamination and its Influence on Optical Signal Performance

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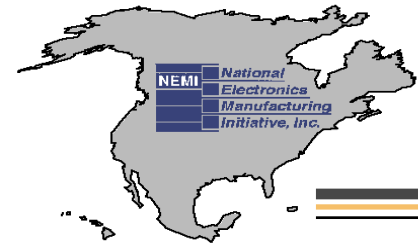
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Eloise Tse- Celestica International Inc

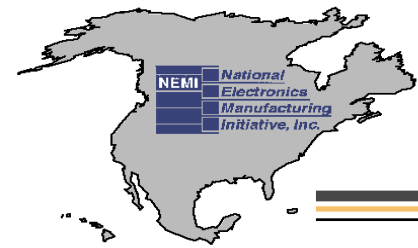


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Presentation Outline

- Introduction
- Experimental Methodology
- Effect of the scratches on IL & RL measurements;
- The influence of the particles on optical performance;
- Oil contamination and its effect on IL & RL measurements;
- BERT results for clean/contaminated fibers
- Conclusions



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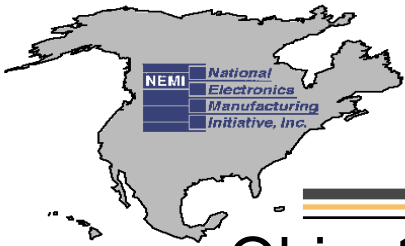
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Introduction

- The cleanliness of fiber optics connectors is recognized as the industry wide-problem;
- There is no industry-standard for cleanliness of fiber optics connectors;
- The cleaning and inspection processes of contaminated connectors affected the manufacturing time and therefore increase the test and product cost for high density port systems;
- The influence of the scratches/particles/oil contamination on optical performance was not investigated in details

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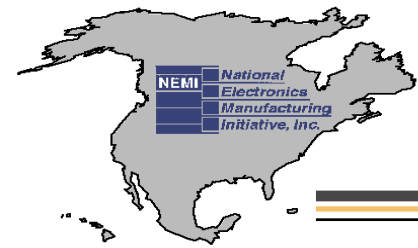
- Object:

- Learn the effects that many anomalies have on the performance of a fiber optic signal
- Identify the severity of optical signal loss due to the most common, potential, hazards found in the supplier and internal manufacturing processes

- Scope:

- Develop connector end-face inspection criteria, which would provide feedback to OEM Incoming Quality, Component Engineering and cable suppliers on specific cleanliness requirements with supporting data
- Provide quantitative evidence to production and test departments to validate their expensive inspection and cleaning strategies, which have been historically endorsed by the industry

Connect With and Strengthen your Supply Chain



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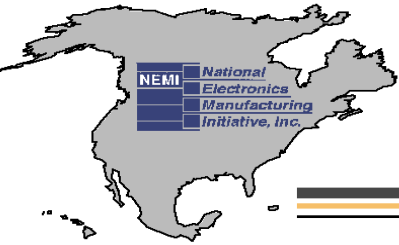
Benefits:

- Develop the Industry Standard for cleanliness of fiber optics connectors. Methods and guidelines will be submitted for incorporation into OE standards, e.g. IPC-STD-040
- Improve the cleaning process and prevent of fiber endface contamination

Project Status:

- First face-to face meeting held June 2002 (Celestica, Toronto)
- Confirmed participants:
Alcatel Canada, Celestica, Nextron SA, Sanmina-SCI, Solectron, Aerotech
- The project will be advertised in SMT journal
- Looking for additional members, particularly cable suppliers

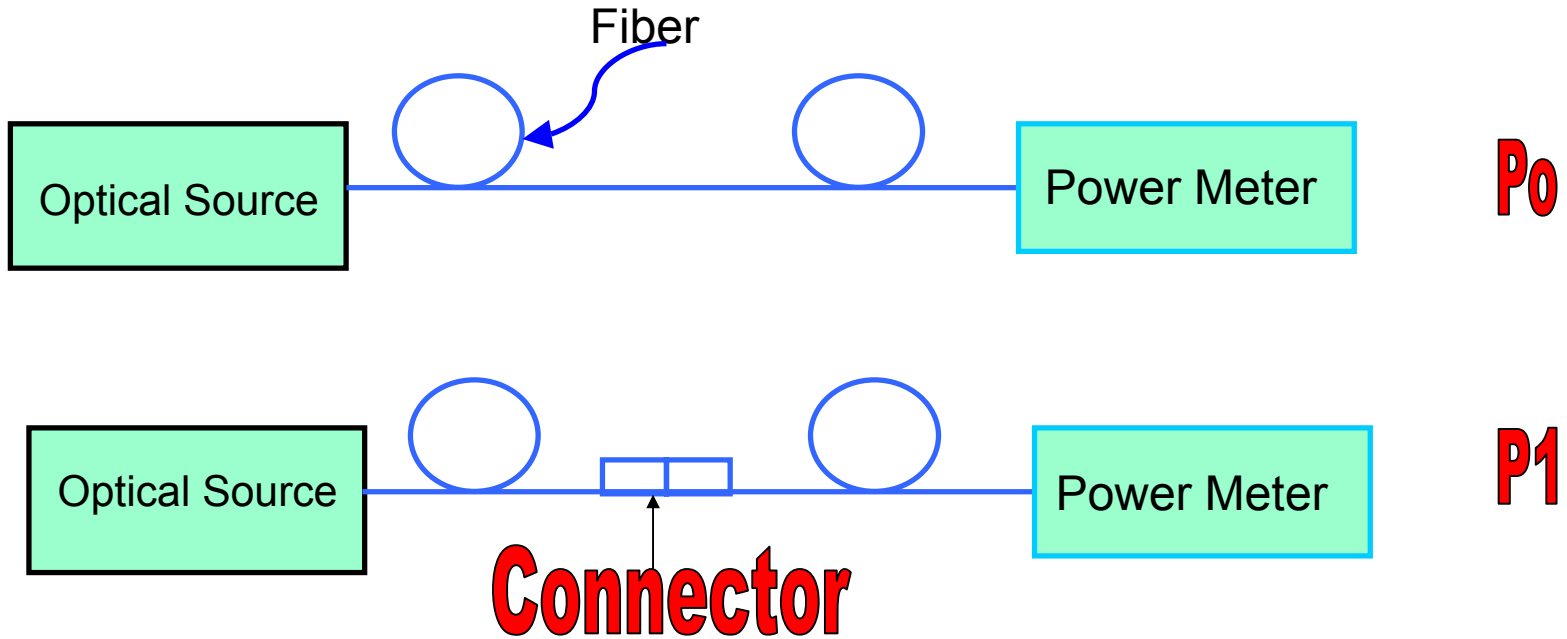
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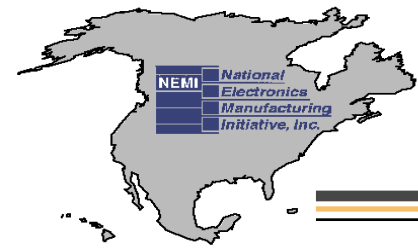
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Experimental Methodology - Insertion Loss (IL)



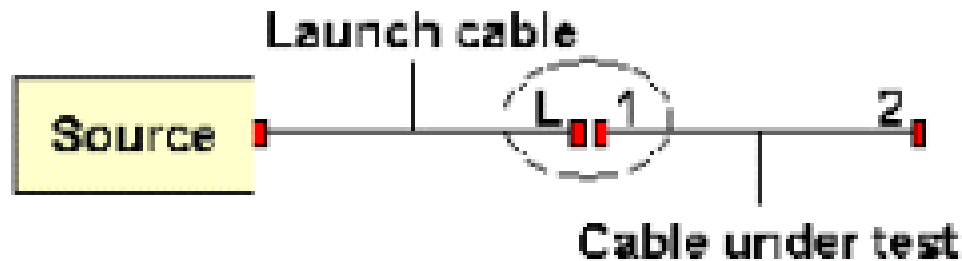
◆ Insertion Loss = $-10 \log(P_1/P_0)$, dB



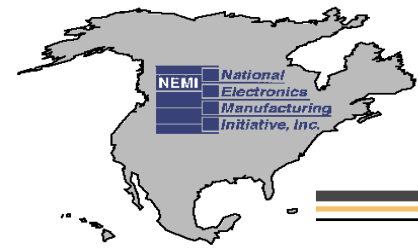
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Experimental Methodology - Return Loss (RL)



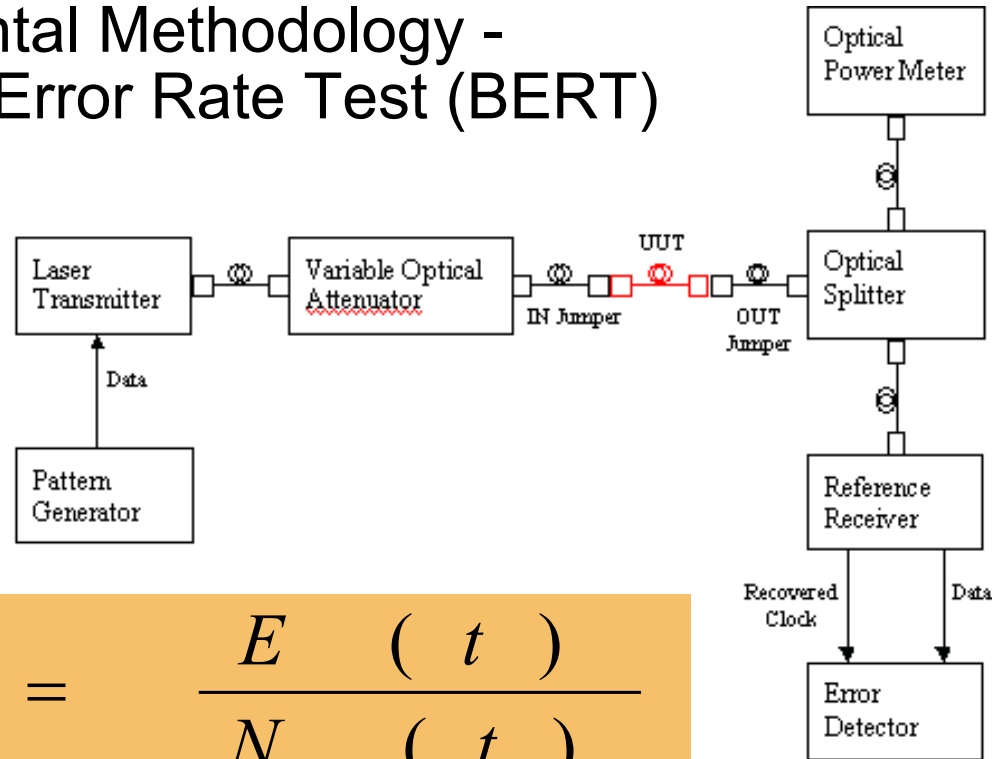
- ◆ Reflectance = $10 \log \text{Preflected, Pr/Pincident}$ [dB]
- ◆ Return Loss = $10 \log \text{Pincident, Pi/ Preflected, Pr}$ [dB]
- ◆ Return Loss = - Reflectance



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Experimental Methodology - Bit Error Rate Test (BERT)

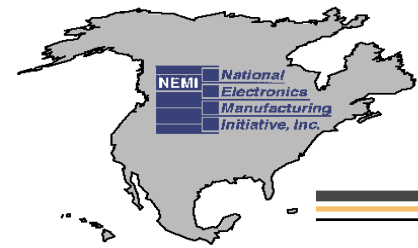


$$BER = \frac{E(t)}{N(t)}$$

Where *BER* is the bit error ratio

E(t) is the number of bits received in error over time *t*,

and *N(t)* is the total number of bits transmitted in time *t*

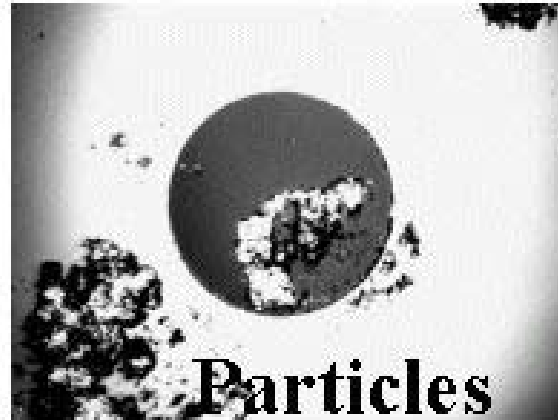


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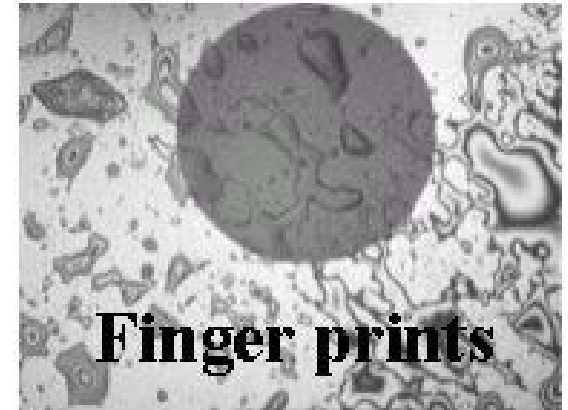
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Scratches



Particles



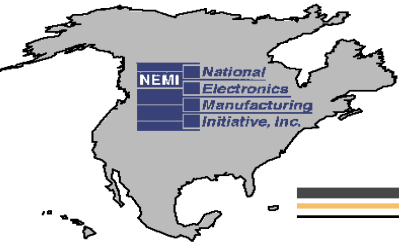
Finger prints

Clean Fiber



- ◆ Polishing scratches
- ◆ Particles
- ◆ Oil contamination (finger prints)

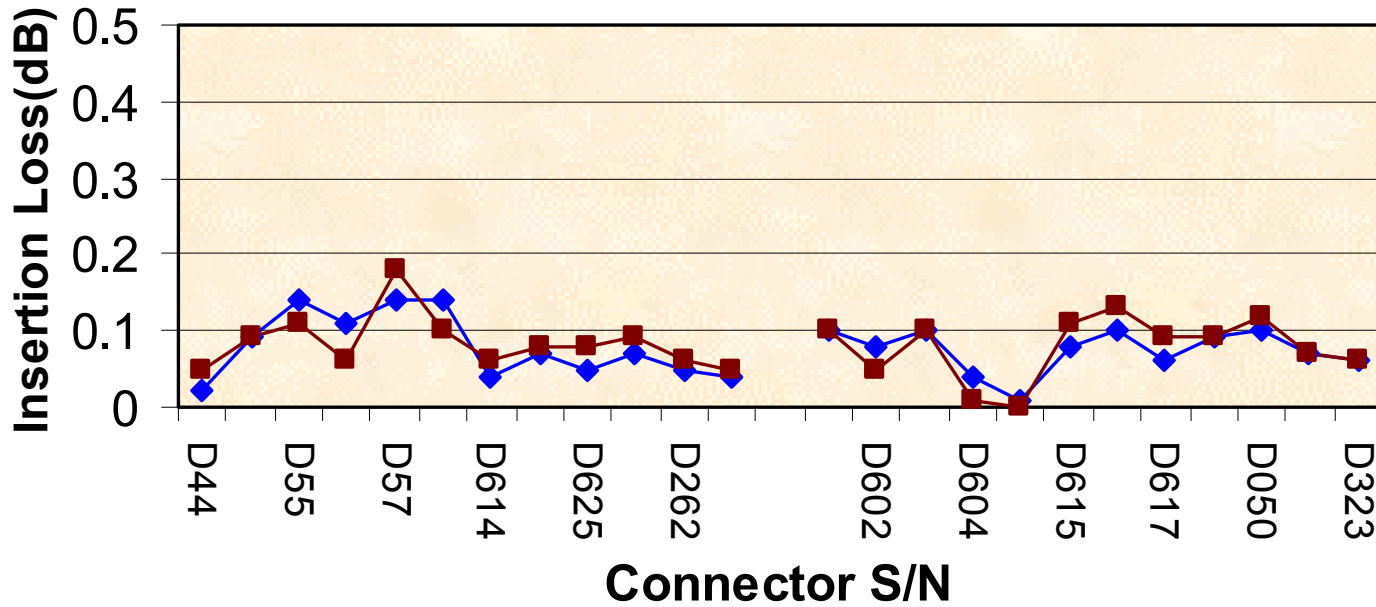
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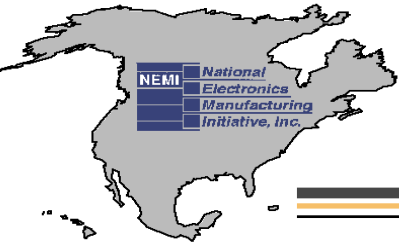
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Effect of Scratches on Insertion Loss



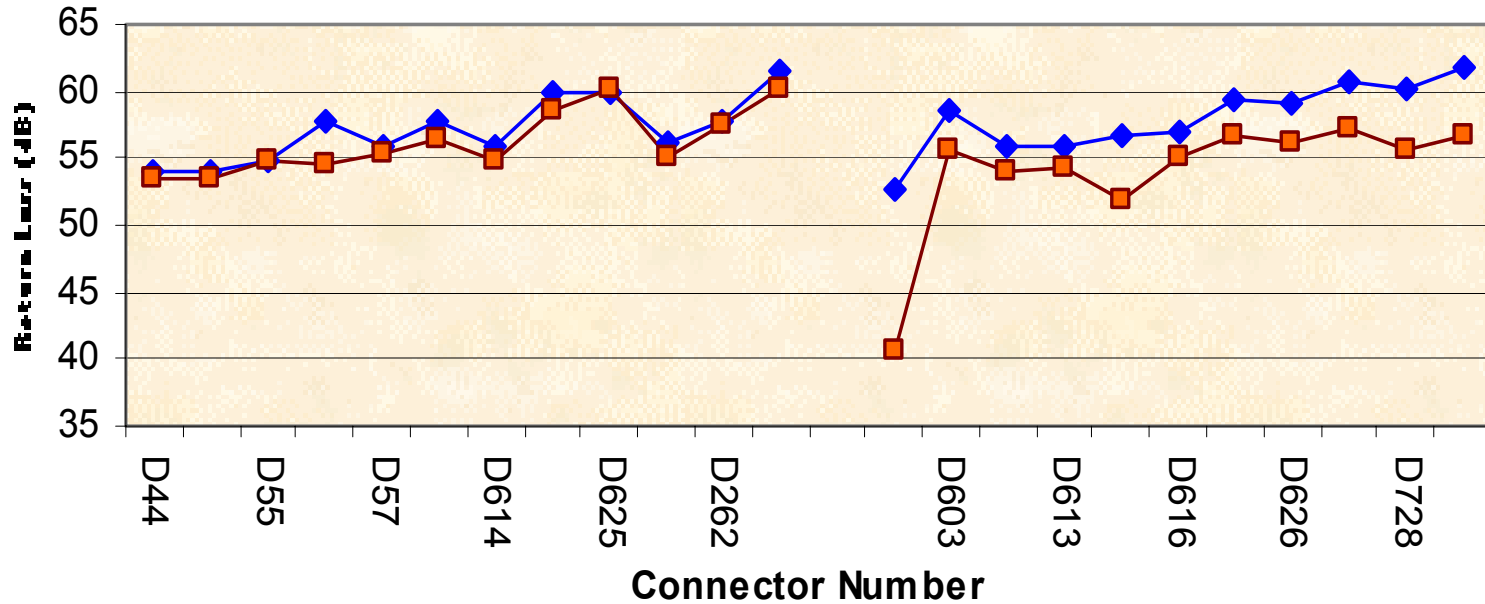
- ◆ Launch cable & CUTs Defects-free
- Launch Defects-free, CUTs S/N D44 to D320 scratches applied to the cladding, CUTs S/N D54 to D323 scratches applied to the fiber MFD"



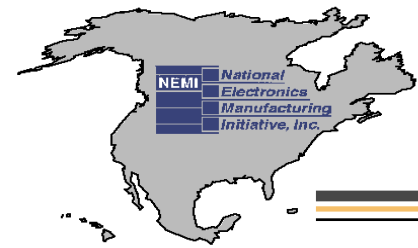
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Effect of Scratches on Return Loss



- ◆ Launch cable & DUTs defects-free
- Launch cable defects-free, CUTs S/N D44 to D320 scratches applied to the caldding area, DUTs S/n D45 to D323 scratches applied to the fiber MFD

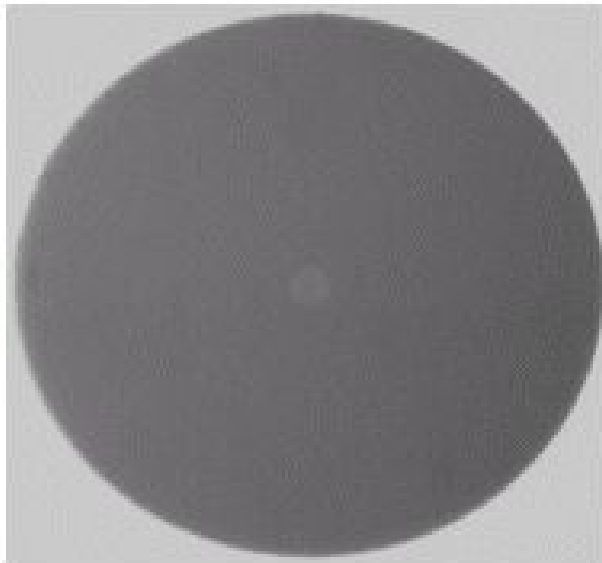


Fiber Optic Signal Performance Project

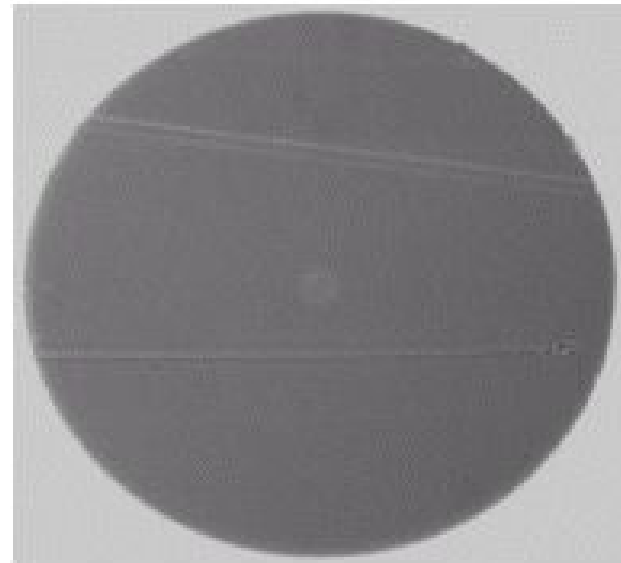
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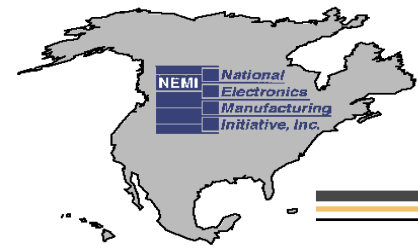
Effect of Scratches Through Cladding on IL/RL

**FC # 55 Max IL: 0.14 dB;
RL: 54.7 dB**



**FC # 55 Max IL: 0.11dB;
RL: 54.8 dB**



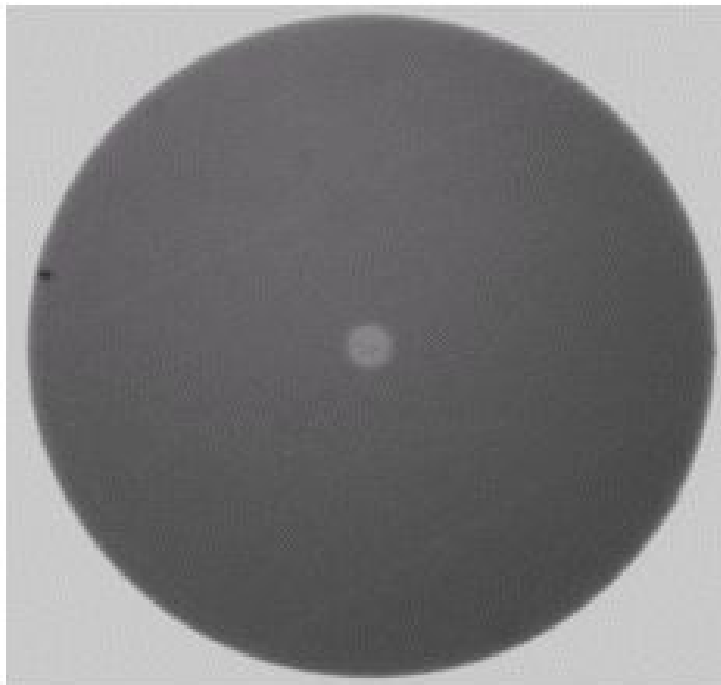


Fiber Optic Signal Performance Project

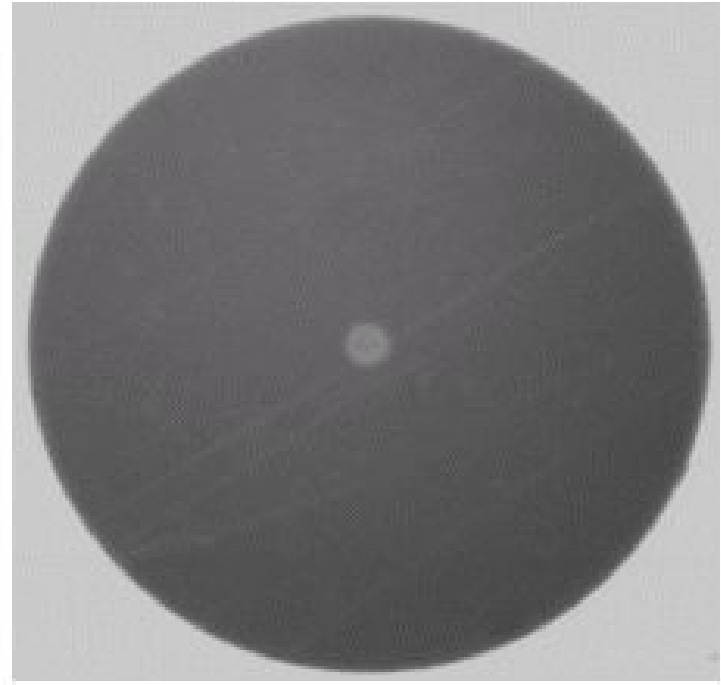
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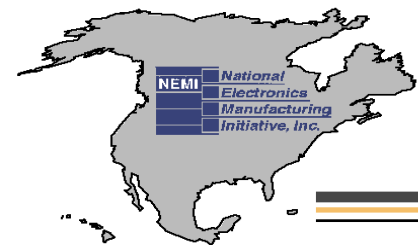
Effect of Scratches Through Core on IL/RL

**FC# 626 Max IL: 0.09 dB;
RL: 59.2 dB**



**FC# 626 Max IL:
0.09 dB; RL: 56.2 dB**

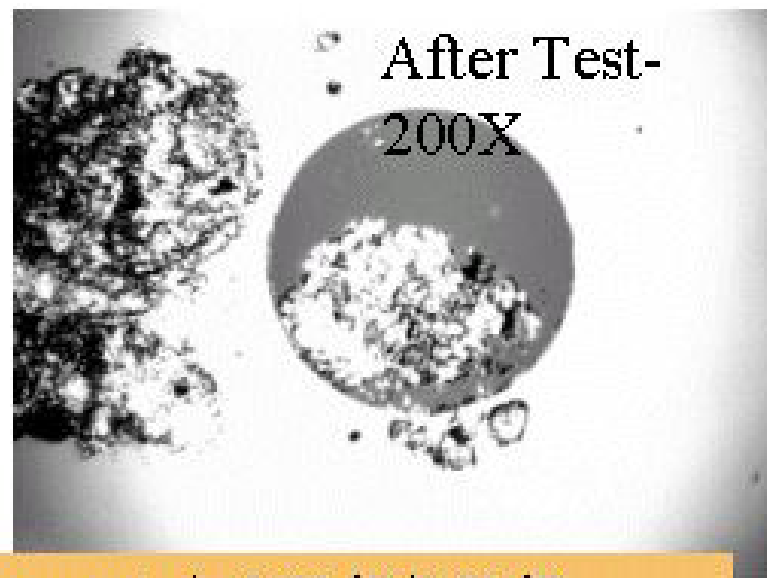




Fiber Optic Signal Performance Project

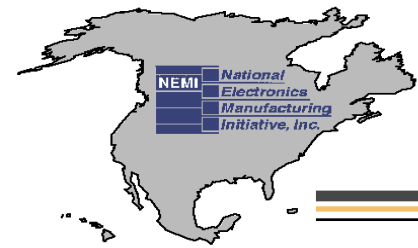
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Particles on Core / Cladding / Ferrule



- IL-1550nm/1310nm (clean connector)=0.23 dB/0.20 dB;
- IL-1550nm/1310nm (contaminated)=21.9 dB/22.8 dB;
- RL-1550nm/1310nm(clean connector)=52.9 dB/53.2 dB;
- RL-1550nm/1310nm(contaminated)=20 dB/20 dB

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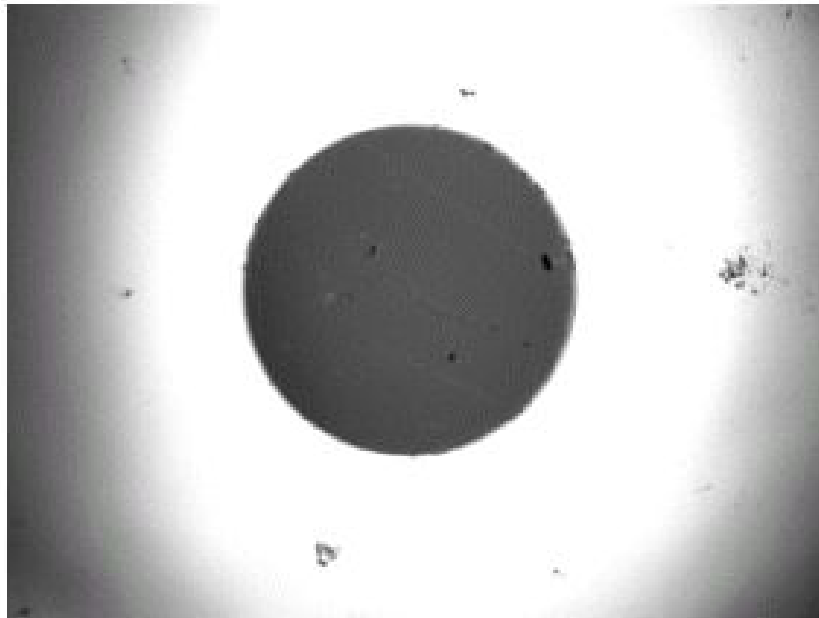


Fiber Optic Signal Performance Project

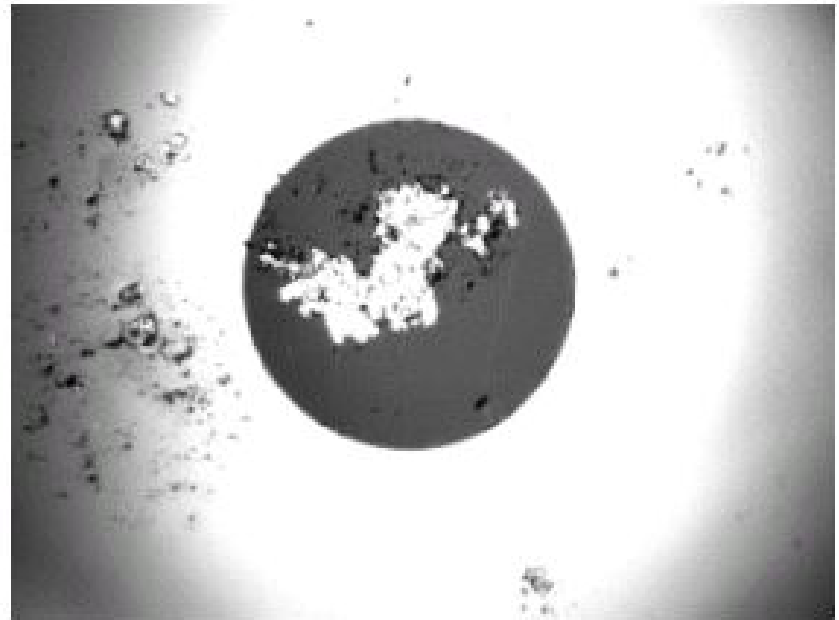
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Particles on Core / Cladding / Ferrule

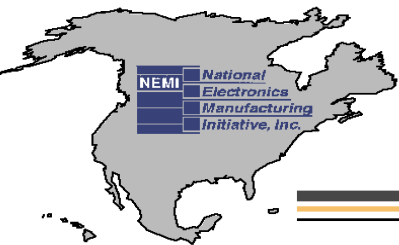
- ◆ Test fiber becomes contaminated after the test



REFSC- Before Test



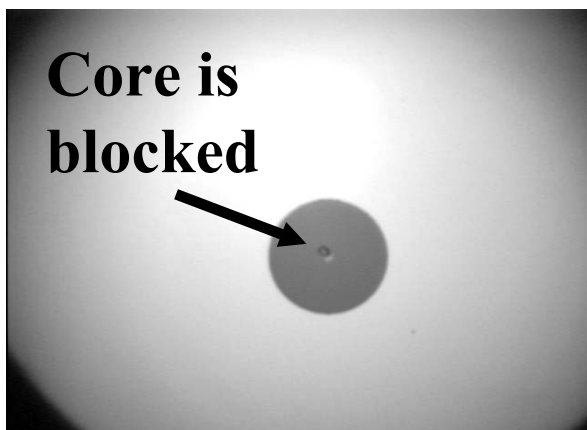
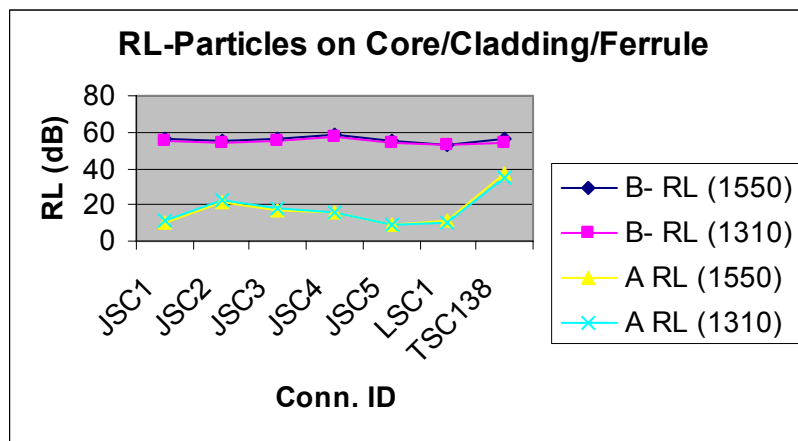
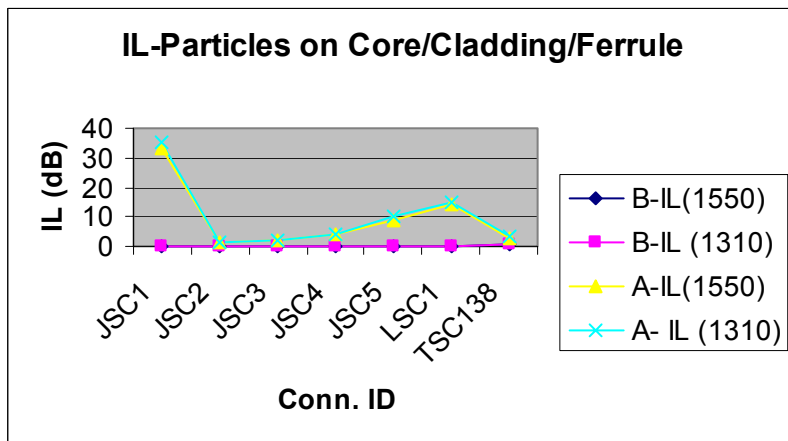
REFSC-After Test



Fiber Optic Signal Performance Project

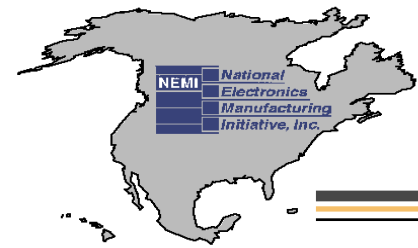
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Particles on Core / Cladding / Ferrule



- IL-1550nm/1310nm(clean)=0.39/0.51dB
- IL-1550nm/1310nm(contaminated)=2.88/3.61dB
- RL-1550nm/1310nm(clean)=56.2/54.6dB;
- RL-1550nm/1310nm(contaminated)=37.1/34.5dB

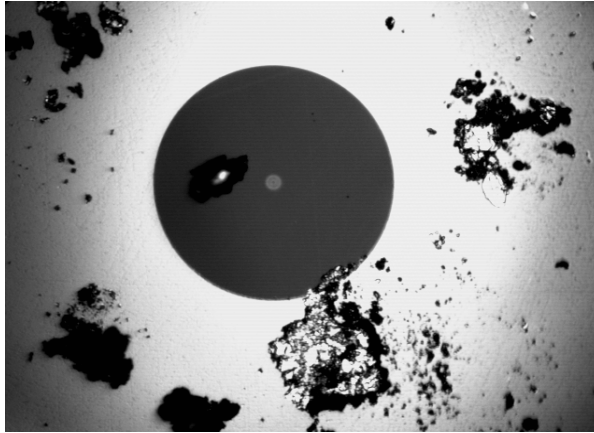
Connect With and Strengthen your Supply Chain



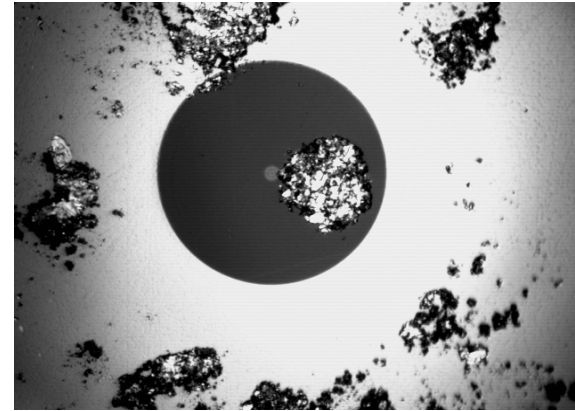
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Particles on Core / Ferrule Area



Before Test



After Test

(Connection)

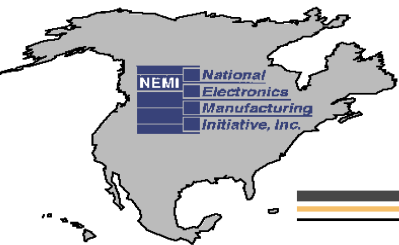
IL -1550nm/1310 nm (clean connector) = 0.14/0.15 dB,

IL -1550nm/1310 nm (contaminated connector) = 0.52/0.57 dB,

RL -1550/1310 nm (clean connector) = 55.6/54.5 dB,

RL -1550nm/1310 nm (contaminated connector) = 12.7/11.2 dB

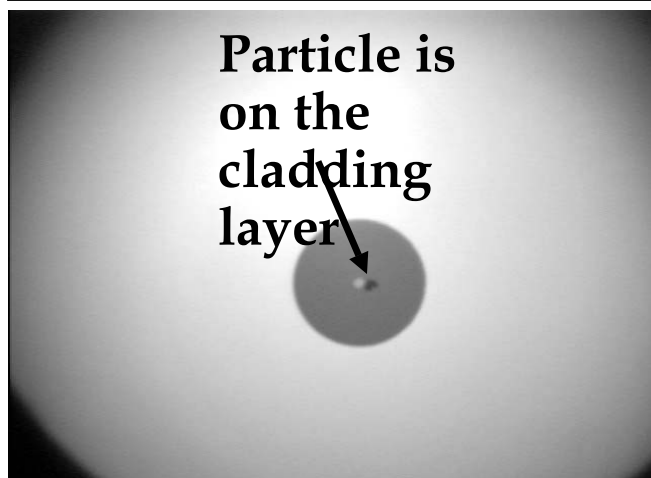
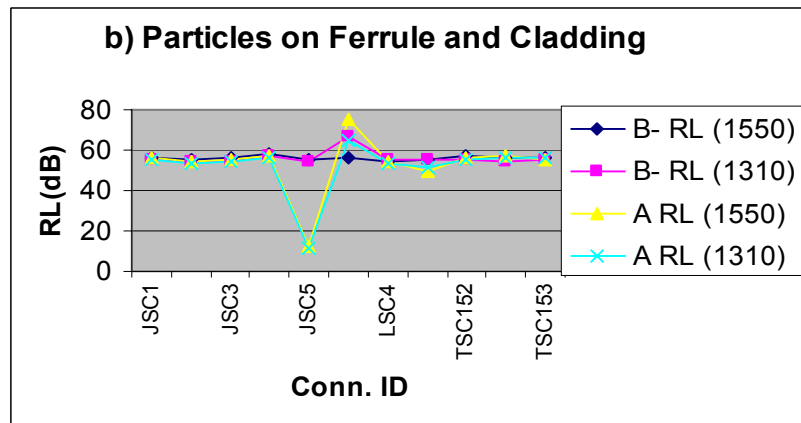
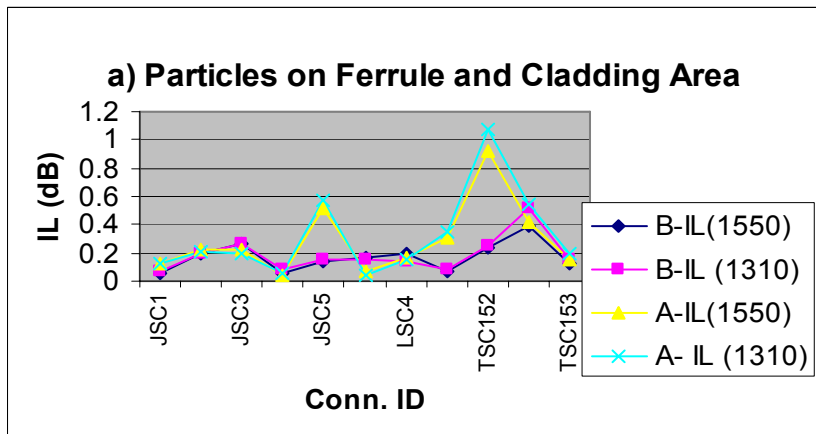
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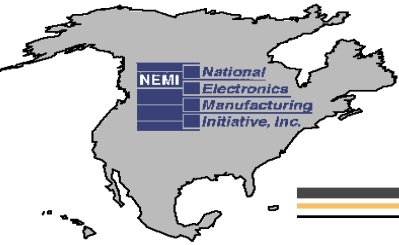
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Particles on Core / Cladding / Ferrule



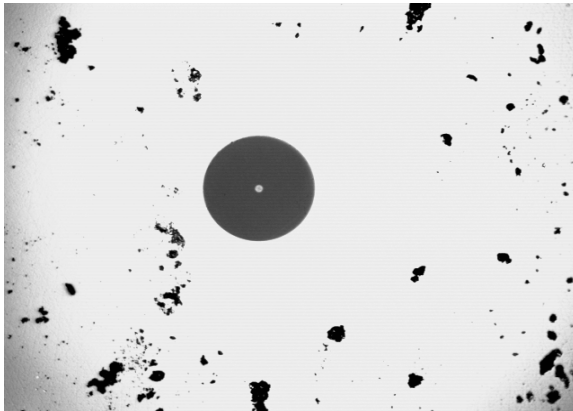
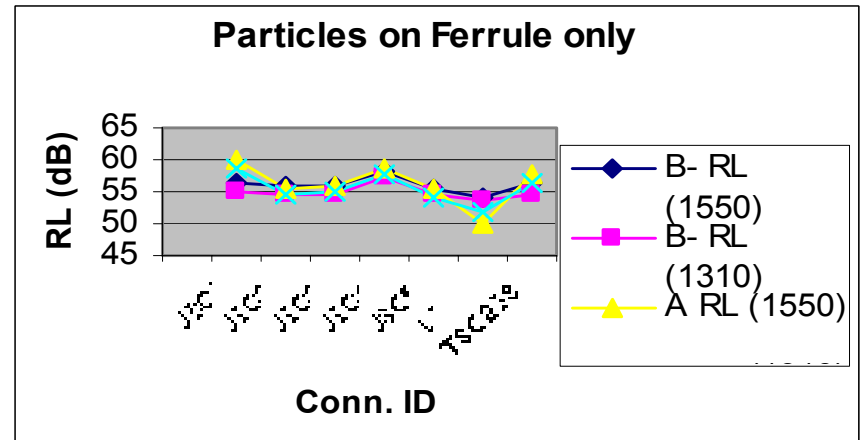
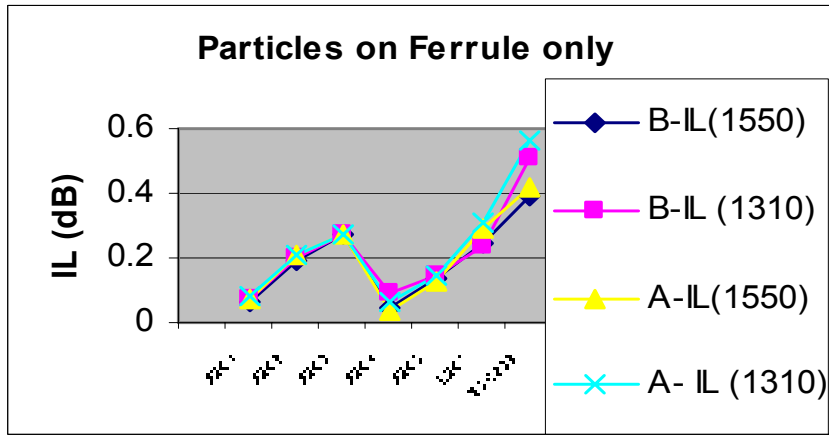
- **IL-1550nm/1310nm(clean)=0.24/0.25dB;**
- **IL-1550nm/1310nm(contaminated)=0.92/1.07dB;**
- **RL-1550nm/1310nm (clean)=57.3/55.5dB;**
- **RL-1550/1310nm (contaminated)=56.5dB/55.6dB**



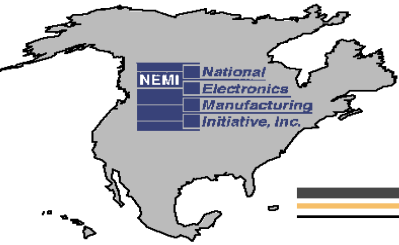
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Particles on Ferrule



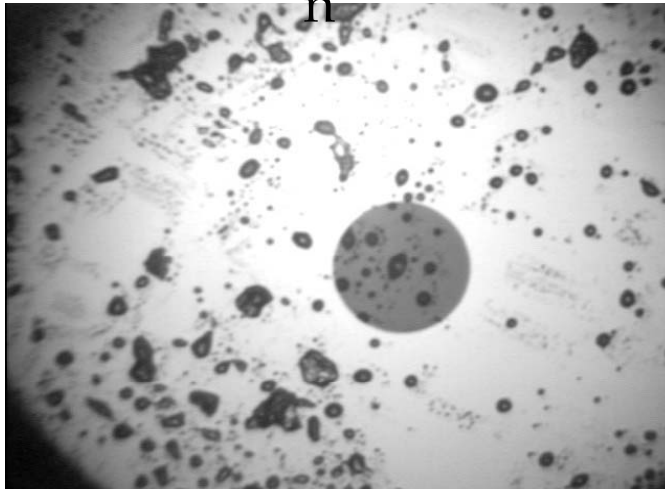
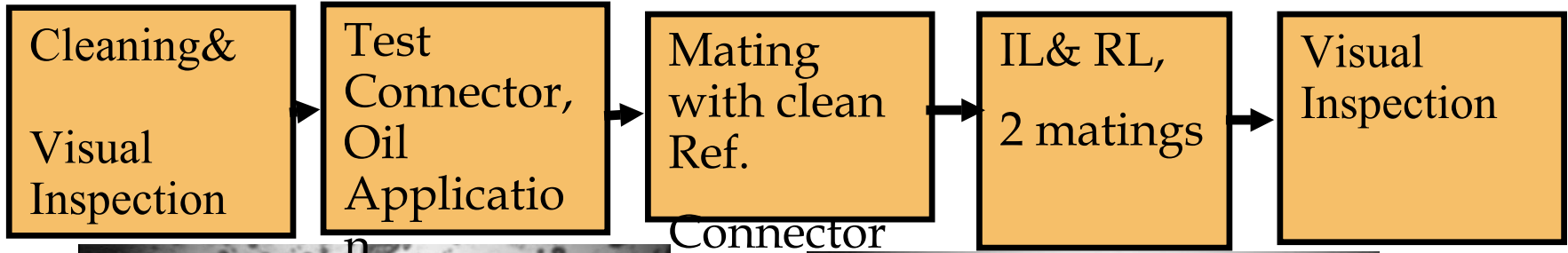
- **IL-1550nm/1310nm (clean)=0.19 dB/0.21 dB**
- **IL-1550 nm/1310nm (contaminated)=0.21dB/0.21 dB**
- **RL-1550nm/1310nm (clean)=55.7 dB/54.5 dB**
- **RL -1550nm/1310nm (contaminated)=55.6 dB/54.5 dB**



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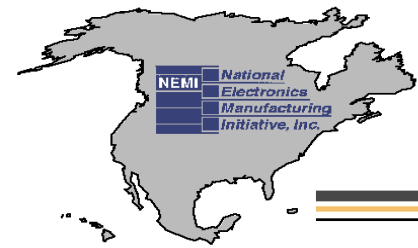
Oil Contamination



Oil contaminated connector before the mating



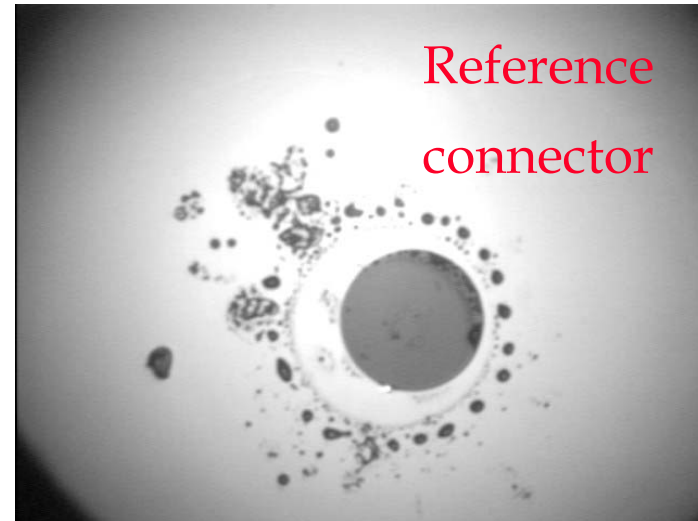
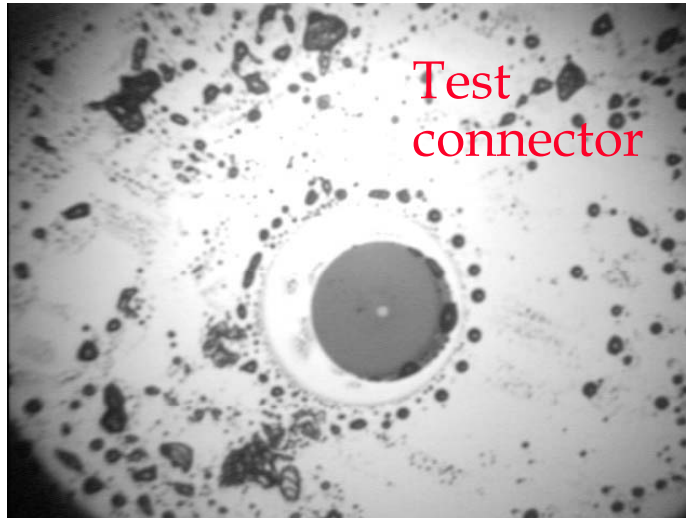
Clean Reference connector before the mating



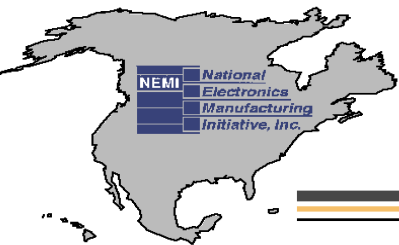
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Oil Contamination



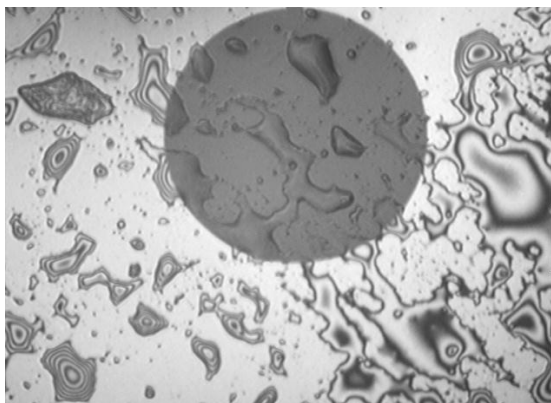
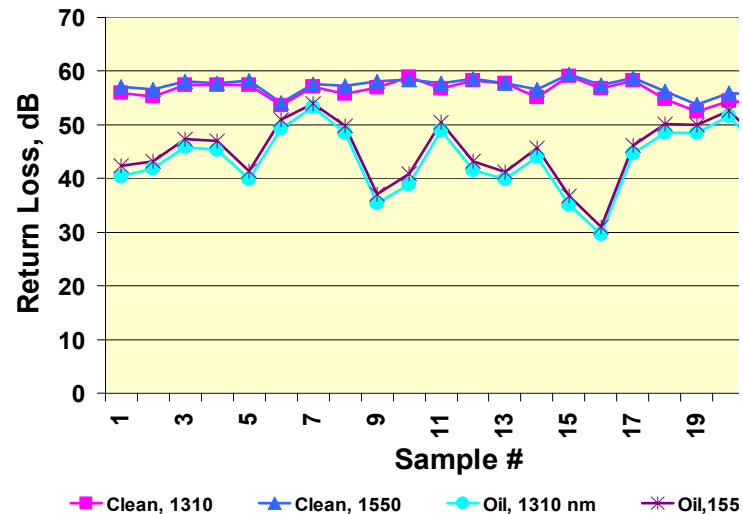
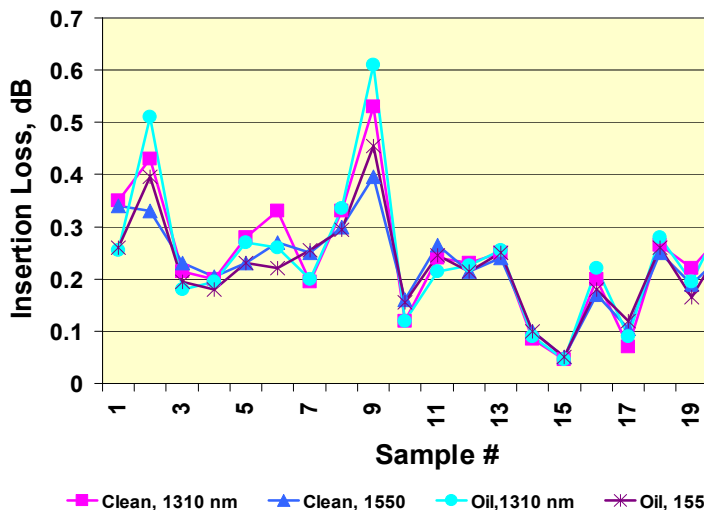
- IL (clean connector)-1550nm/1310nm=0.22dB/0.27dB;
- IL (contaminated connector)-1550nm/1310 nm/=0.23dB/0.27dB;
- RL (clean connector)-1550nm/1310nm=58.1dB/56.9dB;
- RL (contaminated connector)-1550nm/1310nm=41.2/39.8dB



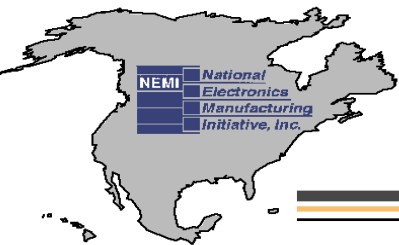
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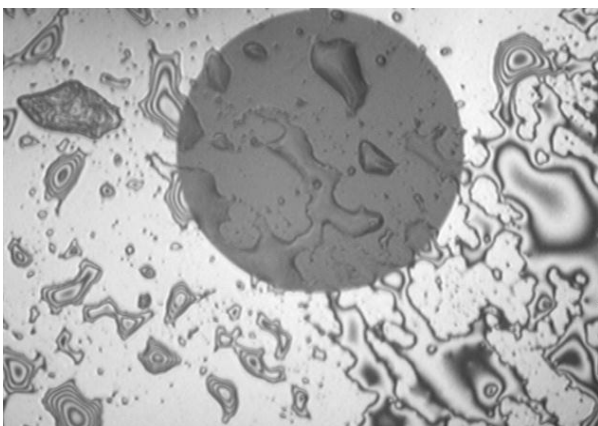
- Oil application resulted in significant changes of RL:
- RL decreased from 56.3 dB to 43.6 dB (wavelength-1310nm) and from 57.2dB to 45.1 dB (wavelength 1550 nm)



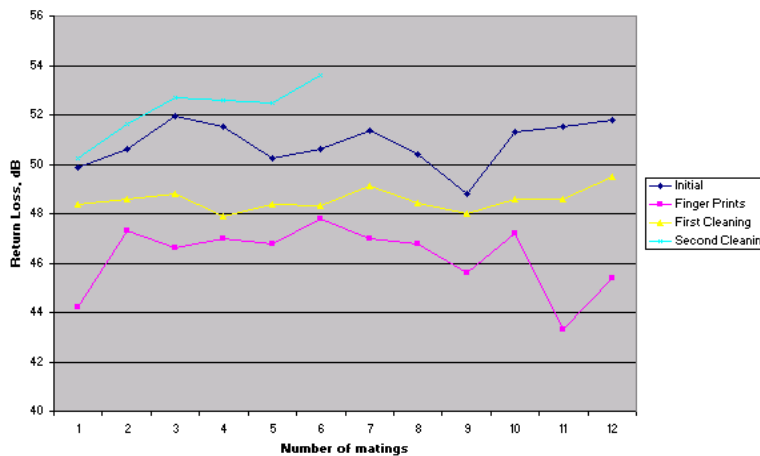
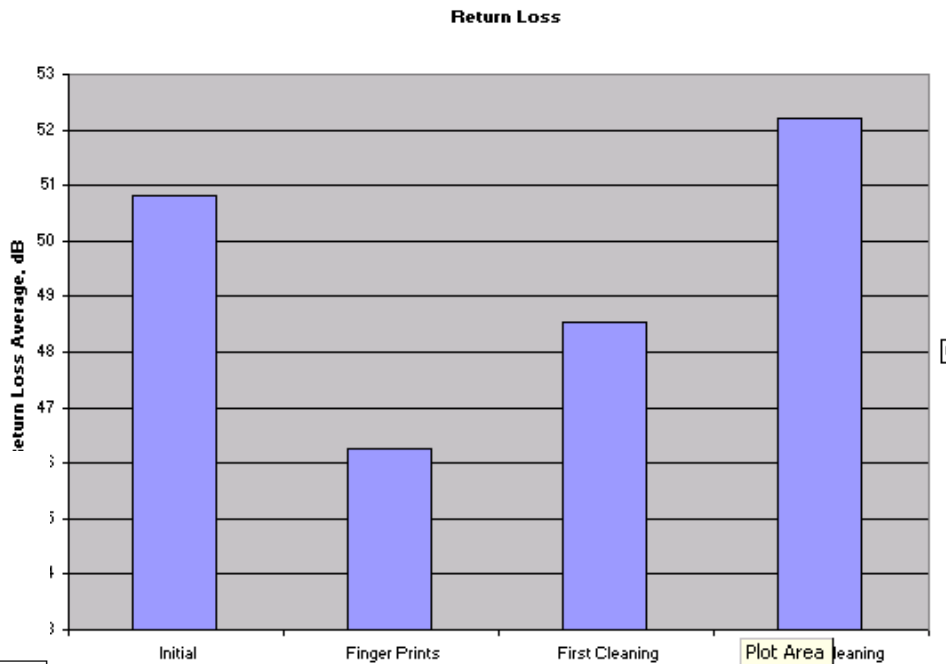
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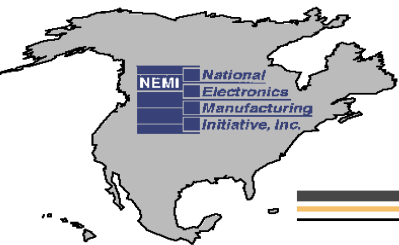
Oil Contamination



Return Loss, Sample 9b



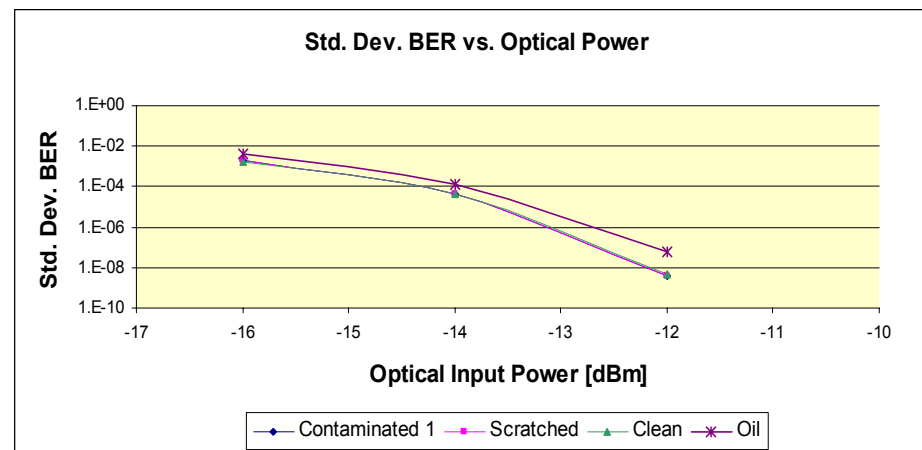
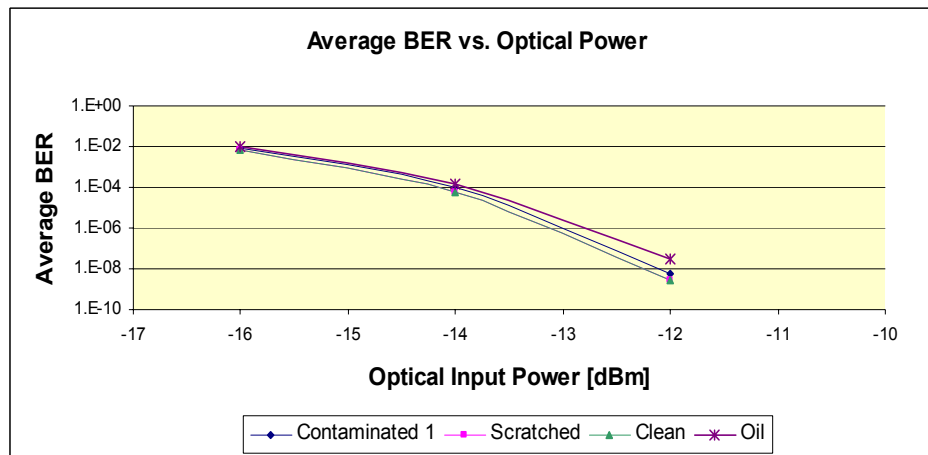
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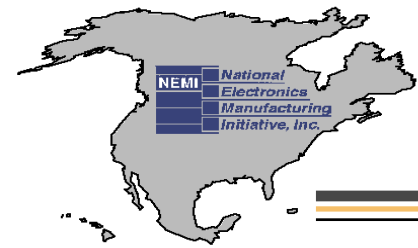
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BERT Results



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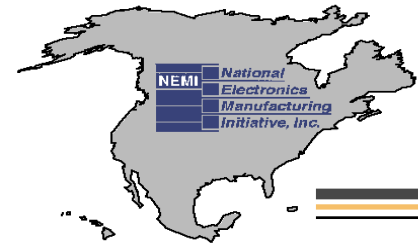


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BERT Results Analysis

	<i>Correlation-BER-Pwr</i>	<i>Coefficient of Determination</i>
<i>BER (Power-12dBm)</i>	-0.84	71%
<i>BER (Power-14dBm)</i>	-0.86	73%
<i>BER (Power-12dBm)</i>	-0.84	71%

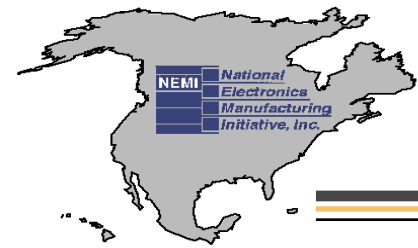


Fiber Optic Signal Performance Project

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Conclusions

- The influence of scratches, particles and oil contamination on optical performance of SC connectors was investigated
- Scratches (2um or less), within MFD, has no impact on IL can degrade the RL
- The level of RL degradation depends on the size (width and depth) and, the number of the scratches crossing MFD
- Polishing scratches outside the fiber MFD have no impact on IL & RL

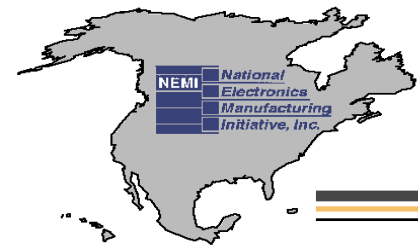


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Conclusions

- Particles on the core were resulted in catastrophic failures while the presence the particles on the ferrule does not show any degradation on its performance;
- Future studies will investigate more on the effects of the particles when they are locate at the cladding layer as well as focusing on particle size, quantity and different particle types
- Application of oil contamination resulted in significant degradation of RL (10-12 dB) and didn't result in any significant changes of IL;



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Conclusions

- The BERT results were anti-correlated with Optical Input Power (coefficient of the correlation is -0.84)
- The development of the mathematical modeling for scratches/particles/oil contamination is the subject of the further research