The Effects of Static Charge Accumulation (SCA) when Cleaning Fiber Optic Connections in OSP and OEM Applications

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Objectives of this presentation:

1. **Understanding Static Charge Accumulation:**
   - What is it?  - How does it occur?
   - What effect it can have on a fiber optic connection
   - Is there a relationship between what we understand of ESD in electronics and Static Charge Accumulation in Fiber Optics
     - In Electronics, 25kv-100kv is considered an ideal range.
     - What static charge accumulates end face contaminants?
     - What static charge does not?

2. **Review of existing processes:**
   - Can a cleaning method generate a static charge?
   - Can a cleaning method eliminate a static charge?

3. **Is there a process that can eliminate SCA?**
   - Can Static Charge Accumulation influence transmission rates?

4. **Understanding Science of Soils and Sciences of Cleaning**
What is Static Charge Accumulation (SCA)? How is it Created?

1. Static Electricity is an imbalance of electrons on the surface of a material.
   - This imbalance produces an electric field that can be measured.

2. “Tribocharging” is created by contact and separation of two dissimilar materials that transfer electrons from one surface to the other. *It is this phenomenon that generates SCA which can attract contaminants during the fiber optic cleaning process.*

3. ESD and SCA are influenced and generated by low relative humidity in temperature extremes most likely present in OSP.
   - A surface at 10-25% Relative Humidity can have 35-60x more ESD Voltage than the same surface at 65-90% relative Humidity.
     * Ambient temperatures <0F -to- >130F

4. SCA is generated by dry materials; influenced by some cleaning processes.
Can Static Charge Accumulation be controlled with grounding straps, treated materials, and/or topical conditioners?

Grounding Straps are not practical for static control at a ferrule

- Grounding straps protect electronic assemblies and PBCs
- **Grounding Straps cannot influence SCA at ferrules or end face because these surfaces are not conductive.**

Conductive Materials, such as treated fabrics, leave residues.

- When cleaning a fiber optic connection, the most plausible way to reduce SCA is to increase the level of "Practical Relative Humidity”.

- This is accomplished by instituting an appropriate cleaning method.
Do Existing Cleaning Processes Generate SCA?

**Dry Cleaning**

- “Dry cleaning is defined as drawing an end face over a wiping material or using a dry wiping tool to clean an end face/ferrule or back plane connection.”

1. Can generate Static Charge Accumulation

2. Can attract dusty particulate to the ferrule end face.

3. Can damage an end face by drawing particulate soils over the ferrule and through the core.

4. An established process that should be challenged

**Wet Cleaning**

- “Wet Cleaning is defined as using a cleaning solvent in an excessive or undefined way to clean an end face/ferrule or back plane connection.”

1. Largely avoids SCA issues

2. Undefined solvent use without drying can surface bond residual soils.

- Surface Bonding occurs when mono layers of contaminant are dried on the surface

- Surface bonded soils are as difficult to remove as other soils or those held by SCA

3. Wet cleaning, with excess amounts of any solvent, and, no defined or effective drying process, can deposit residue that surface bonds contaminants to the end face.

4. Un-defined use of any solvent should be challenged
Results of Dry Cleaning a dusty soil

- This connection was wiped using a commonly used dry wipe reel-type cleaner
  - Some soils removed; large particulate transferred (Fig. B)

- Static Charge Accumulation (SCA) can be generated by Dry Cleaning Process
  - In times of low relative humidity soils can be attracted to the end face and ferrule

Fig. A

Fig. B
Results of Wet Cleaning with IPA and other cleaning solvents...

- This connection was wiped using a high-purity IPA Wiper
  - Wiper was opened and exposed to ambient for ~30 seconds
    - 70F; 55RH
    - Common OSP Practice
      - Pump Containers including Menda® type infuse moisture into all solvents
  - Similar results when excess HFC or HFC is used
    - Manufacturer’s Instructions
    - HFC and HFE Chemistry may be considered as Global Warming Chemicals
Does a soiled connection really effect transmission rates?

- End Face is soiled with ionic contamination
  - Finger Print

- Measured with Optical Light Source and Power Meter

- Soiled connection is 23.75 db loss

Common soils can create large losses.
Initial Conclusions and Considerations:

1. There are scientific limitations to end face cleaning using customary Wet Cleaning and Dry Cleaning processes.
   - Wet Cleaning and over-use cleaners in a wet process is counter productive. Solvent/Moisture residues can remain.
   - Dry Cleaning can generate SCA that attracts soils; transfers soils.

2. A new process is indicated that considers SCA as well as removal of all contaminant types:
   - Adding a temperature and relative humidity measurement to the OSP “work list” is not practical
   - The solvent choice must remove a wide range of non-ionic contaminants.
     - The best cleaning solvent is a multi-phase precision hydrocarbon
     - Single phase HFE or HFC solvents cannot remove (myriad) OSP soils
   - The wiping material must be compliant and absorbent

Can Precision Cleaning and SCA elimination be an integrated procedure?
Static Measurements from the Dry Cleaning Process

Methodology:

An electrostatic field meter was used to measure static change from the dry cleaning procedure.

A 2.5mm UPC connection was drawn “dry” three times over a lint-free wiping material

- 72F; 65% Relative Humidity
- Meter zero-ed out @ -0.01
- Meter modified with a 0.25” stand-off to assure commonality of results

Dry Cleaning can also generate SCA
Static Measurements from the Dry Cleaning Process

- End face lightly drawn over wiping material 3 times

- Initial measurement of only -0.31kv was obtained.

- Subsequent measurements: -0.31kv, -0.34kv, -0.36kv, -0.38kv were obtained in the same session.

- Testing performed with reel cleaning tool, ferrule cleaning tool, and lint-free paper wipers with like results.
Laboratory studies demonstrate lint particulate is easily attracted by relatively low Static Charge Accumulation
(3-3-2006; 11-14-2006; 3-8-2007 and subsequent. S. Max-Laboratory Director; P. Blair-Market Manager; E. Forrest-R&D)

Laboratory Study 3/8-3/11/07

Objectives:
- Emulate an OSP Contaminate
  - Dust, Grit, Lint, Gypsum
- Determine if contaminant could be generated by Static Charge Accumulation
- Determine levels that contaminant is attracted to fiber optic connection

Method:
- Create 0.31-0.38kv
- Place end face in proximity to contaminant: 0.25”.
- Measure at 72F; 65 RH
- Record results

Results
- Relatively Low voltage attracts contaminants
In January, 2006 our Technical Services Group received a series of calls from OSP technicians who reported “dust accumulation while cleaning”.

Investigation of the reports determined the following commonalities:

1.) All were cleaning in the “dry method”

2.) All calls came from New England and Eastern Canada during times of extreme cold and low relative humidity

3.) The phenomenon was recreated in our lab with these results. (3/3/2006)
Static Measurements from the “Combination Cleaning Process”

- End face drawn from the small moist area into the dry three times.

- Reading ranged from -0.03kv to -0.07kv to -0.05kv
Laboratory studies demonstrate lint particulate is not attracted by Static Charge Accumulation

(3-3-2006; 11-14-2006; 3-8-2007 and subsequent. S. Max-Laboratory Director; P. Blair-Market Manager; E. Forrest-R&D)

- Laboratory Study 3/8-3/11/07

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- **Method:**
  - Create -.03kv to 0.07kv
  - Place end face in proximity to contaminant: 0.25”.
  - Measure at 72F; 65 RH
  - Record results

- **Results**
  - Low Static does not attracts contaminants
Reducing Static Charge Accumulation by using a limited amount of cleaning solvent creates Practical Relative Humidity

Practical Relative Humidity significantly reduces static charge accumulation

Solvent use is essential to the end face/ ferrule cleaning process

- Solvent use assures a high percentage of cleaning the first time
- Too many complex soils; too few video scopes to observe contaminants before and after cleaning
  - Complex Soils include: dust, oils, and contaminants that are the result of inadequate “fiber hygiene”.
  - Dusty soils can be intensified and attracted to the fiber connection by Static Charge Accumulation.

Use of a non-IPA solvent cleans both ionic and non-ionic contaminants

- IPA is well-documented to be hygroscopic. Customary methods of storage in pump containers or squeeze bottles infuse moisture into the solvent that contains air borne contaminates.
  - Aerosol containers are the preferred delivery medium
  - IPA is not a universal cleaner that removes complex soils

However, solvent use must be:

- Defined: as not over-saturate the connection
- Reduced: as not to leave residues that exacerbate the cleaning process
- Automatically removed: as an integral aspect of the process

One process is required for cleaning all soils and reducing static field accumulation that can attract more soils

This new method is called: Combination Cleaning
How to Perform:

The Combination Cleaning Process (CCp™)

A small amount of Non-IPA cleaner (<1ml) is placed on a lint-free surface. Cleaning becomes an ergonomic process that automatically dissipates static charge as well as correctly cleans and dries end face geometry.

Spray an amount of NON IPA solvent (1ml/about the size of a quarter-dollar) in one corner the wiper

- When cleaning an end face lightly glide draw the end face from wet-to-dry
- This motion removes soils and eliminates SCA.
- When using a precision swab: lightly moisten the swab by holding it in the moist area: 1-2-3-4-5.

Use a **Straight Line Cleaning Motion**

- The cleaning movement is not a “Figure-8”: This is a polishing motion that can transfer soils during the cleaning motion.
- The cleaning movement is not a “Twist & Turn” that can grind the end face into the particulate.
Particulate attracted to a static charge field can be present in OSP and OEM Environns

- The black particulate in upper right slide was generated in a lab test on 3-3-2006
  - Particulate was removed using CCp© technique depicted in the insert.
  - Lightly moisten the 38542F Precision Swab by holding the head in the wetted area of the QbE: 1-2-3-4-5.
    - The key is proper wetting, which is an “under saturation of all materials”.
    - “Less is Better”

Drawing the end face over dry material created SCA Tribocharge that attracted soil...→

A lightly moistened swab dissipated the SCA Tribocharge and captured the soil in the weave of the swab head
Particulate attracted by Static Charge Accumulation is removed by Combination Cleaning Process

- OSP Operations are not clean environments
- Combination Cleaning adds Practical Relative Humidity
  - Reduces static accumulation
- Best-practice procedure
  - For all soils and conditions
The CCp™ Method: “wet-to-dry”.

Before: End Face Contaminated with Complex Ionic Soils

After using the CCp™ Cleaning Method
End face results: CCp™ “wet-to-dry”.

CCp© utilizes a small amount of solvent in conjunction with a lint free material to: 1.) capture contaminants, 2.) break the static charge holding particulate to the surface, and, 3.) uses an ultra low surface tension solvent to “lift” particulate from the end face.
Conclusions:

- **Static Charge Accumulation can be present in all OSP and OEM Environments**
  - Relatively low static readings create conditions that attract dust & particulate to an end face.
  - SCA is documented: it can attract contaminants to the connector.
  - SCA readings on the level with accepted ESD Standards do not accumulate contaminants.

- **Observation of relative humidity in the work area is important to proper cleaning methods**
  - Observe test readings when relative humidity is <65%.
  - Re-clean if Static Charge Accumulation is a possibility or test readings do not pass.
  - Unfortunately...this is not a realistic expectation for OSP.

- **Combination Cleaning reduces SCA by increasing “Practical Relative Humidity” through appropriate use of solvents**
  - Elimination of SCA becomes an integral aspect of the precision cleaning process.

- **In Cleaning Fiber Optics**:
  1. Dry Wiping Tools and Materials can attract airborne and dust contaminants.
  2. Excess solvent use is as counter-productive as dry cleaning.
  3. Grounding Straps are not effective for static accumulation on end face or ferrules.
  4. A small amount of the proper cleaning solvent assures that cleaning does not generate a SCA Tribocharge.
  5. The use of a non-IPA Solvent assures all types of soils are removed.

- Our field experience and expertise is derived from cleaning more than 7,000,000 connections with a precision hydrocarbon blend.

- Proper chemical selection is critical to address issues of Global Warming.