DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIVISION

NAVAL SHIP SYSTEMS
ENGINEERING STATION
5001 S. BROAD STREET
PHILADELPHIA, PA 19112-1403

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From: Commander, Carderock Division, Naval Surface Warfare Center,
Naval Ship Systems Engineering Station, Philadelphia, PA
To: Commander, Naval Sea Systems Command Headquarters (Code 05Z5)
Commander, Naval Air Systems Command Headquarters Patuxent River (Code 4.5)
Commander, Space and Naval Warfare Systems Command
Headquarters San Diego (Code PMW-165)

GUIDANCE DOCUMENT: APPROACHES TO CLEANING FERRULE END FACES, FIBER OPTIC CONNECTORS AND TERMINI

(1) Approaches to Fiber Optic Ferrule/Fiber End Face Cleaning, Revision D of 13 June 2003
(2) Guidelines and Procedure for Fiber Optic End Face Cleaning, Revision B of 9 May 2003

1. Purpose
This letter addresses guidelines to be used for determining a suitable approach to cleaning of the ferrule end face on fiber optic connectors and termini. Surface to be cleaned is restricted to that of the optical fiber end face and the adjacent surface of the ferrule. It is recognized that no one approach is appropriate for each Platform (such as ship, aircraft or ground-based) or the specific variants of each Platform. The intent of this letter is to define the approaches to consider along with guidance for the selection. Enclosure (1) provides further guidance for selection.

2. Approaches to cleaning
Approaches to cleaning are dependent upon type of contamination expected, minimum accepted value for the optical loss and likely level for cumulative damage to the fiber end face. One vendor providing inspection equipment used this equipment to better identify the effectiveness of various cleaning approaches and different techniques within each approach. Three main approaches are defined: rudimentary, multiple step (inspect, swab/wipe & inspect), and machine cleaning. This guidance document discusses these three approaches in enclosure (1) with the advantages and disadvantages. Guidelines for one cleaning approach and a cleaning procedure are provided for a second of these three cleaning approaches in enclosure (2).

3. Distribution statement
Distribution Statement A: Approved For Public Release, Distribution Is Unlimited.

4. Points of contact
Please direct questions or comments to the Naval Surface Warfare Center Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) point of contact for fiber optic component testing and principle contact for NAVAIR/SPAWAR applications on this subject is E. Bluebond. He can be contacted by FAX: (215) 897-8509 or E-mail: bluebondej@nswccd.navy.mil. The Naval Surface Warfare Center, Dahlgren Division (NSWC DD) point of contact for specification requirements and principle contact for NAVSEA applications on this subject is R. Throm (Alternate: G. Brown). He can be contacted by FAX: (540) 653-8673 or E-mail: thromra@nswc.navy.mil (browngd@nswc.navy.mil).

F. FERRESE
By direction

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Copy to:
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NAVSEA 05Z5 (H. Lewis)
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Guidance Document
Approaches to Fiber Optic Ferrule/Fiber End Face Cleaning

Cleaning approaches.

a. Rudimentary cleaning. (One step process using one of two techniques: blow particles free with compressed air or wipe clean with lint free wipe/cloth.)
   (1) Applications. Contaminants consisting of dry particles only.
      Note: Dry particles are classified into two sizes. Dry particles under 10 microns (small particles) that are held primarily by a static bond. These particles require physical contact to remove. Dry particles over 10 microns (large particles) that can be removed by compressed air. Particles over 30 microns are those most often found to be causing catastrophic signal loss during troubleshooting.
   (2) Advantages.
      (a) Sufficient for removal of large particles.
      (b) Easiest and quickest approach to perform.
      (c) Requires minimum level of skill to perform.
   (3) Disadvantages.
      (a) Blowing particles free with compressed air does not remove smaller particles.
      (b) Wipe clean with lint free wipe may be inconsistent in removal of smaller particles.
      (c) Both techniques do not remove liquids (including oils and dried liquids), particles mixed in the liquids, and particles affixed in dried liquids.
      (d) Both techniques are limited to single ferruled connectors with exposed ferrules.
      (e) Limited success for pin termini within a multiple termini connector where cleaning of one pin by this approach may contaminate adjacent pins.
      (f) Both techniques cannot be used at connector ports, socket terminus or other configurations in which cleaning must take place through and include an alignment sleeve.
      (g) Particles moved away from core versus being removed may cause cumulative damage to the fiber end face.
      (h) No feedback on cleaning effectiveness is obtained since no visual inspection is done.

b. Multiple step cleaning (Inspect, swab/wipe &inspect).
   (1) Applications. Contaminants consisting of dry particles, liquids and particles mixed within liquids.
      Note: Particles mixed within liquids include particles mixed within liquids and held by surface tension as well as particles that are encrusted into dried liquids.
   (2) Advantages.
      (a) Sufficient removal of particles, liquids and particles mixed within liquids.
      (b) Performed using simple methods and cleaning supplies.
   (3) Disadvantages.
      (a) Requires willingness and patience to perform.
      (b) May require multiple steps/iterations for acceptable degree of removal.
      (c) Removal using swab requires expenditure of one swab for each cleaning step.
      (d) Swabs cleaning within alignment sleeves may spin/relocate particles instead of removal.
      (e) Particles moved away from core versus being removed may cause cumulative damage to the fiber end face.

(f) Approach requires use of a cleaner such as reagent grade alcohol.
(g) Higher cost of consumable supplies per ferrule than other approaches.

c. Machine cleaning.

(2) Applications. Contaminants consisting of dry particles, liquids and particles mixed within liquids.

Note: See previous cleaning approaches for discussion of particles and liquids.

(2) Advantages.

(a) Sufficient removal of particles, liquids and particles mixed within liquids.
(b) More complete particle removal then other approaches.
(c) Quick approach requiring little willingness and patience to perform.

(3) Disadvantages.

(a) Requires periodic maintenance to change cleaning fluid.
(b) Requires high initial cost.
(c) Requires use of a liquid solvent.

2. Cleaning effectiveness, optical degradation and damage potential. Table 1 provides relative values of parameters to consider for selection of a cleaning approach.

Table 1. Debris removal effectiveness, optical degradation, potential damage of residual debris 9/

Parameter/Cleaning Approach	Rudimentary	Multiple Step 6/	Cleaning Machine 5/
Effectiveness for contamination types	Large particle	Large particle 1/ Liquid Particle in liquid	Small & large particle Liquid Particle in liquid
Expected optical loss increase, multimode 7/, 10/	> 0.25 dB 2/ 0.4 to 5.0 dB 3/	0.1 to 0.25 dB	< 0.1 dB
Expected optical loss increase, single mode 7/, 10/	> 0.6 dB on core > 0.25 dB off core	> 0.6 dB on core > 0.25 dB off core	< 0.25 dB
Expected optical return loss, single mode 7/	< 55 dB 2/ < 40 dB 4/	< 55 dB	> 55 dB
Potential cumulative damage of fiber end face 8/	Small to moderate	Small	Minimal to small

1/ Inconsistent cleaning results for small particle size.
2/ Assumes only dry particles (no liquid) with successful removal of only the large particles.
3/ Assumes particles mixed with liquid in which the rudimentary cleaning approach is ineffective.
4/ Assumes relocation versus removal of both small and large, dry particles. Also assumes no liquid present.
5/ Assumes cleaning machine that successfully removes dry particles, liquids, and particles mixed with liquids.
6/ Assumes wet swab step followed by dry swab step will successfully remove particles embedded in liquid as well as the liquid itself.
7/ Optical comparisons assume one ferrule surface cleaned by approach listed and mated with a perfectly cleaned ferrule surface.
8/ Damage that can be caused by residual particles remaining on the ferrule end face when mated.
9/ Material in this table for general categorization of cleaning approaches along with cleaning effectiveness of various contaminants, expected optical degradation and the potential for contaminant cumulative damage was obtained from a presentation given at the second NAVAIR Fiber Optic Working Group (NFOWG) meeting. This presentation was prepared and given by Steve Lytle of Westover Scientific, Inc.
10/ Increase in optical loss is relative to two perfectly cleaned and mated ferrule surfaces.

3. Cleaning fluids.

   a. Isopropyl alcohol (IPA).
      (1) Applications. Current cleaner for fiber optic, connector end faces used throughout industry. Approved for shipboard use in this application. Logistic support system in place to procure and store for shipboard use. IPA in purity required available in the Government National Stock System under NSN 6505 00 205 6513 (with solvent dispenser under NSN 8125 01 439 5367).
      (2) Advantages.
         (a) Readily available.
         (b) Sufficient cleaning effectiveness for most common film contaminants.
         (c) Available in towel or wet wipe form to negate need for handling liquid.
      (3) Disadvantages.
         (a) IPA is flammable and volatile.
         (b) IPA is hygroscopic resulting in particle absorption through the air (from particles suspended in moisture droplets).
         (c) IPA film cannot be observed on most microscopes and fiber optic, video inspection systems.
         (d) A highly pure grade must be used to avoid dissolved particle contamination.
         (e) Films or residues are left from some hydraulic fluids, fuels and other aircraft and/or shipboard fluids.
         (f) Since IPA is readily available in other forms, controls are required to prevent substitution of different grades. These controls may be ineffective.
         (g) No field method to determine when IPA should be discarded due to contamination, loss of potency such as due to evaporation, or substitution. Additionally, convenient alternate tests (e.g. visual inspection) are not available.
   b. Ammonia based cleaners.
      (1) Applications. Ammonia based detergents (such as Windex) are used by some aircraft Platforms for in-house production use. An ammonia based cleaner is not approved for use on ships in this application. Use on ships includes cleaning product placement or storage on the ship and cleaning product use may be for either shipboard or aircraft.
      (2) Advantages.
         (a) Formulated for cleaning glass.
         (b) Not flammable.
         (c) Readily available.
         (d) Sufficient cleaning effectiveness for most common film contaminants.
         (e) Dissolves hydraulic fluids and other aircraft fluids in which a film or reside would remain after cleaned with IPA.
      (3) Disadvantages.
         (a) Not approved for use on ships.
         (b) Ammonia in the ammonia based cleaners evaporate leaving water and detergent residues behind.
         (c) Ammonia based cleaners were not fluid immersion tested for material/electrical compatibility with other aircraft components.
         (d) Purity level of commercial ammonia cleaner is not specified resulting in uncontrolled / unknown performance for this application.
         (e) Controls to prevent cleaner cross contamination by adding other products to existing containers cannot be completely enforced.
         (f) No field method to determine contamination level/when cleaner should be discarded.
   c. Emerging cleaning products.
      (1) Applications. Products specific for cleaning the end faces of fiber optic connectors are starting to enter the market place. Cleaning efficacy and chemical acceptability must be determined on a per product basis for a given application.

(2) Potential advantages.
  (a) Evaporates more quickly than alcohol.
  (b) Provided in sealed containers to eliminate potential for contamination.
  (c) Labeled specific for fiber optics so not to confuse it with other cleaners.
  (d) Dispensing in metered volumes for consistent cleaning.

(3) Evaluation criteria.
  (a) **Chemical compatibility:** Chemically acceptable with materials cleaner might come in contact with in and around application on a ship (including aircraft carriers and submarines).
  (b) **Availability:** Product available at a reasonable cost from multiple suppliers.
  (c) **Cleaning efficacy:** Sufficient cleaning effectiveness for most common particle and film contaminants and for ability to dissolve hydraulic oils, fuels and other aircraft and shipboard fluids.
  (d) **Volatility:** Preferred cleaning fluid properties: sufficient evaporation rate, leaves no residue (including a purity level acceptable for application), non hygroscopic, not flammable, not reactive, unlimited shelf life, effective with wipes/lint free cloth and fiber optic swabs, not regulated product in terms of transport and storage.
  (e) **Convenient applicators:** Preferred solvent dispenser properties: sealed to extent that fluid cannot be added and existing fluid contaminated, non aerosol dispensing system, dispenses cleaning fluid so that it can be used on wipes/swabs, directed onto the ferrule end face and adapted with an "air tube" (latter is optional).
  (f) **Flammability:** Cleaner should be sufficiently inflammable to avoid a fire hazard in environment of intended application.
  (g) **Environmentally Friendly:** Cleaners should not present an unacceptable health hazard or environmental risk.
  (h) **Shelf life:** The cleaner should be sufficiently chemical stable using typical storage practices to provide an acceptable shelf life. This includes absorption and evaporation to an ineffective form.
  (i) **Material Control:** Special grades of common materials require tighter controls to avoid grade confusion and substitution. Field tests, to confirm quality of material, may be required, especially if material is a special grade of a common material or evaporates to an ineffective state.

4. NAVAIR fiber optic cable harness/connectors cleaning approach.

  a. Cleaning approach is Platform specific.
  b. Equipment requirements, if any, and consumable supplies are to be defined by each Platform.
  c. Commonality will identify the following items.
    (1) Standardize on type of consumable supplies (swabs, wipes/cloths, etc.).
    (2) Standardize on cleaning procedures/techniques within each approach.
    (3) Standardize on requirements for a cleaning machine.

5. Navy Shipboard, fiber optic connectors cleaning approach.

  a. Cleaning approaches provided as guidance to augment steps for cleaning and inspection currently specified in MIL-STD-2042.

DOC: Cleaningltr0306.doc

Guidance Document
Guidelines and Procedure for Fiber Optic End Face Cleaning

1. Guidelines for the rudimentary cleaning approach.
Note: For termini contained within inserts inside a multiple termini connector (such as MIL-DTL-38999 or MIL-PRF-28876), then use the Multiple Step approach listed in paragraph 2.

   a. Blow particles free with compressed air.
   (1) Method for exposed ferrules. Blow across (parallel) to the ferrule end face. Hold the air tube from the can of compressed air a sufficient distance (at least four inches) away from the end face, and in a slightly upper direction. This orientation is done so that the propellant does not come into contact with the end face.
   (2) Method for adapter alignment sleeves, connector ports and socket termini. Blow in direction (perpendicular) to the ferrule end face. Hold the air tube from the can of compressed air a sufficient distance (at least four inches) away from the end face, and in a slight angle (not directly perpendicular). This orientation is done to minimize the propellant contact with the end face.

   b. Dry clean with wipe/cloth.
   (1) Material. Use a "lint free" paper or a pure cotton cloth. Otherwise, more dry-particles/lint may be deposited than are removed.
   (2) Method. Wipe in a gentle motion so as not to damage fiber or cut into the wipe/cloth. Use different area of the wipe for each pass of the ferrule.
   Note: Use the multiple wipe technique to minimize oil from hands being absorbed on single wipe and transferring to ferrule surface.
   (a) Technique using multiple wipes/cloths.
   1 Stack together at least four wipes/cloths.
   2 Move ferrule across wipe/cloth in a straight line, not repeating this movement on the same area of the wipe/cloth.
   3 Once cleaning is done over the surface of the top wipe/cloth, remove and discard top cloth.
   4 Once finished cleaning for the day, remove and discard bottom wipe/cloth before placing remainder of wipes/cloths back into the package.

2. Recommended procedure for multiple step approach (inspect, swab/wipe & inspect).

   a. Inspect ferrule end face.
   (1) If it is clean, leave it alone and move onto next ferrule.
   (2) If particles and/or liquid (including oil & grease) are observed, clean with a dry swab/wipe.
   b. Inspect ferrule end face.
   (1) If it is clean, leave it alone and move onto next ferrule.
   (2) If particles and/or liquid is observed:
   (a) Clean with a wet swab/wipe (i.e., one moistened with isopropyl alcohol).
   Note: Slightly moisten with isopropyl alcohol so as to dissolve liquid, but not leave excess on ferrule end face.
   (b) Clean with a dry swab/wipe
   Note: The cleaning with the dry swab is to ensure all liquid is removed from the ferrule end face. If needed, further cleaning is to remove any residual particles that were not removed during this dry swab/wipe step.
   c. Inspect ferrule end face.
   (1) If it is clean, leave it alone and move onto next ferrule.
   (2) If particles and/or liquid are observed, clean with a dry swab/wipe.

Enclosure (2)

d. Repeat step c until end face is acceptable.

3. Techniques for using swabs and wipes/cloths.

a. Swab techniques.
   (1) Alignment sleeves separated from connector.
   Technique: Completely push the swab through the alignment sleeve and out the other side.
   Note: Avoid pulling swab back through alignment sleeve in the opposite direction.
   Note: This technique includes alignment sleeves in single terminus adapters (such as ST-to-ST adapters) and those for socket termini.
   (2) Exposed ferrules.
   Technique: A straight-line movement of the swab across the ferrule end face.
   Alternate technique: Press tip of swab against the ferrule end face a couple of times.
   Note: For hard to remove particles, a 90° twist of the swab may sometimes be required.
   (3) Socket termini and connection ports.
   Technique: Insert and rotate the swab 360° down the alignment sleeve. Once contact is made with the ferrule, press, straight down, against the ferrule a couple of times (lifting swab slightly off the ferrule after each press). Lift swab off the ferrule and remove in a straight outward movement.
   Note: For hard to remove particles, a 90° twist of the swab may sometimes be required.
   Note: Depending upon swab tip geometry and material (foam versus cloth), the swab may need to be rotated 360° while rotating 360° around the alignment sleeve to clean the ferrule.
   Alternate technique: Insert and push straight down until contact is made with the ferrule. Rotate the swab for three revolutions (3 x 360°), then pull out straight.

b. Wipe technique.
   (1) Exposed ferrules.
   Technique: Wipe in a gentle motion so as not to damage fiber or cut into the wipe/cloth. Use different area of the wipe for each pass of the ferrule.
   Note: Use of multiple wipes in a stack, as addressed in 1b(2)(a), is recommended.

c. Use of wet (alcohol moistened) swabs and wipes/cloths. Moisten, but do not saturate, the swab tip or wipe/cloth with alcohol.

d. Life of swab (single versus multiple use).
   (1) Industry practice. Use one swab per contact with the ferrule, then discard. This practice will ensure maximum particle removal capable of being done with a swab. The result minimizes degradation of the optical loss as well as the potential cumulative damage of the fiber end face.
   (2) Economy practice. Use the same swab until retention of particles on the ferrule is observed during inspection after the last cleaning.