Application Notes

Sterlite Tech

CLEANING OVERVIEW

Author
John Peter & Timo Perttunen

Issued
June 2014

Abstract

This document presents Sterlite Technologies' view of fiber optic cleaning products and procedures for fibers, cables, and optical connectors that effectively remove the most difficult soils and products that can make the fiber cleaning job safe to perform.This subject has taken on increased importance as a result of studies conducted by end users that repeatedly show that over 75% of all fiber optic trouble shooting problems are solved by cleaning the connectors in the optical network.In Sterlite's view, issues discussed herein should be met in order to provide for satisfactory operation of an optical telecommunications physical plant.

Keywords

Connector, Ferrule, IPA, HFE, HFC, Fiber scope, Wiper, Cassette, Gas duster, Solvent, Dispenser

General

This document presents Sterlite Technologies' view of fiber optic cleaning products and procedures for fibers, cables, and optical connectors that effectively remove the most difficult soils and products that can make the fiber cleaning job safe to perform. This subject has taken on increased importance as a result of studies conducted by end users that repeatedly show that over 75% of all fiber optic trouble shooting problems are solved by cleaning the connectors in the optical network. In Sterlite's view, issues discussed herein should be met in order to provide for satisfactory operation of an optical telecommunications physical plant.

This document is an effort to present the fundamental issues that affect the effectiveness of fiber cleaning products and methods.Users of this document may select the products and procedures that are appropriate for their particular application.Comments are made in an impartial and scientific manner based on contemporary experience and long-term field trials. The procedures and products are intended to be used under typical telecommunications operational conditions.

As new products emerge, the information in this report may change. Sterlite will continue to examine products and procedures to meet current and future telecommunications needs of its end users.In addition, Sterlite supports worldwide standards activities, such as those in the Telecommunications Industry Association (TIA),International Electro-technical Commission (IEC), and International Telecommunications Union (ITU, formerly CCITT).

Overview

As demands on fiber networks for faster and greater communications traffic volume increase, the need for high performance network components also increases. Individual devices must deliver low insertion loss, low reflectance, less polarization dependence, and be less costly to install and use. Optimum optical performance often requires near pristine cleanliness and good physical contact between the mating optical fibers. In order to achieve this level of performance by the fiber infrastructure, all connector interfaces must be thoroughly cleaned and dried using the most effective materials and procedures available. Experience has shown that most optical system physical plant problems other than with the end equipment can be repaired by thoroughly cleaning all optical connectors.

A large variety of fiber cleaning products and procedures are available. This document discusses issues regarding the ability of such products to clean connectors which have been exposed to various soils such as dust, grease, and mineral deposits that contaminate their ferrule ends.

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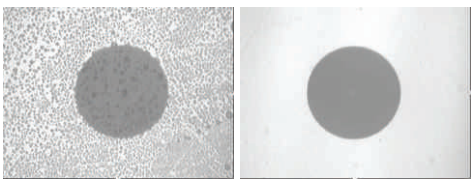

Figure 1 – View of Connector Ferrule End-Face After Exposure to 99.9% Pure Isopropyl Alcohol (IPA) and Then Air Dried, Right View is After Cleaning

For a product and procedure to be accepted, it must be safe and easy to use, effective, safe for the environment, and reasonably priced. It is also important that repeated use of such cleaning products not damage the connector, its user, or the environment
One of the major suppliers of fiber cleaning products tells its clients, "… more (is) usually thought of as being better, but this is not always correct in the fiber cleaning business". In the science of cleaning fiber, less is better in regard to efficiency of the cleaning technique but also for environmental, health and safety matters.

A useful tool in the fiber cleaning process is the fiber scope. It has a video probe with exchangeable tips that fit an optical connector ferrule or the alignment housing of the connector adapter. The fiber scope generates an electronic image of the magnified end-face of the optical connector (ferrule and glass fiber). These fiber scope images can be stored in various popular graphic formats for later use or further analysis by software. The file provides a clear magnified view of the conditions at the end face of the connector ferrule and glass fiber (see). This device is becoming more common as a field tool to evaluate optical connections.

Figure 2 – Example of a Fiber Scope to Examine Fiber Connector Plug End-Faces

The fiber scope's indirect view of the fiber connection is a guaranteed safe view of the fiber end-face and will protect the visual health of the technicians that use it.

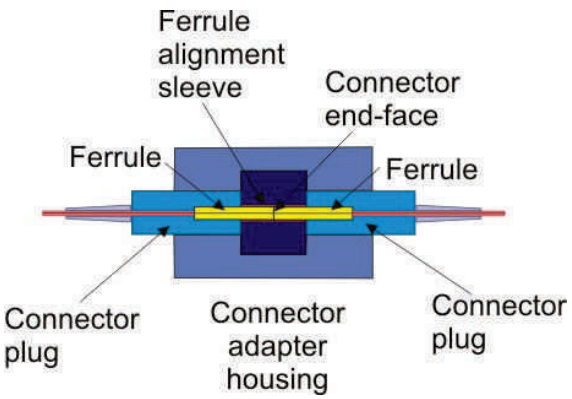

Figure 3- Typical Optical Fiber Connection

Terminology
The following are some of the typical cleaning tools and materials available to the communications technician:

Wet/Pre-Saturated Wiper is a cloth which may or may not be individually wrapped and is pre-saturated with a cleaning solvent that may or may not contain isopropyl alcohol(IPA). If the wiper contains IPA, the wiper should be minimally 94% IPA with no other components other than 6%water.

Figure 4 – Two Examples of Pre-Saturated Wipers Kept Sealed Before Use to Avoid Hygroscopic Absorption of Water

A Dry Wiper is a lint free, non-100% cellulosic wiper designed to be used either dry or with a cleaning solvent. Dry wipers or dry tools have limited ability to absorb dusty contaminants. They can generate a static field that can attract dusty soils such as those present in central offices (COs) as well as the OSP.

Over saturation of an optical connector with a wet wiper or direct spray can flood the ferrule's end face and deposit cleaning solvent and soils on the sides of the ferrule.

Figure 5 – An Example of the Large Variety of Available Dry Wipers

Dry Cleaning Tools include various cassettes or ratchet style tools that contain dry wiper material used to clean the fiber end face, connectors and adapters plus swab mounted wipers to reach deep into optical devices.

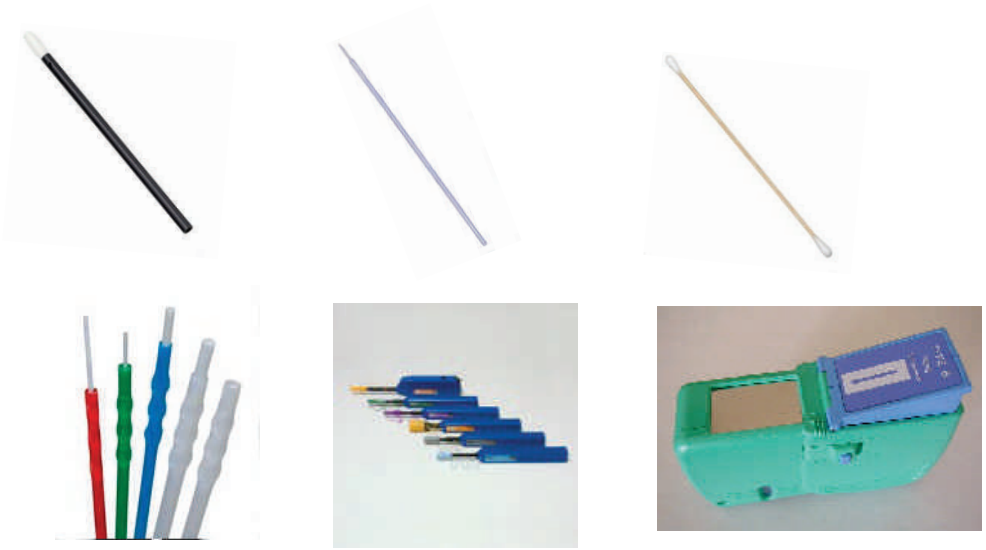

Figure 6 – Examples of Dry Wipe Tools: Top Row Dry Swabs; Bottom Row Assortment of Swabs, Assortment of Adapter Housing Cleaning Tools, Cleaning Cassette

Compressed Gas Dusters use aerosol propellants to remove moisture and large particle contaminants. Some duster propellants are non-flammable such as 134a and safe to use in any environment. Other propellants such as 152a and DME have varying degrees of flammability and should be used with caution. Avoid using volatile flammable solvents near any possible ignition source or enclosed space. Some propellants may be incompatible with some plastics.

Figure 7 – An Example of the Large Variety of Available Gas Dusters

Compressed gas dusters are effective at removing large visible dust. Smaller particles have an electrostatic or surface bond to the ferrule end face and their attraction becomes stronger despite theirsmall size.Often compressed gas dusters are less effective at removing these smaller particles.
High velocity compressed gas dusters are effective removing moisture in a storm-damage or water damaged situation or for large particle contaminants. Most gas dusters should be used in the vertical position

Solvents

While a connector's end face may appear to be clean, excess solvent can hide on the side of the ferrule and over time, excess solvent or moisture and soils are drawn into IPA and eventually cloud the

connector end face. If IPA is used as a solvent, it will attract moisture due to its hygroscopic nature, especially if it is stored in a container that exposes it to ambient air or if it has been stored for a long period of time. What started as high-purity IPA can be converted to a much less pure mixture of absorbed water because of the hygroscopic nature of IPA. IPA is an effective solvent that can be used to clean fibers, but should be used properly, considering its hygroscopic propensity. See Figure 1 for the extent of hygroscopic contamination of 99.9% IPA if it is allowed to air dry on a ferrule end-face before drying and wiping clean.
Solvents such as IPA, precision hydrocarbons, hydrofluoroethers, and hydrofluorocarbons aid in soil removal by:

- breaking the bond between the soil and its substrate,
- dissolving the soil
- Creating an affinity in a soil for a wiper.

Figure 8 – An Example of the Large Variety of Available Solvents and Dispensers

A wide variety of cleaning solvents are available in an assortment of chemical blends to impart specific properties such as :

- effectiveness in removing specific soils
- cost
- availability
- flammability
- environmental impact
- drying rate
- Material compatibility.

For a solvent to be selected, it must be easy to use, effective, safe for technicians to use, safe for the environment, and reasonably priced. It is also important that repeated use of the solvent not damage to the connector, its user, or the environment.
The Material Safety Data Sheet (MSDS) is available for each of the solvents used for fiber cleaners.The MSDS contains pertinent information on each solvent relating to how it should be safely used, how to treat or deal with accidental ingestion or over exposure to the solvent, and any other safety issue that relates to the use of the material.

Wipers

The size of the wiping surface should be considered as should the surface on which the wiper is placed. Experience has shown that the larger the wiping surface the more effective the cleaning is likely to be.

Figure 9- Common Wipers Used to Clean Optical Fibers

The size of the wiping surface should be large enough that the cleaning action not only works on PC and UPC end face connectors, but also provides sufficient space to clean APC and MT connectors.

Cleaning Methodology

Always examine a connection before and after cleaning with a video fiber scope. If possible disassemble the entire connector assembly and clean each plug and its adapter housing separately. If this is not possible, there are several innovative tools to clean the inside bore of a connector adapter and the fiber-end of the back-plane connector while it is plugged in to its adapter. These tools basically are automated versions of the manual procedure described in Section 1.2. As is the case with wet and dry wipes and precision-swab tools, care must be exercised when using these techniques. A technical challenge for precision swab is the small cleaning surface on which they are used. An effective cleaning technique moves soils away from the fiber end-face.

Do not clean a connector fiber plug end-face using a wiper supported over a finger or palm of the hand. It is possible to contaminate a wet or dry wiper if cleaning is attempted using a finger or palm to back up the wiper. It is recommended to always examine a connector's end-face condition with a video fiber scope (see Figure 10) both before and after cleaning.

Figure 10 – Fiber Connector End-Face Inspection Tool

A hard surface such as a work bench used as a backing surface for a wiper during cleaning can entrap sand or soil between the fiber end-face and wiper that could damage the fiber end.

Cleaning should be accomplished using a non-paper wiper backed up by a compliant surface. Such a surface can be emulated by stacking 4-5 non-paper wipers as the cleaning surface. Minimally moisten a dry wiping tool or dry wiper. Using the wetted tool or wetted wiper, lightly scrub the fiber ferrule end-face. Dry the fiber end-face by wiping on the stack of dry wipers or a dry tip on the tool.

Solvent selection is critical to the ultimate effectiveness of the cleaning procedure to remove soils. Their chemical formulations range significantly causing a wide variation in their performance, characteristics, costs, and EH&S impact. Common cleaning solvents, as of this time, include:

- high purity IPA >99%,
- hydrofluoroethers (HFE), fiber optic precision hydrocarbons,
- hydrofluocarbons (HFC), fiber optic grade precision hydrocarbons,
- precision Hydrocarbon fiber optic cleaners, and
- aqueous fiber optic cleane rs specifically formulated for the application.

A solvent should be effective on both ionic (polar) and non-ionic (non-polar) soils. In addition to water, ionic (polar) molecules include alcohols and sugars. Non-ionic (non-polar) molecules are more like oil or silicone.

Examples of ionic and non-ionic soils:

- Ionic soils: finger print, dried water, and moisture from an excess solvent such as IPA.
- Non-ionic soils: buffer gel, dust, and lubricants; static contamination from “dust caps”; moisture from excess solvent that has dust or oily residue

The end-user of any of these solvents is urged to investigate each of the chemical families.

1.1 Cleaning Fiber Connector Plug or Near-End Front Plane Connectors

There are basically three procedures to clean to clean an optical connector :

- **Dry wiping:** Using either a dry wiper or cleaning tool to clean the ferrule end-face

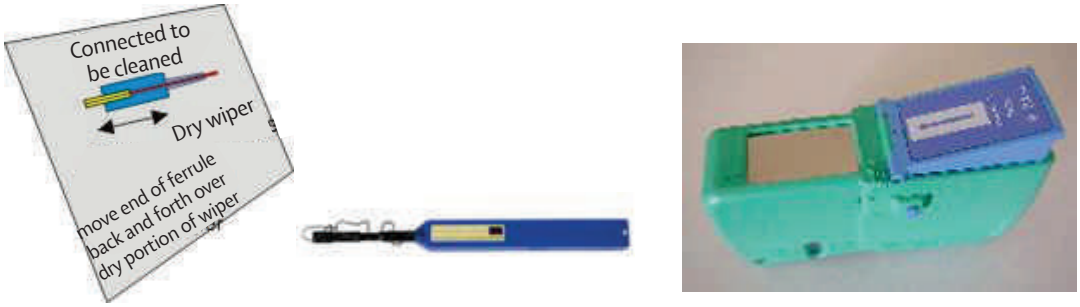

Figure 11 – Dry Wipe Process Illustration (Using Dry Wipe, Tool, or Cassette)

When atoms of different electro-negativities form a bond, the electrons in the resulting molecule are controlled by the atom with the higher electro-negativity and result in a dipole bond. An ionic molecule (polar molecule} is aligned such that one end is positively changed and the other is negatively charged. Not all molecules with ionic bonds are polar molecules. A polar molecule, requires that the entire molecule to be a dipole. An asymmetrically organized molecule such as water has the hydrogen and oxygen on opposite ends and tends to have a positive and a negative side. Symmetrically arranged molecules are arranged such that its atoms are more uniformly spaced such as carbon dioxide. In the Non-ionic molecule (Non-Polar), electrons tend to be evenly controlled by both atoms with a covalent bond. The resulting molecule is evenly charged on all sides.

- **Wet wiping:** Using a wet wiper (or wetted tool) to saturate the fiber end-face with a cleaning

solvent and then drying the saturated surface with either a compressed gas duster, a dry wiper, or dry tool end.

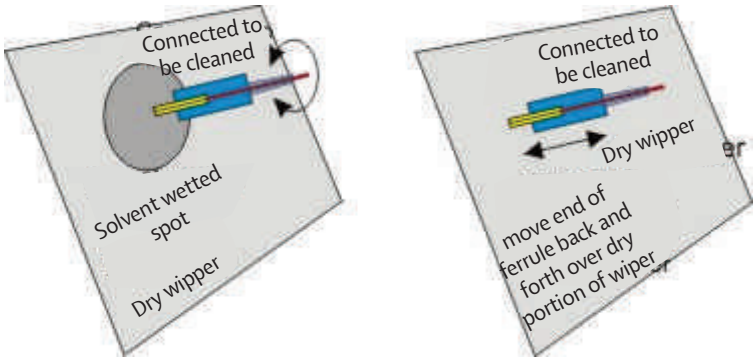

Figure 12 – Wet Wipe Process Illustration

. **Combination** process: Using a small spot of solvent applied to the wiping material to scrub the connector end-face in the wetted wiper spot. Dry and wipe the scrubbed connector end-face with the dry portion of the wiper.

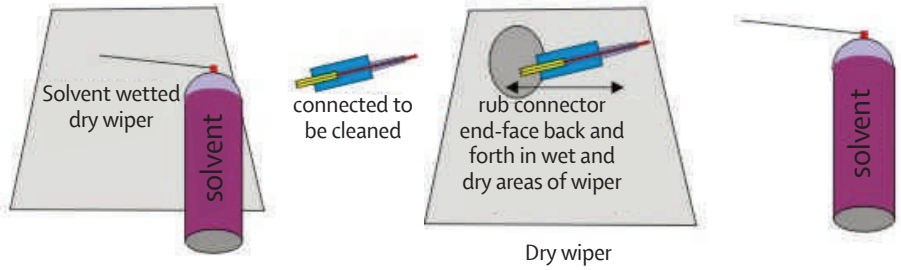

Figure 13 – Combination Dry/Wet Clean Procedure Illustration

It is important to note that "dry cleaning" procedures often move soils around and can create an electro-static field that attracts more dust contaminants to the ferrule."Wet cleaning" can cause excess solvent to migrate to the sides of the ferrule and as a result is more difficult to remove. The table below provides an over view summary of the three cleaning procedures

Table 1 - Comparison of Three Common Methods to Clean Optical Connector Plug

	Method	Advantages	Disdvantages
Dry	· Cleaning cassette or non-paper lint-free wiper. · Cleaning swab for backplane connections	· Most effective on ionic soils such as fingerprint. · Easy to use.	· Transfers dusty soils. · Not always effective on non-ionic soils (gels, lubricants or combination soils). · Can create an electrostatic field that attracts dust contaminants. · Cleaning small surfaces can be difficult for APC/ MT connectors.

Wet	· Any solvent can be used, IPA recommended. 1. Pre-saturated wipers.	· Releases ionic, non-ionic, and combinations of contaminants. · Reduce electro-static fields. · Easy to use.	· Excessive solvent can be trapped in the side of the ferrule making drying surprisingly difficult. · Excessive solvent not seen in normal video inspection may 'reside' on side of ferrule and move to end face a future time.(flooding) · Higher expense of some solvents.
Compound	· Uses expendables more efficiently.	· Ionic, non-ionic, and combinations of soil contaminants. · Reduce electro-static fields. · Easy to use. · Dries end-face as integrated part of cleaning. · Least cost per application.	· Requires two interactive products. · Selection of solvent may require careful consideration of Environmental, · Health and Safety issues.

The following steps are recommended for cleaning an optical connector plug:

1. Remove the front plane optical connector.
2. If possible, disassemble both connector plugs from their housing.
3. Examine both fiber-ends of the two mating optical connectors with a fiber scope.
4. Blow out the ferrule alignment tube in the adapter housing with a gas duster.
5. Wet the tip of a ferrule swab with an all-purpose solvent. Note: it is better to under-use solvent than to over-use the solvent.
6. Dry the solvent from the inside wall of the ferrule alignment tube with a dry ferrule swab sized to scrub the inside diameter of the ferrule alignment tube.
7. Clean each connector plug end-face using the following recommended procedure.
8. Blow off each ferrule end-face with a gas duster.
9. Wet a wiper swab sized to fit in the space between the ferrule and the plug housing. This is intended to wipe the side walls of the ferrule barrel.
10. Wipe the ferrule barrel with the wetted swab using a circular motion. Note: it is better to under-use solvent than to over-use the solvent.
11. Re-wipe the ferrule barrel with a dry version of the wiper swab used above.
12. Wet a small spot on a dry wiper with an all-purpose solvent. Note: it is better to under-use solvent than to over-use the solvent.
13. Lightly rub the end-face of the ferrule on the wet spot on the wiper.
14. Dry the solvent from the end-face of the ferrule with a dry wiper (or a dry portion of the solvent wetted wiper).

15. Repeat steps 4 through 14 on the mating connector plug (if the connector can be disassembled, otherwise follow the steps outline in Section 1.2).

16. Check the cleanliness of both connector plugs with an after examination of their end-faces using a fiber scope.

17. If the two connector end-faces are clean, assemble the connection and move on to the next connection.

1.2 Cleaning Back Plane Connector Plug, if Connector Can't be Disassembled

Thus, disassembly and cleaning both sides, when practical, is recommended. Always examine a connection before and after cleaning with a video fiber scope. When this is not practical follow the steps described in this Section. This procedure assures that a wide variety of contaminants are removed, the static field is reduced, and an area beyond the contact patch is better cleaned.

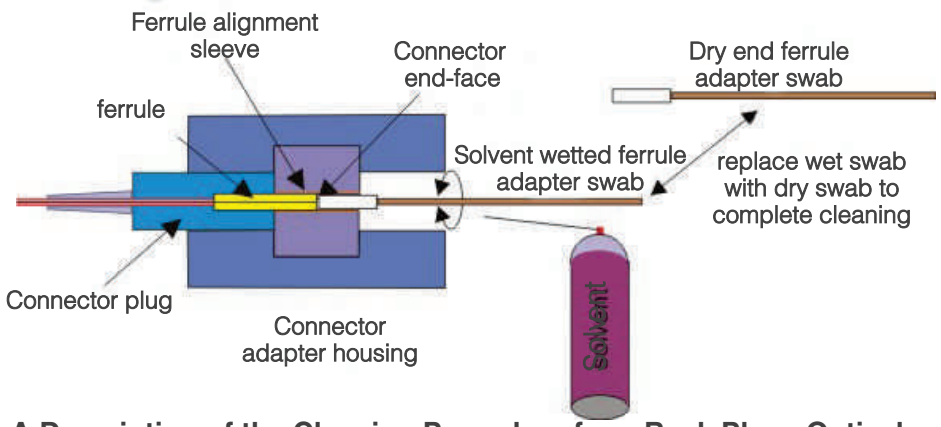

Figure 14 – A Description of the Cleaning Procedure for a Back Plane Optical Connector.

The following steps are recommended for cleaning the back plane optical connector if the connector assembly cannot be disassembled:

- Remove the front plane optical connector.
- Examine both fiber-ends of the two mating optical connectors with a fiber scope.
- Clean the front plane optical connector plug following the steps in Section 1.1.
- Blow out the ferrule alignment tube in the adapter housing with a gas duster.
- Wet the tip of a ferule swab with an all-purpose solvent. Note: it is better to under-use solvent than to over-use the solvent.
- Dry the solvent from the inside wall of the ferrule alignment tube with a dry ferrule swab sized to scrub the inside diameter of the ferrule alignment tube.
- Wipe the back plane ferrule end-face with a smaller sized swab.
- Check the cleanliness of both connector plugs with an after examination of their end-faces using a fiber scope.
- If the two connector end-faces are clean, assemble the connection and move on to the next connection.

Subtleties of End-Face Cleaning

The actual cleaning motion used on the ferrule end-face is an important and essential consideration. There are three basic cleaning motions used to clean connectors:

- the Figure-8,
- twist and draw,
- straight line motion.

of the three motions, the third action is recommended. It uses a “light drawing motion” that never re-traces itself. The ferrule end-face is always passed over a pristine surface of the cleaning medium.

Recently there have been various devices and tools designed to clean ferrule end-faces. Various sizes of cleaning tools are available. Having a large cleaning surface makes for more effective cleaning on all connections but especially the APC and MT type connections where the larger surface better enables a technician to find the angle of the fiber end. If a cleaning tool is used, its cleaning medium should be inspected on a regular basis. A large cleaning surface makes APC cleaning easier.A convenient time for this inspection is when the cleaning medium in the tool is replaced. The cleaning surface of the tool should be compliant to conform to the ferrule end-face.

Static Electricity: Creating Charge

Static electricity is an electrical charge caused by an imbalance of electrons on the surface of a material. This electric field can be measured and it can influence other objects. Electrostatic discharge (ESD) is the transfer of charge between bodies at different electrical potentials. ESD may degrade or destroy the electrical characteristics of a semiconductor device. It also may upset the normal operation of a communications system, causing equipment malfunction or failure.

ESD can be generated during the cleaning of a fiber ferrule. When this occurs, the ferrule will draw ionized particles to it, recontaminating the ferrule end-face that was once clean. Often connector dust caps, even new ones, are contaminated with dust or dry soils. This soil can be drawn to the ferrule end-face once the dust cap has been placed over the connector. A study of connector end-faces has shown that 20% of new capped connector end faces were contaminated within one week of being capped. As a result, all connectors, even those that have been capped when not in use, need to be cleaned before use. Studies have shown that the use of an approved fiber cleaning solvent or deionized, dry gas duster tends to mitigate this situation.

Additional information

If there are additional questions on this topic or other fiber optic issues, please contact Sterlite Technologies at:

Contact Information

telecom.sales@sterlite.com
www.sterlitetechnologies.com