FLUKE networks

White Paper

Despite industry best practice of inspecting and cleaning fiber optic end-faces, contaminated connections remain the number one cause of fiber related problems and test failures in data centers, campus and other enterprise or telecom networking environments.

STANDARD-COMPLIANT CERTIFICATION & BEST PRACTICES

As the industry moves to higher data speeds, more stringent loss budgets and new multifiber connectors, proactively inspecting and cleaning fiber end-faces is more important than ever to ensure network uptime, performance and equipment reliability.

Even when users think they have properly cleaned the fiber, every connector end-face-either field terminated or factor terminated-should always be inspected before connecting to a component or piece of equipment. However, relying on subjective human inspection of fiber end-faces often produces inconsistent results.

Thankfully, International Electrotechnical Commission (IEC) industry standards and new innovations enable automatic, consistent and repeatable certification of fiber cleanliness based on specific acceptance criteria.

Cleaning for Performance

Every fiber installation relies on proper end-face cleaning practices for good reason. Network performance is only as good as the weakest link, and the weakest link is wherever a fiber end-face is exposed—whether at a patch panel, equipment port or at the end of a patch cord or jumper.

Regardless of the type of fiber, application or data rate, the transmission of light requires a clear pathway along a link, including through any passive connections or splices along the way. A single particle on the core of a fiber can cause loss and reflections, resulting in high error rates and degraded network performance. Contamination on a fiber end-face as shown in Figure 1 can also adversely impact the interface of expensive optical equipment, and in some cases even render equipment inoperative.

With fiber networks at the core of a business's most important asset - the data center - and with the need to keep up with consumer demand for high-speed access to information anywhere and anytime, downtime and poor network performance are simply no longer an option. As network applications require more bandwidth and transmission speeds continue to climb from 1 and 10 gigabits per second (Gbps) to 40 and 100 Gbps, loss budgets have become tighter than ever. Dirt, dust and other contaminants are the enemies of these higher-speed data transmission rates over fiber networks. It is therefore critical that all optical connections be kept free of contaminations to avoid application performance issues.

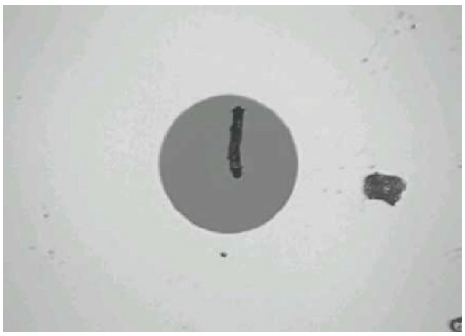

Figure 1: Dirty fiber end-faces as shown here can degrade network performance or damage equipment

With contamination being the single greatest cause of fiber failures, spending the extra few seconds to properly inspect and clean every connector end-face will save time and money in the long run.

While accidently touching a fiber end-face and working in dirty, dusty construction environments are known causes of contamination, there are plenty of other ways to mishandle fiber that may not be obvious sources of contamination. Brushing an end-face on clothing that can contain body oils, lint or other substances can cause contamination. In fact, any time an end-face is exposed to the surrounding environment, it is subject to contamination - even if it was recently cleaned. Dust in the air can easily collect on a fiber end-face, especially in the presence of static electricity.

Contamination also easily migrates from one port to another every time a connector end-face is mated. Even a dust cover designed to protect the fiber end-face can be a significant source of contamination. Unfortunately, many users are under the impression that if the endface was previously protected by a dust cover, it must be clean. However, no one can really know for sure what was in that dust cover. This is even the case for end-faces on new factory-terminated connectors. While dust caps are great at preventing damage to the end-face, the plastic used to create dust caps can emit a residue as it deteriorates over time and the surface of the cap may contain mold-release substances used in high-speed production processes. Therefore you should not be surprised to find a contaminated end-face upon removal of a protective cap on a connector fresh out of the bag.

Many also believe that an end-face plugged into a piece of equipment, must be clean and can therefore be unplugged and remated without concern. However, this too can cause contaminants to pass from one end-face to another. Even if the initial contamination was outside of the fiber core, mating can break up a contaminant and cause particles to travel across the end-face and redeposit on the core. The same holds true for equipment ports, which are often overlooked as being a source of contamination.

Inspecting for Assurance

It is not enough to just clean every fiber end-face. Users have no way of knowing if the end-face is clean unless they inspect it using a fiber inspection tool designed specifically for that purpose, such as a professional video microscope or a handheld fiber microscope. That is why the golden rule is to always inspect, clean and inspect again before connecting.

In fact, the very act of cleaning the end-face can cause contamination. Every end-face should be inspected after every cleaning attempt.

This is especially a concern for multi-fiber connectors such as the multi-fiber push-on (MPO) style connectors that are rapidly becoming the norm in today's data center fiber backbone channels as the required interface for 40 and 100 gigabit Ethernet (GbE) applications *(see Figure 2)*.

Consider a 12-fiber MPO interface with an array that features a much larger surface area than a single fiber connector. When cleaning these larger surface areas, it is much easier to move contaminants from one fiber to another within the same array. And the larger the array, the higher the risk. With 24-, 48- and 72-fiber MPOs used in high-density fiber interconnects, the greater number of fibers are more difficult to control and not all the fibers always protrude at the same height. Height variances across the fibers in a single multifiber connector can increase the risk of not every fiber being properly and equally cleaned.

Grading and Certification via Standards

One of industry's longtime concerns with manually inspecting fiber end-faces for cleanliness has been that determining cleanliness has largely been a subjective and inconsistent process. What one person deems as clean can vary greatly from another person's point of view. Additional variables such as skill level, years of experience, eyesight, ambient lighting and the fiber inspection tool being used can also lead to inconsistencies in determining fiber end-face cleanliness. With more fiber networks being installed and maintained by a greater number of individuals, there is also a greater chance of inexperience regarding what constitutes end-face cleanliness.

Figure 2: MPO connectors required for 40 and 100 GbE applications should always be inspected as it can be difficult to ensure that all fibers in the array were properly cleaned.

In an effort to establish consistency in fiber inspection and achieve more repeatable results for performance across multiple end-faces, the IEC developed 61300-3-35 Basic Test and Measurement Procedures Standard for Fiber Optic Interconnecting Devices and Passive Components. This standard contains specific cleanliness grading criteria to assess pass or fail certification for inspection of a fiber end-face, removing the human subjectivity factor.

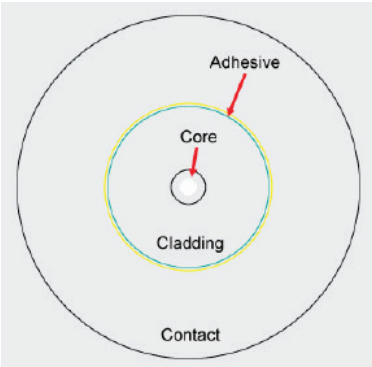

Figure 3: IEC 61300-3-35 grades fiber cleanliness based on the quality and size of scratches and defects in each region of the endface.

The certification criteria in IEC 61300-3-35 varies based on connector type and fiber size, as well as types of defect. Defects include pits, chips, scratches, cracks, particles and embedded and loose debris, and the IEC standard categorizes them into two groups - scratches and defects. Scratches are identified as permanent liner surface features while defects include all detectable non-linear features that can typically be cleaned. Certification to determine pass or fail is based on the number of scratches and defects found in each measurement region of the fiber end-face, including the core, cladding, adhesive layer and contact zones, as well as the quantity and size of the scratches and defects *(see Figure 3)*.

For example, as shown in Table 1, multimode fiber with polished connectors can have no scratches greater than 3 µm in width or defects greater than 5 µm in width. Within the cladding zone, there can be no scratches or defects greater than 5 µm in width, 5 defects ranging between 2 and 5 µm in width and no limit on the number of defects less than 2 µm in width. The number and size of scratches and defects allowed in each zone varies based on the connector type and diameter.

Zone	IEC 61300-3-35 Recommended Acceptance Criteria Multimode Polished Connectors	
	Scratches	Defects
Core	No limit ≤ 3 µm None > 3 µm	4 ≤ 5 µm None > 5 µmm
Cladding	No limit ≤ 5 µm None > 5 µm	No limit < 2 µm 5 from 2 µm to 5 µm
Adhesive	No limit	No limit
Contact	No limit	None ≥ 10 µm

While the IEC 61300-3-35 standard can be used as a guideline for manually grading cleanliness, a manual procedure would require technicians to determine the size and location of the scratches and defects, which can still introduce human error and inconsistency.

Thankfully automated certification solutions like Fluke Networks' FI-7000 FiberInspector Pro use algorithmic processes to automatically and quickly inspect, grade and certify fiber end-faces based on the criteria of the IEC standard.

These types of devices eliminate human subjectivity and result in faster, more accurate and repeatable results to help ensure optimum fiber network performance (see sidebar).

Knowing What to Inspect and Clean

The best answer to the question of what to inspect and clean is everything—every end-face should be inspected, and every end-face that fails IEC 61300-3-35 certification should be cleaned *(see Figure 4)*. If upon inspection, the end-face passes IEC certification, do not clean it. Cleaning can attract dust due to static electricity.

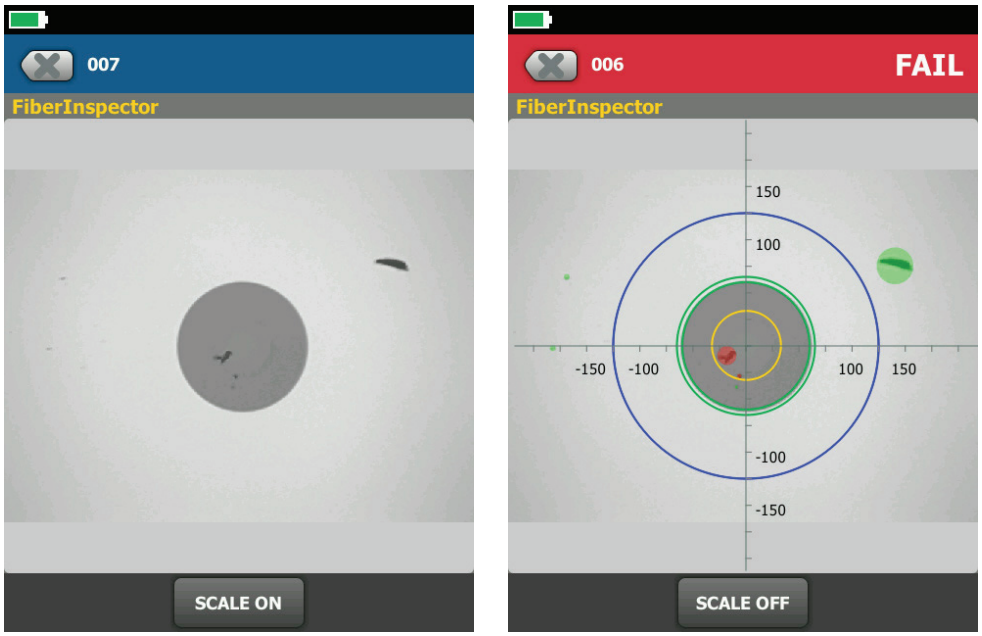

Figure 4: Is the end-face shown on the left clean or dirty? Automated certification demonstrates that it is dirty per IEC 61300-3-35 due to defects in the core.

Any and all end-faces, even brand new ones and factory-terminated plugs and pigtails, should be inspected for cleanliness before mating. That includes both ends of fiber optic test cords, fiber jumpers and pre-terminated trunk cables.

If using an adapter to mate two plugs, the end-faces on both sides and the sleeve of the adapter itself should be inspected and cleaned before inserting them into the adapter. Interchangeable adapters used with optical power meters also need to be inspected and cleaned on a regular basis. Often the adapter has a light shield with pin hole that can accumulate debris. Always consult the documentation that came with the testing equipment as some vendors require sending certain adapters back for factory cleaning.

When testing or troubleshooting any equipment, including the tester itself, all plugs and ports should be inspected and cleaned before mating. That includes test equipment ports, adapters, test cord end-faces and any ports into which you will be connecting the test cord.

As previously mentioned, dust caps and mating can be a source of contamination. Therefore every time a fiber end-face is unplugged or removed from a dust cap or port, even when it is brand new, it should inspected and cleaned as necessary prior to being inserted. Ports should also always be inspected and clean before inserting a connector, even if one was just recently removed.

Understanding Tools and Consumables

When it comes to cleaning fiber end-faces, there are basically two materials required—wipes and solvent. Canned air and dusters are ineffective for cleaning fiber end-faces as they only succeed in blowing particles around, which simply moves the contaminants to another location. Canned air and dusters cannot effectively clean oils, residues, or small, charged dust particles, and dusters often expel a propellant that can simply become a whole new contaminant to remove.

Fabric and composite wipes made of lint-free material provide the absorbency to remove contaminants from the end-face. In general, it is recommended to avoid cleaning against a hard surface. When using a wipe or cassette type cleaner, typically one or two short (i.e., 1cm) strokes on the cleaning material is sufficient. Enough pressure should be applied so that the wipe can conform to the end-face geometry and ensure that the entire end-face has been cleaned.

When wipes are used alone, it is referred to as "dry cleaning," which has been proven to be only partially effective in eliminating contaminants. Dry cleaning can also leave a static charge on the end-face that can actually attract statically charged dust particles after cleaning.

A better method of cleaning is to use solvents in conjunction with wipes. Solvents add a chemical action that increases the cleaning ability of the wipe to lift particles and debris from the end-face while eliminating the issue of static charge with dry cleaning. It is important to avoid using excessive amounts of solvent, which can leave behind a film of dissolved contaminants. To remove excess solvent, wet cleaning should be followed by dry cleaning by either moving to the dry area on the wipe or by following up with new dry wipe. Just be sure to not overdo it to avoid creating static discharge.

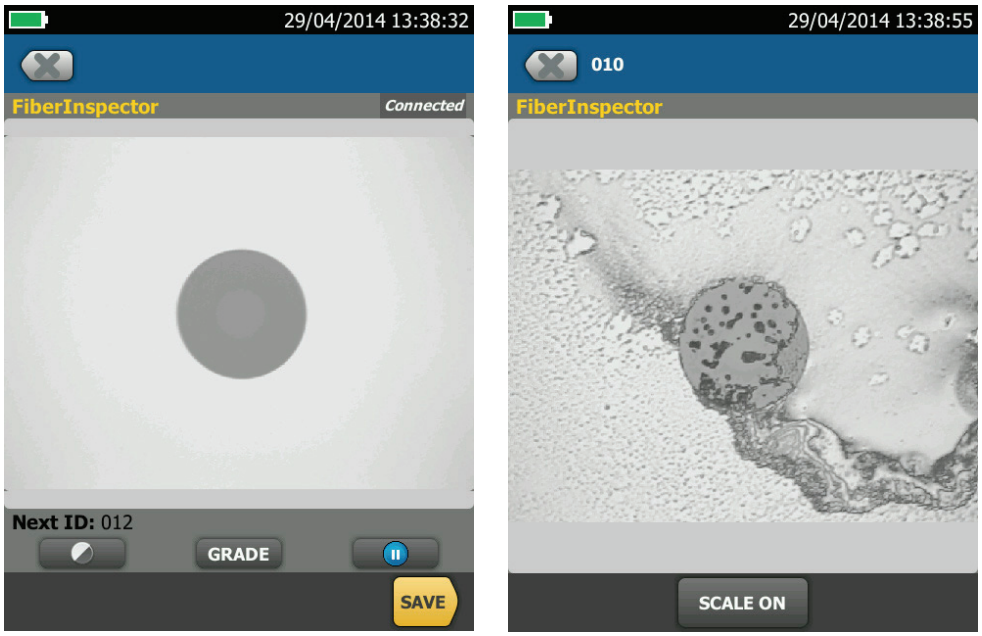

Figure 5: Specialized solvents (left) are far more effective at cleaning end-faces than IPA that can leave behind a residue (right).

The solvent itself should also be specially formulated for fiber end-face cleaning, such as Fluke Networks' Fiber Optic Solvent Pen. While isopropyl alcohol (IPA) was used for many years to clean fiber end-faces, specialized solvents have a lower surface tension that makes them far more effective at enveloping debris for removal and dissolving contaminants *(see Figure 5)*. IPA can also leave behind a "halo" as it dries that not only causes attenuation, but also can be difficult to remove. No solvent should remain on the end-face after cleaning.

To clean fiber end-faces inside ports or equipment, specially designed lint-free swabs or mechanical port cleaning devices like Fluke Networks' IBC Cleaners are used instead of wipes (see sidebar). When using swabs for port cleaning, it is important to apply just enough pressure to clean the end-face while rotating the swab several times in one direction. When using solvents with port cleaning, it is even more important to not use excessive solvent that can saturate the plug interface. The evaporation rate of a solvent becomes significant with port cleaning as it is harder to guarantee removal of all solvent. Lingering solvent can become trapped during mating and cultivate a harmful residue over time. This is another reason to use solvents that are specially formulated for cleaning fiber—these solvents stay around long enough to work but evaporate much faster than IPA.

It is also important to remember that these consumables are just that, meaning that once a wipe or swab is used to clean an end-face, it should be immediately discarded.

Reusing a dirty wipe or swab is one of the easiest ways to spread contamination. While cleaning of jumpers and test reference cord end-faces is important, these components are also consumables that eventually fail-sometimes cleaning is not enough if these components have reached their end of life following the vendor's specified number of insertions.

Summary

If network uptime, signal transmission performance and equipment reliability are important to your business, skimping on inspecting and cleaning fiber optic end-faces can result in dire consequences. And just because you may think you properly cleaned, does not mean you can forego inspection. Not only are best practices for fiber cleaning essential, but every end-face should be carefully inspected and certified per the IEC 61300-3-35 standard prior to making a mated connection-including both end-faces and ports.

By incorporating fiber inspection and certification into your process, you can eliminate human subjectivity and quickly inspect, grade and certify fiber end-faces per the standard. In doing so, there should be no excuse for network failures due to contaminated end-faces.

FI-7000 FiberInspector Pro Automatically Certifies Fiber End-Faces to IEC Standards

Fluke Networks' FI-7000 FiberInspector Pro certifies fiber end-faces to the IEC 61300-3-35 industry standard in just two seconds, providing automated PASS/FAIL results that take the human subjectivity and guesswork out of fiber inspection.

Ideal for inspecting end-faces inside ports or on patch cords, the FI-7000 FiberInspector Pro detects and measures defects found on fiber end-faces and automatically certifies the results based on the IEC 61300-3-35 standard. To provide clear graphical indication of which defects pass or fail the standard's requirements, the FI-7000's pinch-and-zoom touchscreen colors each defect and highlights the defect's background - defects that fail are colored Red while defects that pass are colored Green.

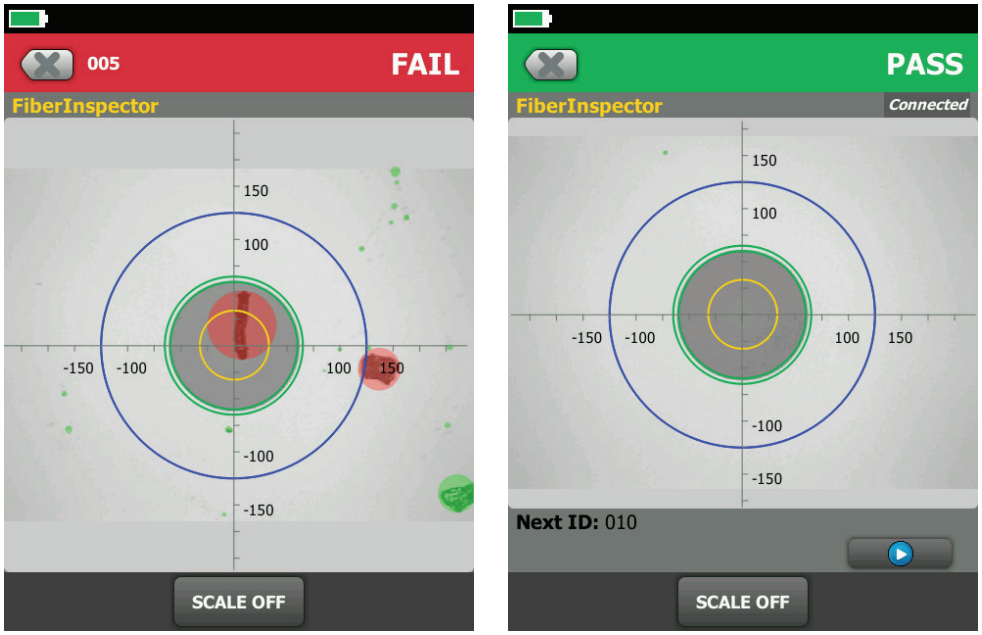

Figure 6: The FI-7000's certification results allow you to quickly determine if the fiber end-face pass or fails. An example of a failing end-face is shown on the left and a passing end-face is shown on the right.

The FI-7000 is built on Fluke Networks' Versiv Cable Certification Platform that enables storing endface images and certification in Versiv test results and taking advantage of Versiv capabilities like ProjX™ for managing job requirements, the Taptive™ user interface for easy set-up and the multifeatured LinkWare Software for managing data and generating professional test reports. The FI-7000's PASS/FAIL fiber end-face certification is available to all Versiv owners by downloading the latest Versiv firmware.

Fluke Networks' Fiber Optic Cleaning Kits Contains the Tools You Need to Effectively Remove the Toughest Contaminants

In keeping with industry best standards for fiber cleaning, Fluke Networks' Fiber Optical Cleaning Kits contain everything you need to eliminate the #1 cause of fiber failures - contamination.

With support for all connector types, the kits include Fluke Networks' Fiber Optic Solvent Pen with specially formulated fiber cleaning solution, convenient cleaning cube/card and easy-to-use IBC Cleaners that use a simple insertion and push motion to remove contaminants from end-faces on cord plugs and within adapters or patch panels.

IBC Cleaners come in three different sizes for cleaning 1,5mm, 2,5mm and MPO style connectors. All cleaning materials are lint-free and enable an optimal wet and dry cleaning process, while the rugged carrying case makes it easy to store and transport all the tools you need for precision end-face fiber optic cable cleaning.

CertiFiber® Pro - Accelerates every step of the fiber certification process

The CertiFiber Pro improves the efficiency of fiber certification with a 3 second, dual wavelength, dual fiber, test time. The Taptive user interface simplifies set-up, eliminates errors and speeds troubleshooting. A set reference wizard ensures correct reference setting and eliminates negative loss errors. Built on the future-ready Versiv platform, CertiFiber Pro provides merged Tier 1 (Basic) / Tier 2 (Extended) testing and reporting when paired with OptiFiber Pro module. A convenient quad module supports both singlemode and multimode and is multimode Encircled Flux compliant. Copper certification and Wi-Fi Analysis and Ethernet troubleshooting modules are also available. Analyze test results and create professional test reports using LinkWare Management Software.

DSX-5000 CableAnalyzer™ - Accelerates every step of the copper certification process

The DSX-5000 CableAnalyzer improves the efficiency of copper certification with unmatched speed for testing Cat 6A and Class FA while meeting darft IEC Level V – the most stringent accuracy requirement. The ProjX Management System helps ensure jobs are done correctly the first time and helps tracks progress from set-up to systems acceptance. Versiv platform supports modules for fiber testing (Both OLTS and OTDR) and Wi-Fi Analysis and Ethernet troubleshooting. The platform is easily upgradeable to support future standards. Troubleshoot faults faster with the Taptive user interface which graphically displays the source of failures including crosstalk, return loss and shield faults. Analyze test results and create professional test reports using LinkWare™ Management Software.

OptiFiber® Pro OTDR – Built for the Enterprise

OptiFiber Pro is the industry's first OTDR built from the ground up to meet the challenges of enterprise fiber infrastructures. This troubleshooting and certification tool combines uncomplicated power, unparalleled efficiency and the exact functions needed for troubleshooting campus, data center and storage fiber networks.

The OptiFiber Pro OTDR elevates fiber testing with the industry's only smartphone interface that turns a technician into a fiber expert. The DataCenter OTDR configuration eliminates uncertainty and errors that occur when testing data center fiber. Its ultra-short dead zones enable testing of fiber patchcords in virtualized data centers. These capabilities, plus the fastest-in-the-industry trace times, make the OptiFiber Pro OTDR a must-have tool.

FI-7000 FiberInspector™ Pro - 2-second automated PASS/FAIL certification of fiber end-faces

Graphical indication of problem areas due to contamination, pits, chips, and scratches.

Certify to industry standards - IEC 61300-3-35 and eliminate human subjectivity from end-face measurements.

More information at: ***www.flukenetworks.com/content/versiv***

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