Best practices for fiber optic installation start with inspection & cleaning

For centuries, optics have been inspected and cleaned to ensure the proper passage of light. The advent of fiber optic cabling systems resulted in one more application where optical care and cleanliness are important. While inspecting and cleaning fiber connectors is not new, it is growing in importance as links with increasingly higher data rates are driving decreasingly small loss budgets. With less tolerance for overall light loss, the attenuation through adapters must get lower and lower. This is achieved by properly inspecting and cleaning when necessary. Yet there is no reason to feel intimidated by these tighter loss budgets because inspecting and cleaning connections is straightforward and easy.

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What's the problem

Fiber basics

Fiber optic cabling carries pulses of light between transmitters and receivers. These pulses represent the data being sent across the cable. In order for the data to be transmitted successfully, the light must arrive at the far end of the cable with enough power to be measured. Light loss between the ends of a fiber link comes from multiple sources such as the attenuation of the fiber itself, fusion splices, macrobends and loss through adapter couplings where end-faces meet.

In lower data rate networks with shorter lengths, loss budgets may be generous enough to allow for significant attenuation through-out the link and still the link will function properly. However, there is one perpetual trend in structured cabling: the constant push for greater bandwidth. As fiber links are pushed to carry higher data rates, loss budgets get correspondingly smaller, requiring all loss events to be minimized.

Enemy #1 — a dirty face

Among key sources of loss that can bring a fiber network down, dirty and damaged end-faces are the threat most underestimated. In a survey commissioned by Fluke Networks, dirty end-faces were found to be the #1 cause of fiber link failure for both installers and private network owners. Contaminated end-faces were the cause of fiber links failing 85% of the time. It's astounding and yet easy to prevent. Nevertheless, there continues to be a lack of appreciation for this crucial issue and lots of misinformation about proper techniques.

What to look for and when

Network professionals need to know what to look for when evaluating end-face conditions. There are two types of problems that will cause loss as light leaves one end-face and enters another inside an adapter: contamination and damage.

Contamination

Contamination comes in many forms from dust to oils to buffer gel. Simply touching the ferrule will immediately deposit an unacceptable amount of body oil on the end-face. Dust and small static-charged particles float through the air and can land on any exposed termina-tion. This can be especially true in facilities undergoing construction or renovation. In new installations, buffer gel and pulling lube can easily find its way onto an end-face.

Ironically, protective caps – also called "dust caps" – are one of the most common contributors to contamination. These caps are made in high-speed production processes that use a mold release compound that will contaminate end-faces on contact. Further, as the plastic cap ages the plasticizers deteriorate resulting in an outgas residue. Last, airborne dust itself will find its way into the protective cap and will move to the end-face when the cap is pushed onto a ferrule. It's a very common mistake to assume that end-faces are clean when patch cords or pre-terminated pigtails are removed from a sealed bag with protective caps in place.

Inspection of the end-face should verify that no contaminants are within the field of view. The most crucial area to ensure is clean is the core of the fiber, followed by the cladding. Yet contamination on the ferrule – outside of the end-face – could slide towards to core as the fiber is mated or handled. Therefore, all visible contamination should be removed if possible.

Damage

Deciding to mate every connection first and then inspecting only those that fail is a dangerous approach as the physical contact of mated contaminants can cause permanent damage. This permanent damage would require more costly and time consuming retermination or replacement of pre-terminated links.

Damage will appear as scratches, pits, cracks or chips. These end-face surface defects could be the result of poor termination or mated contamination. Regardless of the cause, damage must be evaluated to determine if action is required as some of it can be ignored or remedied. Up to 5% of the outer edge of fiber cladding generally may be chipped as this is a common result of the polishing process. Any chips on the core are unacceptable. If scratches or excess epoxy bleed is found, repolishing with fine lapping paper can eliminate the problem. If the end-face is cracked or shattered, then the fiber must always be reterminated.

In every instance, all end-faces should always be inspected before insertion. If a connector is being mated to a port, then the port should be inspected as well. Inspecting one side of a connection is ineffective as contamination inside a port can not only cause damage but also migrate to the connector being inserted. Too often equipment ports are overlooked not only as contaminated themselves but also as a source of contamination for test cords.

How to inspect
Fiber microscope choices
From the first days of fiber optic cabling, microscopes were used to inspect end-faces. Initially stereo bench top microscopes were modified to handle the task in manufacturing environments. Over time new microscopes were designed specifically for the task, resulting in smaller units that could be taken down the hall to the cabling closet or outside into the field.

Microscopes can be divided into two basic groupings: optical and video. Optical microscopes incorporate an objective lens and an eyepiece lens to allow you to view the end-face directly through the device. Today, the barrel shaped microscopes are ubiquitous in termination kits and used to inspect patch cords during troubleshooting. The best feature of these microscopes is their price as they are the least expensive way to see end-face details. Their drawback is that they are unable to view end-faces through bulkheads or inside equipment. As a result, you will sometimes here these microscopes referred to as "patch cord scopes."

Video microscopes incorporate both an optical probe and a display for viewing the probe's image. Probes are designed to be small so that they can reach ports in hard-to-access places. The screens allow images to be expanded for easier identification of contaminants and damage. Because the end-face is viewed on a screen instead of directly, probes eliminate any chance of harmful laser light from reaching a person's eye.

End-face inspection, using either a handheld optical or video microscope (shown here), should be done both during and after termination to check for contaminated or improperly polished connector end-faces.

Microscope evaluation
What matters most about a microscope is what it shows the user. In the case of fiber optic inspection, the goal is to identify all contaminants and damage of a minimum size and within a critical area. Users must first identify the appropriate minimum size contaminant or defect that will affect their system. The smallest-sized item that a microscope can detect is referred to as its detection capability. Next, look for the microscope that has the largest field of view while also maintaining the necessary detection capability. It is preferable to see as much of the surface area as possible while maintaining requisite detection capability. Detection capability and field of view require a trade-off as improving on one dimension tends to require a detriment to the other.

If detection capability and field of view are the most appropriate measurements of a microscope, then why is magnification the prevalent metric. Magnification is perfectly applicable to optical microscopes as their performance is a direct function of the objective and eyepiece lens inside the device. Where magnification becomes less applicable is in video microscopes where the size of the image is a function of both the magnification of the lens as well as the size of the screen. Complicating matters further is the effect of contrast on the ultimate goal of detection capability. Magnification specifications for video microscopes are a vestige of the historical prevalence of optical microscopes. Though magnification is directly related to detection capability, it is a less precise measure of a fiber microscope's capabilities than detection capability and field of view.

How to clean
Beware of bad habits
Because cleaning has been part of fiber maintenance for years, most people have their own approaches for cleaning end-faces. However, beware of bad habits as many have developed in the industry over time. With an evolving base of knowledge, the industry has moved recently towards new best practices. One common approach to cleaning end-faces is to blast them with canned air, either on a connector or inside a port. Canned air is only effective on one type of contaminant: large dust particles. Canned air is ineffective not only on oils and residues but also on smaller, charged dust particles. Moreover, canned air will tend to blow large particles around inside ports rather than carefully remove them.

Use of solvent

Another suboptimal approach is to clean without use of a solvent. Solvents provide multiple benefits, the most being their ability to dissolve contaminants that have dried or adhered onto the end-face. In addition, solvents will envelop particles and debris to effectively lift them from the ferrule surface so that they can be carried away without damaging the end-face. Last, solvents will prevent a static charge from developing during cleaning with a dry wipe or reel. There are many stories of end-faces becoming statically charged during solvent-free cleanings such that they were strongly attracting static-charged dust floating in the air. The developed charge can be so strong that static dust accumulates on the end-face during the short move from a microscope into port.

Solvent selection

Isopropyl alcohol (IPA) has been used for years in the fiber cabling industry to successfully clean end-face and continues to find broad use today. But there are solvents now available specially formulated for fiber end-face cleaning that are far superior to IPA in every way. These new solvents are more effective at dissolving virtually every contaminant than IPA. Further, these custom solvents will dissolve non-ionic compounds such as pulling lube and buffer gel that IPA will not. With a specified lower surface tension, the specialized solvents will do a better job of enveloping debris for removal than IPA. When cleaning inside ports, evaporation rates become important as lingering solvents can become trapped during mating, resulting in a harmful residue. Fiber-specific solvents have tailored evaporation rates that give them time to work yet disappear before mating. Last, IPA is highly hygroscopic which means it will draw water moisture from the air and onto the end-face. This water mixes with the IPA and leaves a residue if it dries on the end-face. To be safe, leave the IPA in the medicine cabinet.

Cleaning tools

There are a wide variety of tools available to clean end-faces. The most basic tools are wipes and swabs used to clean patch cords and inside ports, respectively. More involved approaches include mechanical, hand-held contraptions designed to make easier work of cleaning. The most complex devices incorporate blasted solvents or ultrasound in water to achieve the best result. While the more complex systems may achieve better results, they cost far more money. Individuals should determine the best approach for their application and budget. The one key criterion for wiping materials is that they be lint-free. Shirtsleeves are unacceptable!

The right tools will help with fiber end face cleaning. Solvent from a fiber optic solvent pen, applied to a special purpose, disposable cleaning pad, is a best-practice method cleaning fiber optic cabling.

The primary cause of fiber failures is dirty connections. Using swabs designed and sized to clean inside ports will clean an often overlooked problem source.
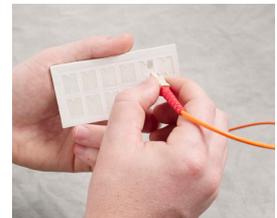
Best practices

Whatever approach is selected, certain truisms apply to fiber optic end-face inspection and cleaning. First, inspection must occur not only before but also after cleaning to ensure a good result. If a post-cleaning inspection shows remaining contamination, then a second cleaning must follow. Second, both sides of any connection need to be inspected as every mating involves two surfaces coming into contact. And last, it is almost always easier and cheaper to inspect and clean as a preventative measure than as reactive response. Consistent inspection and cleaning up front will avoid unexpected and costly downtime in the future.

Contact Fluke Networks

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