THE NEED FOR PRECISION CLEANING AND INSPECTION PROCESSES TO FUTURE PROOF ALL FIBER OPTIC INSTALLATIONS:

A SEARCH FOR BEST PRACTICE

EDWARD J. FORREST, JR.

ABSTRACT:

Often separated into segments of “OEM versus OSP”, “commercial services versus aerospace”, or “Telco versus CATV” existing fiber optic standards tend to be portrayed as maximum requirements when, in the face if ever increasing speed and capacity, these are actually “minimum requirements”. This is not acceptable for *any* rapidly evolving science. To develop and commercialize a total view the Industry requires research and development that considers a new standard type that evolves continually and not bound by a structure of updates every 5 or 10 years interspaced by lengthy composition processes.

By and large unchanged since inception, the tenets of IEC 61300-3-35 have influenced and developed standards that includes: a.) the importance of cleaning the fiber optic connection, b.) the concept of diameter of debris or contamination, c.) the area of the end face to be cleaned, and, d.) a series of procedures and implied products. This may not be adequate or accurate.

There are myriad types of debris and contamination. Some are “dry” and others are “fluidic”. Often times the debris on a connection is present in “combinations”. Regardless of type, the cleaning procedure should strive to be a first time process and not as currently considered: multiples of procedures therein when one procedure and then another is an attempt to return the end face to an acceptable condition.

Dry, fluidic, or combinations of the two contaminations have height. Some of these are depicted in **FIGURE-I**. A commonly used cleaning technique can create fluidic contamination **(Type 2)** emanating from the area outside the view of most-used video inspection and software analysis. Another technique can create a static field that attracts additional debris**. (Type 1)** Still others are complex **Type 3** that are unknown. <u>Not considered in existing standards</u>: a*<u>ll contamination has height and connectors themselves are three-dimensional structures.</u>*

As well not fully considered is that an ineffective cleaning procedure may result in *removable* debris mis-characterized as an *unmovable* artifact. There is also a sense the IEC 61300-3-35 standard is relative to both production line applications (OEM) and field service (OSP) applications. These are two worlds separated by critical topics outlined herein.

This paper is an effort to define and update inspection and cleaning procedures to facilitate existing operations and anticipate future needs. Understanding differences is fundamental to “future proof”.

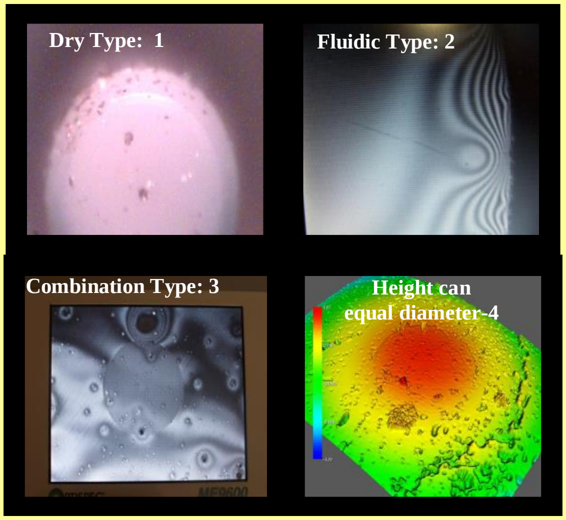
<u>END FACE GEOMETRY: HOW IT INFLUENCES PRECISION CLEANING AND INSPECTION:</u>

By current standards (derived from IEC 61300-3-35) debris and contamination is measured and observed in a two dimension measurement that has width and length. These measurements are in ranges of micron units and contamination is calculated in juxtaposition to the fiber or “core”. The “core” is “Zone-1”.

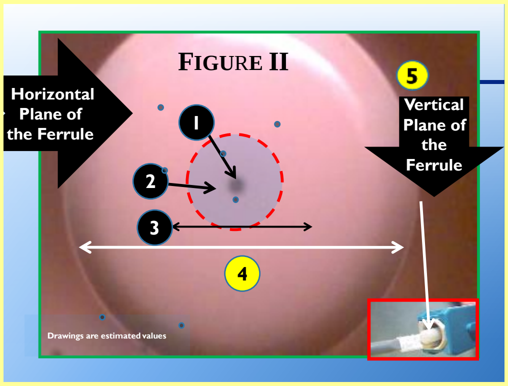
Existing standards and devices for video inspection easily analyze the diameter of debris or contamination in relation to the core **(Zone-1).** However, dry, fluidic and debris-in-combinations also have height. Measurement of the height of debris and contamination requires an interferometer. The interferometer reading **(bottom right-4)** shows debris of equal diameter and height. **(Figure I)** Various debris **(TYPE 1, 2, 3)** also exist on the complete surface.

An essential facet missing from existing standards is the awareness that both contamination and the connector are three dimensional structures. For existing standards this means that removal of debris may be limited to certain “simple types”. As related to the connection, this misinterpretation means removal procedures are not as complete and effective as desirable and may depart residual contamination.

FIGURE I



Existing standards for end face inspection limit the field of view to zones within a two-dimensional field-of-view limited to (video) magnification ranging between 100x-400x usually measured at 250-300mu radius of the core. By these standards, the end face is divided into three or four “zones”, all contained on the horizontal axis, Of course, a connection is a three



dimensional structure with a perspective beyond this limited field of view and extending through the complete 'geometry' of the connection. **(FIGURE II)**

However, there is an area outside this limited field of view that includes the remainder of the "horizontal axis ferrule" and intersects with a "vertical axis ferrule" to create the complete three dimensional assembly. Surrounding the ferrule are various plastic, metal or ceramic assemblies that comprise the connector.

Certain types of debris outside the field of view **(Zone-3)** can migrate into the core. This type of migration would most likely be a fluid contamination. Fluidic contamination can be excess cleaning solvent, an oily type contaminate, or even condensation contamination wherein a connection is moved from one ambient to another.

There are often-used cleaning techniques that wipe- or spray-apply excess cleaner in the initial phase of cleaning. Excessive cleaning solvent can be harbored in Zone-5 and migrate in the post cleaning, post-inspection process. Fluidic contamination is depicted in **IMAGE TYPE-2.**

While video inspection inside "Zone-3", is common, and this is accomplished at 200 or 400x, few instruments are of discrete image resolution of sufficient value at lower magnification to provide a wide field of view to see the entire "horizontal surface" I term as "Zone-4". No practical instrument (other than a microscope) can see "Zone-5".

While it may be impractical to change a standard such as IEC 63100-3-35 in the short term, it is practical to heighten awareness and establish a best practice standard that exceeds this baseline. In fact, for rapidly evolving technology (such as fiber optic transmissions) "standards" may best be separated into: a.) "Minimum Baseline" and b.) "Technology Advancing" as (in the instance of fiber optics) transmission equipment and deployments outpace the time between review and publication. As well, "internal standards" can be established. These distinctions may be relative to other industry as well.

Since the fiber optic ferrule assembly and the debris are three-dimensional, this science becomes important for all fiber optic precision cleaning applications. A jumper-side ferrule inserted through an alignment sleeve can both transfer debris from one end face to the other as well as capture debris on the alignment sleeve and certain residues from the adapter itself can cross contaminate connector components. These phenomenon are possible for both direct contact and expanded beam.

Interaction of contamination and debris and the geometry of the connection are essential awareness. As capacity and speed are doubtless to increase, implementation of effective cleaning techniques that do not cause recontamination are critical to future connectivity. Inspection is mandatory. As well, cleaning procedures that work more reliably, not only based on convenience, are essential to best practice.

ARE THERE DIFFERENCES OR SIMILARITIES BETWEEN FIELD AND MANUFACTURING OPERATIONS?

The surface of the end face as it passes through various production line operations, must be cleaned prior to equipment assembly. The strict control and discipline of the production floor is not mirrored in the field. Understandings of field operations personnel (Outside Plant, OSP) range from "any way we clean is good enough" to disciplined procedures demanded by high capacity transmissions. Thus, any differences are largely the result of the environment in which the precision cleaning procedure is performed and not a quantification of a specific technician's ability or skill. Proper training is the key to success.

In each and every FTTx application the fiber optic transmission and processes are very much the same. Some transmissions use single mode and others multi mode. Some connections are fundamental SC-UPC and others are more esoteric or expanded beam types. In the end, it is the environment and debris type as well as an applications specific connection that ties all fiber optic connections together.

An actual cleaning process for an expanded beam may differ as the contaminant on a ball lens may not require as much detail as a common SC or LC. However, the "Zone-5" concept either on expanded beam or direct contact SC or LC have the same concern: contamination migration from outside field of view into the active transmission path at "Zone-1". While the responsibility of a commercial carrier is immense, there is also a like sense of due diligence for a consumer carrier, data center, 911 network or security/traffic control installation.

It is on the production line that the most likely contaminant may be finger oil or possibly light dust as measured in the context of Arizona Test Dust in IEC 61300-3-35. However, there is an unfounded sense that complex debris is as easy to remove as simple contamination or that one cleaning technique will work as well as another. Seemingly to assure this, standards suggest cleaning multiple times when a first time cleaning technique is highly desirable and practical. The technician should not have to be a geologist to determine a contaminant type and select from a cornucopia of cleaning products. Neither should that person be a chemist to determine a contaminant. Technicians are schooled to analyze test data and devise a repair. Precision cleaning is a straight-forward science with a clear path to the simple task of doing the job right the first time.

The cleaning process should never influence a test and measurement result. This is possible if a specific "product" is not effective in the cleaning "procedure" and departs a "removable contaminant" that is mischaracterized as an "un-removable artifact". Such as a weakness of the current range of "pass/fail" instruments that will be corrected in future designs as software advances. A specific ambient is far too varying and debris and contamination likewise, to even begin to assert that most types of debris are one type. However, precision cleaning science is such that one technique can clean the widest range of debris and accomplish this the first time. Existing standards suggest and enable "up to five times".

WHAT DEBRIS IS POSSIBLE

As wide a range of contaminants as imaginable should be catalogued. One such evaluation was made in 2006 with a series of contaminates from Cisco®. The "Cisco Series" ranged from Arizona Test Dust to dried water. Graphite, Simethicone and Dryer lint were included. In recent times, testing was suggested on dust from Afghanistan, which is remarkably finer than ATD. Beach sand is coarser than ATD: prevalent and relevant to effective an effective cleaning technique.

A second series of laboratory evaluations was conducted in 2011 at the ITW Chemtronics® Laboratories where an additional series of debris and contamination was applied to the end face of a 2.5mm UPC connection. In these evaluations 99.9% IPA was compared to a proprietary HFE-7100/IPA formulation and a second proprietary HFE-7100/non-IPA formulation against a proprietary precision hydrocarbon.

The debris included Arizona Test Dust as representative of a dry-type and vegetable oil as representative of a fluidic-type contaminant. In all there were a 10 variety of ten neat contaminants. (neat is defined as pure, full-strength, unadulterated). The dry contaminants and fluidic contaminants were then mixed into combinations of types. The intent of the study was to create worst case debris that would lead to best practice for OEM (production) and OSP (installation) as well as OEM that may have field service or installation capability.

In addition to the dry and fluidic types of debris and contamination, a third type is also possible. Combinations of debris such as human body oil and Arizona Test Dust, mineral oil and carbon black as noted from field service of coal fired power plants. Silicone oils, dust other than ATD such as found in other desert regions, and a host of diverse types of debris should be considered when creating a sense of future proof precision cleaning against new transmission technologies.

A third extensive test series was conducted in December-2014 that compared and contrasted current cleaning tools through a wide range of contamination to baseline "best practice".

IEC 61300-3-35 and all derivative standards are based on relatively removal of relatively simple debris and contamination. Therefore, the fundamental understanding of precision cleaning a fiber optic connection tends to be overly simplified. This over-simplification leads to confusion for both field service technicians as well as OEM implementation personnel who are seeking to increase output and reduce costs. OSP technicians, realizing that they may not have the most effective means of cleaning, either downplay the task or work tirelessly to precision clean when their analytical skills to interpret, for example, an OTDR trace would be a more meaningful use of time.

FIGURE III

While there is an effort to categorize debris and contamination, in reality the types of debris and contamination should be open-ended and as they are: virtually infinite in nature and presented in the environs of a fiber optic deployment. Some of these are typical and others 'unusual'. **(FIGURE III).** The cleaning process should be judged by worst case debris rather than a limited cleaning technique that removes a simple soil being considered "best practice".

In addition to the range of dry debris types, Static Field Contamination is also possible. This is termed *ESA* (Electrostatic Attraction) by the ESD Association Standard S-2020. ESA is likely to occur when the ambient temperature ranges in the 20-50F range or >95 with relative humidity in the 35-60% range. Likewise, ambient in the >90F range can promote ESA.

Static field contamination should be considered as one of many debris types. Generally speaking, there are four ways to control static field contamination: 1.) is use of an air ionizer, 2.) use of a grounding strap, 3.) use of static topical coatings, 4.) dissipation by intriduction of a precision cleaning solvent.

The images with common dust and an uncommon eyelash, **(FIGURE III)** were captured at 72F and 50% relative humidity. The actual static field was only 78v and attracted the light dust to the end face. At <38v there was no attraction of debris.

In the world of production line ESD, typically there is a 2000v/in limitation. Therefore, ESA of debris at values <100v is a significant number. The images above were captured by passing the 2.5mm SC/UPC end face over a dry cleaning device in three passes. The subsequent *tribocharge* attracted the dust to the end face that was placed within 1" of the debris.

Of these, air ionization, as mentioned in IEC 61300-3-35, is the most effective means to control ESA. Air ionization for an OEM work bench is practical and desirable, practical and effective within a 12" range of the actual work.

It is conceivable that air ionization might be practical in the OSP Central Office or Head End. Such a unit would have to be moved in relation to the actual connection cleaning work area. However, air ionization would not be practical for many OSP operations that range from a flight deck to a cellular antenna installation or FTTx node along the side of the road. Thus these applcations, as the fiber optic cleaning procedure itself, are highly applications specific to myriad factors.

While both wrist and heel grounding straps are effective OSP devices for electronic component replacement, for fiber optic applications there is no conductive connection from the user to the actual cleaning surface. Therefore, use of a grounding strap is not effective to control ESA in the fiber optic end face application.

Static topical coatings might be effective to control

FIGURE IV

ESA on equipment surfaces, but counter-productive for fiber optic precision surfaces. Static topical coatings would become contantamination in themselves.

For the end face application static dissipation is the most effective and practical means to ESA when cleaning a fiber optic connection. This means of static dissipation requires that the end face that is cleaned with a precision solvent and immediately connected. Use of a solvent when cleaning, in effect, is the same as high humidty, which significantly reduces ESA.

In all, the matter of ESA or static field attraction distills to how the end face is contaminated and in what environment. In short, an end face may be contaminated by ESA attraction, gravity depositing debris on the surface, or some type of accidental contact with the end face and the host debris.

In addition to various dry, fluidic and combination types, and those caused by ESA, there is also the potential for condensation contamination. The Cisco® Series of contamination includes dried water and dried IPA. Condensation contamination **(FIGURE-IV)** can be exceptionally complex to remove as this type typically deposits a mono-molecular layer of debris that surface-bonds to the end face as the condensation may evaporate. Typically this occurs within a few seconds as the surfaces equalize temperature.

Condensation contamination can occur when an end face is moved from one extreme ambient to another: 20-F to 70-F as an example. There are multiple potential sources of contmination and best practice considers as many as currently catalogued and looks to the future as well as other applications specific possibilities.

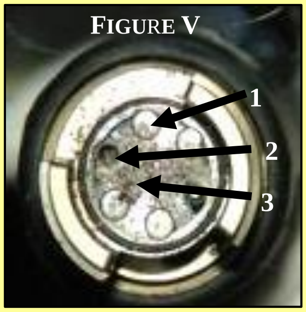
<u>What components of the connection should be cleaned</u>

A proposed concept that 80% of debris is dusty debris can mean that the remaining 20% can be 80% of the problem! Pareto Logic might not be the best choice when considering the needs of existing and future networks, systems and deployments. An effective best-practice cleaning procedure to future-proof an installation (of any type) considers all potential debris and contamination.

<u>Worst case leads to best practice</u>.

To this end, the concept of a three dimensional structure of the end face requires consideration and specification update. The end face horizontal surface is only part of the overall connection. In addition, there is a horizontal ferrule as well as alignment sleeve geometry. Debris deposited in the split ring or other internal structures of the adapter can immerge if consideration is not given to all components of the connector.

FIGURE V



Each dimension alone and in combination can contribute to contamination failure. Surely it is unlikely that a dry-type debris on Zone-5 will migrate to Zone-1. However, repeatable test and evaluation clearly exposes that excessive fluidic contamination from Zone-5 can migrate to Zone-1. Furthermore, drying fluidic contamination is troublesome and complex. It is here that a deficiency in contemporary video inspection is disclosed: the vast majority of video inspection only views the area 250-300mu radius of the core at 400x which has become the *defacto* standard.

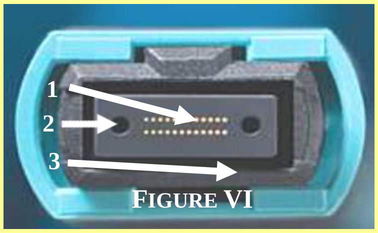
Be it fluidic-type, dry-type, combination-type, or unidentifiable-type, the technician can have an effective the means to confidently clean the end face.

Even the expanded beam connection can be influenced by debris outside the area of the ball lens. In the image **(FIGURE V)** debris is evident on the surface area that could be transferred to the transmission area. There are actually three areas of concern, the lens area (1), the alignment pins (2) and the horizontal surface area of connector (3). In this image, debris from the *intersurface* also has entered the alignment pins. Alignment pin contamination can create a stand-off or other damage when the connectors are mated. Un-dried fluidic contamination can migrate to a transmission surface.

Factory recommended cleaning of the expanded bean connector may be done with done with anything from dish-washing soap to a precision cleaner.

An area of concern arrives when the technician is given dish-washing soap to clean a connection type other than expanded beam. Clear and concise applications specific training is essential. While these concerns may seem whimsical, far worse regularly occurs in the real world outside the disciplined regimen of a production line. Minimally, it is essential to understand that not all precision cleaning techniques work to the same result.

As well, existing standards and products associated with them are to be considered as "minimum requirements" as capacity, speed and innovation exceed publication of these works. There is a need for "flexible standards" as well as those acting as "baseline" minimums.



These same concern exists for the MT® type **(FIGURE VI)** where fibers (1), alignment pins (2) and connection intersurface areas (3) all present various 'contamination points'.

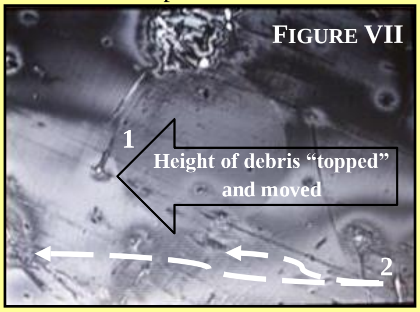
In fact, precision cleaning the fiber optic end face is a relatively easy science. Neither should the technician be a chemist to determine the fluidic component of contamination or a geologist to identify dry-debris.

Ideal and realistic is one cleaning process that considers the widest range of potential debris, various components of the connector, and a cleaning technique that does not aid and abet a negative result! These are easy concepts to grasp and provide clarity to the end user.

This process should be accomplished in as close to a First Time Technique as possible.

ACTUAL CLEANING TECHNIQUES CONDENSED INTO THE CONCEPT OF 1ST TIME CLEANING

Per IEC 63100-3-35, the dry process is identified as the first-choice followed by a "wet/wet-to-dry" technique if the first does not work. A cleaning attempt is suggested for five times at which field replacement or other options considered.



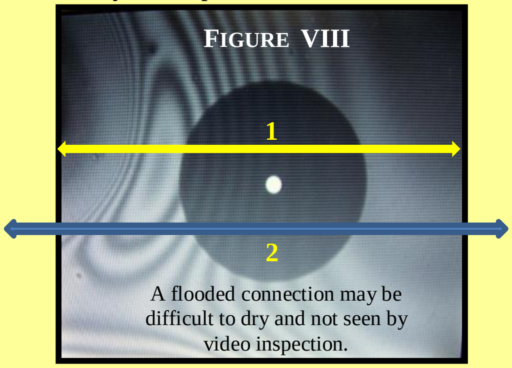
Dry cleaning a complex debris has several significant limitations. Among those is the possibility of ESA attraction but more significantly is the reality that drying cleaning tends to move and not remove debris and contamination. The image **(FIGURE VII)** shows two aspects of dry cleaning: 1.) debris has height and 2.) the process moves debris. Dry cleaning may be effective on an oily contamination; this is dependent on the wiping material within the dry device itself.

A "dry process" works best to remove fluid contamination in a "mopping action". However, on dry contaminant, as noted, the process can generate a static field that attracts additional debris. Since debris has height as well as diameter, some types of debris (metal/Cisco®Series, carbon black-coalfired plants, hard stone-mining) may damage a connection during cleaning. As with all connector service, video inspection is a critical aspect of fiber optic production and deployment.

As depicted in **FIGURE VIII** especially troublesome is fluidic contamination **(1)** likely to be seen within the 250-300mu radius, but <u>not</u> outside the "field of view" of contemporary video inspection. This fluid will continue to "flood" from excess solvent from Zone 4-5 **(2)** in the time of post cleaning and inspection and is portrayed in the image and is a repeatable phenomenon. The vague wording of prevalent "wet-to-dry" technique leaves a wide misinterpretation.

The "wet-to-dry" process is an advance over the "dry" in that the technique and remove a far wider range of contamination, as well as, achieves static reduction through dissipation. However, clear meaning to instructions and misleading marketing attempts to overly simplify and confuse what is straight-forward applications specific terminology.

The "wet to dry" terminology is vague. The actual process is vague, misleading and lends a sense to the worker that something "wet" can be "dried". This is not always the case. In fact, the simple and often used technique of wiping an end face in a wetted wiper can result in Zone-5 to Zone-4 contamination Zone-1 failure. This is the time to clearly state and redefine a series of unique and innovative products into a process that can easily be adapted to all each one.



A flooded connection may be difficult to dry and not seen by video inspection.

AN APPLICATIONS SPECIFIC PROCESS

Fiber Optic deployments begin with design and end with deployment and installation. It has become too easy to promote one product over the other in much the same form as 45rpm records superseded 78rpm, VHS® conflicted with BETA® only to be supplanted by CDs and cloud storage…and those systems new this year to be supplanted in some future time!

With once-theoretical speed and capacity now well into the Gigabit range, un-regenerated signals sent for more than 1500km in practical application (in Australia), and test-capacity well into terabit ranges, comes the need to baseline to a "best practice" precision cleaning and inspection procedures to match these innovations. Well known are phenomenon of reflectance, insertion loss and damage from improperly cleaned connectors. This is the time to advance beyond minimum standards to higher level and practical field proven best practices.

This is also the time to understand that while an aerospace or DOD application may be mission critical, as well, are the needs to commercialize for consumer applications. At the end of the day, be it plastic fiber or glass fiber, direct contact or expanded beam, single or multiple fiber…all are based on the transmission of a signal at the speed of light! All segments can work together to advance best interests of the fiber optic industry.

Any process should be clearly defined. "Dry Cleaning" should not be the "first attempt" except for "fluids" which this process can "mop" or absorb "dry". "Wet-to-dry" cleaning is best updated using the term: Hybrid or Combination Cleaning. This best practice process is appropriate for all connectors and is simply described as: 1.) clear definition of minimal solvent, 2.) selection of a precision solvent with the ability to remove the widest range of debris and contamination, 3.) an integrated drying step within the actual cleaning procedure, resulting in, 4.) a high-probability first time cleaning, This procedure is outlined in Telcordia GR-2923-Core as best practice.

This technique was conceived about ten years ago and defines the wiping material as well as the amount of cleaning solvent. The technique uses less than 1ml of cleaner. The end face is drawn in a straight line action to emulsify the contaminant, move contaminant away from the initial point of contact, and automatically dry it in one motion. The technique is not a Figure-8 action which can retrace debris over the cleaning path. The technique does not twist or turn in the initial contact as that motion can grind debris into the surface. The process is never performed on a hard surface or over a forefinger or palm of the hand. The procedure is adaptable to all existing cleaning products including "probe tools" and "swabs/sticks".

A precision cleaning process should encompass all aspects of the connection. These include the horizontal ferrule, the vertical ferrule, the alignment sleeve and all aspects of the adapter.

MATERIALS SELECTION AND VIDEO INSPECTION

Proper cleaning requires attention to detail in materials selection. Since the best technique is a combination of a wiping material and a precision chemical, both fundamental components require clear definition. The only way to assure a connection is clean is to visually inspect it. This is done with a "Video Microscope". Most typically these range from 100x-400x: the more magnification the better the resolution at the cost of losing a complete "field of view". Advances in automatic detection are ongoing: some of these devices provide a "go-no/go" but are limited in ability to discern contamination types even though meeting IEC 61300-3-35 standards.

The wiping material must never be 100% (paper) cellulose or cotton. While a paper-like material is absorbent and cost-efficient, the cleaning surface may be subject to "linting residues". Cotton also is not acceptable for the same reasons. Likewise, 100% polyester materials, while strong and non-shredding, do not have the absorbency of other acceptable materials such as non-woven combinations or some (not all) microfibers which may be 'cleanroom grade' and not as found in clothing.

Certain cleanroom-grade microfibers are an excellent advanced wiping material. Likewise, certain of a broad list of non-woven polyester/cellulose materials provide a cost-efficient alternative to cleanroom grade microfiber. Certain foam, often maligned, is also acceptable. Clues and cues to effective fiber optic precision cleaning may be garnered from the massive cleanroom segment.

Precision solvent selection is often controversial. The primary consideration is worker safety in the recommended dosage per an MSDS. A parallel concern is environmental impact. Contemporary choices range from esoteric non-chlorinated formulations solvents to precision hydrocarbons and new aqueous formulations. Solvent selection is best considered when seeking a cleaner that works on the widest debris and contamination. Performance, cost of material is a consideration; shipping is not a performance criteria: all chemicals are regulated and shippable per either DOT, IATA, or specific carrier.

Chemical selection should be based on an evaluation of all available chemical types. The reality is that there is no "universal solvent" that removes all debris and contamination. However, there are some solvent types that are simply better for the widest range of contaminant. There are tradeoffs: some of the esoteric formulations are less capable cleaners and have environmental impacts. Precision hydrocarbons are flammable but far better precision cleaners. Aqueous cleaners require an active drying phase while possibly as good as precision hydrocarbons. Aqueous fiber optic cleaners may achieve the same status as their counterparts in electronic and electrical applications. There may be nations or locales that ban "solvent chemistry" in favor of aqueous formulations as has been done in other industries. Some esoteric solvent formulations tend to be expensive; precision hydrocarbons are close to the flammability of IPA and are high performers. Aqueous cleaners are sure to continue to evolve.

As such, standards themselves should be fluid and updated as new installations present new challenges. Under existing standard practices, as a standard is published it may not be disseminated into the field for some years and not updated for many more years. The industry of fiber optic transmission changes quickly and the precision cleaning process should envision those changes by working from worst case to best practice rather than convenience and utility as the main goal.

THE BEST PRACTICE STANDARD:

Existing standards are conceived by some of the brightest minds in the Industry and are valid for the time they are first written and then are obsoleted as the committee dissolves and turns to other matters. There are two types of standards, one is exemplified by SAE J-429 which characterizes and details metal strength for construction and manufacturing. Here understanding the difference between a Grade-8 and other types is critical and a stable standard.

For evolving technology such as fiber optics, I suggest an "evolving technology standard". Existing practice within committees is to discern the need and create the standard over a period of time that may be as long as five years. This has merit as within that time there is evolution that can be incorporated as well as opinions and research. However, between publication and review there may be as long as ten years.

Committee meetings themselves serve as a means to select both the brightest who can attend, but also, eliminate others who (for one reason or the other) many never be able to participate. Envisioned is a standards process that reaches out to web-based publications such as *SAE Open Forum Digest* and utilizes The Internet to invite field experiences from individuals otherwise unable to attend international meeting and other Industry groups: ARINC (Commercial Aviation) BICSI (IT Technology), SCTE (Cable TV), and various FTTx Groups (Telecommunications Technology). An inter-organizational and interactive group can be created.

Thus a standard is created by "virtual committee" on the Internet in real time and once in place, updated on an annual basis by peer review. The value seems obvious: a.) advance evolving technology standards in real time than retrospective to meet design, manufacturing and deployment sciences, requirements, b.) solicitation and input from those who normally could not participate in formal committee sessions, and, c.) practical matters to run in coordination with advances in the complex sciences of fiber optic transmission for all Industry segments.

CONCLUSION:

Existing standards for production line and field operations are currently intertwined. This is not best practice. A production line is well-disciplined and trained for repeatable operations. Field service (OSP) encounters a wide range of potential challenges. Neither operations benefit from simplifying, obscuring or downplaying awareness of the potentials of contamination during deployment, testing, maintenance or production cycles. A standard should not wait for a five or ten year update but rather be modernized annually.

An essential awareness are type and location of contaminants and contamination points on and within the connector surfaces. There are myriad potential sources of contamination including the jumper-side end face, the alignment sleeve, plastic or metal housings in addition to the horizontal plane of the end face as it intersects with a vertical plane in a three dimensional structure. Video inspection is critical and instruments with high resolution and wide field of view are preferred. Automatic detection is in infancy and will evolve.

There myriad potential debris and contamination. These are not only dry, but also fluidic and in combinations. These various soils have diameter as well as height. Debris of all types can extend beyond the existing Zone Standard and best considered in reality of three dimensions with five zones.

Multiple cleaning effort of an end face is not desirable, nor practical, nor necessary. A 1st Time Cleaning Standard should be the goal of all working the Industry and championed by both all interests.

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CONTACT INFORMATION:

Edward J. Forrest, Jr.
RMS (RaceMarketingServices)
Marietta (Atlanta), GA. USA
edwforrest@gmail.com
+770-971-8100 (office)
+770-329-2422 (cellular)
www.fiberopticprecisioncleaning.com

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