PREFERRED RELIABILITY PRACTICES

OPTICAL FIBER CABLE TERMINATIONS TECHNIQUES AND PROCEDURES

Practice:

Apply approved requirements and assembly techniques and procedures in the termination of optical fiber cables used in spaceflight applications.

Benefits:

This practice ensures the performance reliability of optical fiber cable assemblies by requiring the selection of optical fiber cable components that have been tested and approved for spaceflight use and by specifying approved assembly and acceptance inspection and test procedures

Programs That Utilize Practice:

GSFC X-Ray Timing Explorer Mission (XTE)
GSFC Tropical Rainfall Measuring Mission (TRMM)

Center To contact For More Information:

Goddard Space Flight Center

Implementation Method:

The termination of optical fiber cables used in spaceflight applications is performed in accordance with the GSFC approved training document, Ref. 1, which defines approved material requirements and detailed assembly techniques and procedures. Ref. 1 is used by engineers, senior technicians and those involved in training personnel in the techniques of terminating optical fiber cable. The procedures defined in the Ref. 1 training document are applicable to the following items from the MIL-STD-975 NASA Standard Electrical, Electronic, and Electromechanical Parts List, (NSPL), and the GSFC Preferred Parts List-20, (PPL-20):

1) MIL-T-29504/4&5 Type II adhesive
2) Optical fiber termini manufactured by Amphenol/Bendix and used in MIL-C-38999 Series III connectors
4) OC-1008 optical fiber cables manufactured by Brand-Rex

This procedure may not be applicable to other types of optical fiber cable and termini which may require different stripping techniques, polishing

steps, tools, materials, and assembly instructions, all of which must be documented and controlled when spaceflight hardware is assembled.

Personnel are cautioned about the use of parts from manufacturers not specified in the procedure as the use of those parts could result in unreliable cables. Other manufacturer's parts may be used, however, provided they are tested at GSFC, meet GSFC performance requirements, and are interchangeable with approved parts as determined by GSFC.

Ref. 1 provides lists of approved materials required by the procedure including part numbers, manufacturer/source, and specifications. Also included is a list of equipment required by the procedure including model/part number and manufacturer or source.

The assembly of an optical terminus onto an optical fiber cable is performed in the following four steps:

Step 1- Equipment Parts, Preparation and Pre-cleaning

This step ensures that all tools, materials, and equipment are checked against required part numbers, labeled, calibrated, and cleaned as required. The cleanliness of all parts which come in contact with the adhesive is critical to a reliable bond and end product. All parts which come in contact with the adhesive, including all dispenser parts and mixing pans, as well as the fiber and connector to be bonded, must be thoroughly cleaned with appropriate solvents before bonding. Note that some dispensers used for medical applications are internally coated with silicone for ease of dispensing. Silicone can mix with the adhesive and produce an unreliable bond. After cleaning is performed, care must be taken not to re-contaminate cleaned items by inadvertent contact with dirty surfaces. Also, equipment and setup information, tool part numbers, material lot numbers and other data are recorded in the certification logs in order to provide traceability in the event of problems.

Step 2- Optical Fiber Cable Preparation and Stripping

The optical fiber outer jacket, strength member, inner jacket, and fiber coating components are prepared for the bonding process by stripping and cleaning and are inspected for correct stripping dimensions before bonding. Cracks, nicks, cuts, excessive chemical strip wicking, or other potential damage to cable components including the fiber and the strength member are inspected after stripping and prior to bonding in accordance with an in-process inspection criteria. Required data including acceptance inspection is recorded in the certification log. Chemical stripping is used to remove the acrylate fiber coating since the fiber can be nicked inadvertently even by trained operators when mechanical stripping is used. Nicks in the fiber are very difficult to detect, and an

undetected nick could result in a latent defect which may not become apparent for a considerable length of time.

Chemical stripping solutions as well as other chemicals or materials may be limited life items (i.e., their potency may be reduced over time) and are marked, controlled, and handled to ensure that expired chemicals are not used for assembly of spaceflight hardware.

Step 3- Terminus To Cable Bonding

The optical fiber cable is bonded to the terminus and the excess glass fiber is cleaved in preparation for terminus polishing. Care is excerised to ensure that the temperature-controlled ovens are stabilized at the required temperatures, the stripped cable ends are clean, and that the epoxy does not spill out onto any parts of the terminus except the rear barrel.

Cleanliness is critical to a reliable bond and end product.

Mixed adhesive systems are degassed (i.e., by use of a centrifuge) before they are applied to optical fibers and connectors to minimize the potential for fiber breakage due to bubbles or voids in the adhesive surrounding the fiber.

The proper weighting, mixing, and curing of adhesive systems are critical to a reliable product. Detailed instructions on weighting proportions and tolerances, number of mixing cycles or mixing time, and cure time and temperature with time and temperature tolerances (cure schedule) are included in the engineering documentation.

The pot life or working life of an adhesive is determined as a function of temperature. The engineering documentation includes requirements for the adhesive's shortest pot life or working life for the temperature range specified during adhesive application.

After connector bonding, inspection criteria is defined in the engineering documentation for the fiber and cable as well as the connector to ensure reliable connectorization.

Data such as adhesive lot numbers, room temperature and humidity, and pot life are recorded in the certification log for traceability in the event of problems with the adhesive. The glass transition temperature (Tg) of the adhesive used to bond an optical fiber to an optical connect, contact, substrate, or other piece part is at least 10o C greater than the maximum temperature that the optical assembly will be subjected to, including test and storage temperatures. The Tg of an optical fiber adhesive is controlled to minimize optical performance variations caused by the potential movement of the bonded fiber within the optical assembly after temperature cycling.

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Step 4- Bonded Terminus Polishing

Polishing of a terminus bonded to a cable is accomplished in three stages; course hand polishing and a two step machine fine polishing procedure. Refer to the polishing procedures in Ref. 1.

The connector assembly is inspected for excess adhesive on the fiber endface and other parts of the connector, as defined in the engineering documentation, which could interfere with proper operation of the connector. Excessive adhesive on the connector endface can flake off over time and create contamination which can affect performance. Excess adhesive on other connector parts can prevent springs and other mechanisms from operating properly or fitting properly together.

The optical fiber is back-lit using a flashlight from the opposite end of the cable assembly without touching the fiber when inspecting a finished fiber optic connector for cracks in the fiber.

The polishing process produces a "flat" polish and the use of an interferometer is recommended to measure the profile of a fiber endface. The amount of fiber protrusion and the amount of fiber undercut is specified in the engineering documentation.

Physical contact connectors, angle polished connectors, or other specialized polished endfaces have specific requirements for endface finishing. The amount of fiber protrusion, amount of fiber undercut, connector endface geometry parameters and tolerances, such as flatness, radius of curvature, vertex offset, or angle, as a minimum, are specified in the engineering documentation.

Final Polish Verification

Visual examination of the polished, bonded terminus is performed to ensure that the finished termination is of high optical quality and free of unacceptable defects, such as chips, contamination, cracks, scratches, pits, or hackles. A 200X hand held microscope is used and because of the high magnification, the microscope lens and terminus adapter and the polished terminus must be clean. Loose debris or dust is removed by using dry nitrogen. Care is used to insure that lenses of the microscope and the polished terminus are not scratched. Cleaning and inspection is accomplished in accordance with the step by step procedures of Ref. 1.

Acceptance Criteria

The following define the acceptance criteria:

1) The terminus must have a smoothly polished face and glass fiber free of visible scratches and imperfections which affect optical performance or reliability.

2) No visible scratches on the terminus ceramic face.

3) No fiber edge chips, scratches, pits, or hackles.

4) No contamination.

5) No fiber cracks or cracks anywhere in the ceramic ferrule.

6) No excess epoxy around the fiber or spots of apoxy anywhere on the ceramic face.

Optical Performance Verification

The optical fiber cable has been terminated on both ends and conforms with all acceptance criteria up to this point. Optical performance verification is performed by conducting a power loss measurement in accordance with a test setup and the procedure defined in Ref. 1. The first step is to perform power loss measurements without the optical fiber cable in the test setup to establish reference measurement values. The second step is to insert the cable to be verified into the test setup without changing anything else in the test setup and repeating the power loss measurement. The difference in the two power loss measurements, is the power loss of the optical fiber cable.

Power Loss Acceptance Criteria

Power losses of -1.0 dB per terminus or -2.0 dB per cable is the acceptable value for the two termini of each completed cable. In addition acceptable cable length losses for cables less than 34 feet long is 0.1 dB. Acceptable cable length losses for cables longer than 34 feet are based on -0.003 dB per foot of cable length.

Cables that fail the power loss acceptance criteria may be repaired by cleaning or additional fine polishing of an terminus or by replacement of a defective terminus if the cable length permits replacement of a terminus.

Connector Installation

A terminated optical fiber cable is installed into a MIL-C-38999 connector before it is used in a spacecraft harness assembly. The optical fiber terminus is installed into the connector in the same way that a wire contact is installed. Care is exercised to ensure that the termini ends are not touched, contaminated, or scratched during installation. Standard contact extraction tools for the MIL-C-38999 connector are used if the termini are to be removed from the connector. Mechanical strain relief backshells are used as appropriate. Socket termini have springs which

allow for movement inside a connector when optical termini are mated together. Care is excerised to ensure that the strain relief allows for a slight movement of all socket termini cables in the harness.

Optical fiber cable connector terminations are inspected and cleaned if necessary before each mate. Under no circumstances are 100 mate and demate cycles exceeded without cleaning the fiber optical termination to ensure consistent optical performance.

Dust caps which are non-outgassing in laboratory or room environments are used as covers for optical assemblies. Vinyl dust covers are not used.

Technical Rationale:

The use of components, materials, and techniques used in the fabrication of optical fiber cables that have not been tested and approved for spaceflight use could result in significant loss of performance during the mission. Outgassing of contaminates in space can be a serious problem with optical fiber systems. Also, space radiation can cause significant loss in performance of certain optical fibers. Nicks in the small and fragile glass fiber can result in latent optical defects and failures.

Impact of Nonpractice:

Failure to select approved materials and to follow the fabrication and inspection procedures of this practice can result in limited initial performance and further significant degradation during space flight. This degradation could result in mission failure.

References:

1) GSFC Document No. 733-FO-29504-TERM-TRAINING "Entitled "Optical Fiber Cable Termination Procedures For Spaceflight Applications Using MIL-T-29504 Optical Fiber Termini"