NAVAIR 01-1A-505-4
T.O. 1-1A-14-4
TM 1-1500-323-24-4

13 AUGUST 2004

TECHNICAL MANUAL

INSTALLATION AND TESTING PRACTICES

AIRCRAFT FIBER OPTIC CABLING

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL AIR SYSTEMS COMMAND

0801LP1035786

NUMERICAL INDEX OF EFFECTIVE WORK PACKAGES/PAGES

List of Current Changes

Original .... 0 .... 13 August 2004

Only those work packages/pages assigned to the manual are listed in this index. Insert Change, __ dated ______. Dispose of superseded and deleted work packages/pages. Superseded and deleted classified work packages/pages shall be destroyed in accordance with applicable regulations. If changed pages are issued to a work package, insert the changed pages in the applicable work package. The portion of text affected in a changed or revised work package is indicated by change bars or the change symbol "R" in the outer margin of each column of text. Changes to illustrations are indicated by pointing hands or change bars as applicable. Changes to wiring diagrams and schematics are indicated by shading.

2. Total number of pages in this manual is 189, consisting of the following:

WP/Page No.	*Change No.	WP/Page No.	*Change No.	WP/Page No.	*Change No.

THIS PAGE LEFT INTENTIONALLY BLANK

LIST OF TECHNICAL PUBLICATIONS DEFICIENCY REPORTS INCORPORATED

Installation and Testing Practices
Aircraft Fiber Optic Cabling

Identification No./ QA Sequence No.	Location
NONE	

THIS PAGE LEFT INTENTIONALLY BLANK

Alphabetical Index of Effective Work Packages

Installation and Testing Practices
Aircraft Fiber Optic Cabling

THIS PAGE LEFT INTENTIONALLY BLANK

Introduction

Installation and Testing Practices
Aircraft Fiber Optic Cabling

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

None

Record of Applicable Technical Directives

None

1. PURPOSE AND SCOPE.

2. This manual was prepared for the following reasons:

a. To gather under one cover the recommended techniques, procedures and methods to be used for general practices (including cleaning and laser safety), and for operations such as fabrication (including termination, assembly, and maintenance/repair), installation and testing (including troubleshooting) of fiber optic cable topologies (optical fiber interconnection systems with the cabling associated components) on military aircraft. The methods specified herein are not identifiable to any specific aircraft class (such as high performance) or type (such as rotary or fixed wing), but are intended to standardize and minimize variations in processes, techniques, procedures and methods to enhance the compatibility of these fiber optic operations on all military aircraft. The topology includes fiber optic links, cable assemblies and cable harnesses although only one topology may be cited at times.

b. To standardize these techniques and methods so that fiber optic installation, test and maintenance will be done in a uniform manner.

c. To indoctrinate all personnel with the importance of good workmanship.

d. To point out the failures which may result from poor workmanship.

e. To promote safety by pointing out and prohibiting unsafe practices.

3. This manual covers general-purpose fabrication, installation, troubleshooting/test and maintenance/repair of aircraft fiber optic cable topology used for the interconnection of equipment in aircraft.

4. ARRANGEMENT AND USE.

5. This manual is prepared in work package format. A Work Package (WP) is defined as an independent, self-contained set of data or procedures, necessary to support an equipment or functional task.

6. Each WP is identified by a permanent number. The WP numbers, with the applicable publication number, are used for referencing between manuals and between work packages within manuals.

7. The WP numbers are in Arabic numerals beginning with the number 001 00.

8. The Numerical Index of Effective Work Packages/Pages which is in the first WP (001 00), contains a listing, in numerical sequence, of all work packages in this manual.

9. The first page of each WP contains a listing in alphabetical order of the processes covered by that WP.

10. PUBLICATION DATE.

11. The publication date shown on the manual title page and on each WP title page is the copy freeze date. The copy freeze date is the date established after which no additional information or changes will be incorporated into the manual. Additions, deletions, and changes required after the copy freeze date will be issued as changes to this manual.

12. SUPPORT EQUIPMENT REQUIRED.

13. The equipment required for each task/procedure is listed in the corresponding WP. When alternate procedures exist, different tools may be required. Where possible, the alternate tools are identified.

14. CONSUMABLE MATERIALS REQUIRED.

15. The materials required for each task/procedure are listed in the corresponding WP. When alternate procedures exist, different materials may be required. Where possible, the alternate materials are identified.

16. REFERENCE MATERIAL.

17. A list of reference material required for each task/procedure is listed in the corresponding WP.

18. TECHNICAL DIRECTIVES.

19. A record of applicable technical directives appears in each WP in this manual and list technical directives that affect the text and illustrations of that particular WP.

20. WARNINGS, CAUTIONS AND NOTES.

21. Warnings, Cautions and Notes are used throughout this manual. They are defined as follows:

WARNING

An installation, test or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in injury to or death of personnel.

CAUTION

An installation, test or maintenance procedure, practice, condition, statement, etc. which, if not strictly observed, could result in damage to, or destruction of, equipment or loss of mission effectiveness.

NOTE

An installation, test or maintenance procedure, practice, condition, statement, etc. which must be highlighted.

THIS PAGE LEFT INTENTIONALLY BLANK

Definitions, Symbols and Labels

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Definitions	003 01	13 August 2004
Symbols	003 02	13 August 2004
Labels	003 03	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for definitions, symbols (schematic representations) and labels. The WP on definitions is specific to end face geometry requirements for connector termination guidance in WP 010˚01 and for fiber optic cable assembly configurations listed throughout the fiber optic manual.

THIS PAGE LEFT INTENTIONALLY BLANK

Definitions

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This work package lists definitions specific to end face geometry requirements for connector termination guidance and fiber optic cable assembly configurations used throughout this fiber optic manual.

3. DEFINITIONS.

a. Attenuation, Fiber. Fiber attenuation is the loss of optical power as light travels along a the length of a fiber. The attenuation in an optical fiber is caused by absorption, scattering and bending losses. The equation for attenuation is as follows:

$$A(l)= -10 \text{ Log } [P_i(l)/P_o(l)]$$

where:

$A(l)$ = Spectral attenuation at wavelength l
P_i = Optical power injected into a fiber from the optical source
P_o = Optical power received at the fiber end or power meter

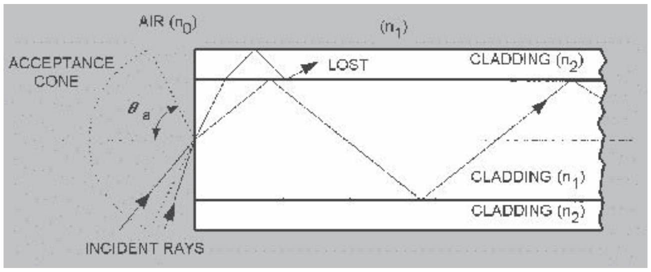


Figure 1. Acceptance Angle

b. Attenuation, Cable Link. See Optical Loss.

c. Acceptance Angle. The acceptance angle (α_a) is the maximum angle to the axis of the fiber that light entering the fiber is propagated (see Figure 1). The value of the angle of acceptance (α_a) depends on fiber properties and transmission conditions. Exit angle will be the same as the acceptance angle.

d. Bandwidth. Fiber bandwidth is defined as the lowest frequency at which the magnitude of the fiber frequency response has decreased to one-half its zero-frequency value. This is the -3 decibel (dB) optical power frequency (f_{3dB}). This frequency is referred to as the fiber bandwidth.

e. Bend Diameter, Minimum. The minimum bend diameter is the diameter at which a cable or cable harness can be bent without degrading optical performance or the diameter at which a loose tube cable, convoluted tube or conduit can be bent without kinking (tube collapse causing fiber breakage). Two types of minimum bend diameters, short-term and long-term bend diameters, must be considered.

f. Bend Diameter, Minimum, Short-Term. The short-term bend diameter applies during handling and installing. The short-term bend diameter may be different for simplex tight buffer cable, for simplex loose tube cable, and for convoluted tube or conduit.

g. Bend Diameter, Minimum, Long-Term. The long-term bend diameter applies to the completed installation. The long-term bend diameter may be different for simplex, tight buffer cable, for simplex, loose tube cable and for convoluted tube or conduit.

h. Bend Radius, Minimum. One-half of the minimum bend diameter. It does not matter whether you are working with bend diameter or bend radius as long as you stay with one or the other in your consideration of the factor (i.e.; if the factor is 16, then 16 remains the same whether the bend diameter is 16 times the cable diameter or the bend radius is 16 times the cable radius). It is when you mix unlike values (e.g.; such as when a bend diameter is compared to a cable radius) that you have to change factors. Be consistent and use cable diameter with bend diameter or cable radius with bend radius.

i. Bending Loss, Microbend. Optical loss due to small microscopic bends. In post cable production, it is the optical loss due to microbends may occur as a result of excessively tight cable clamps or ties or from localized external forces that deform (cause a small bend in) the cable jacket surrounding the fiber. During fiber/cable fabrication, it is the optical loss that occurs mainly when a fiber is cabled and is caused by small discontinuities or imperfections in the fiber, uneven coating applications, or improper cabling procedures.

j. Bending Loss, Macrobend. Optical loss due to the fiber optic cable being placed in too sharp a bend diameter.

k. Buffer. The coating or buffer is a layer of material used to protect an optical fiber from physical damage.

l. Cable Assembly (Fiber Optic). One or more segments of fiber optic cable with connectors on the end of each segment.

m. Cable, Captive Strength Member. A component in the cable that increases the cable's strength, protects the optical fibers from strain and, when stranded in opposing lays, assists to minimize microbending. When terminating a connector/terminus onto the end of a fiber optic cable, the captive strength member is secured to the connector/terminus. The intent is for a force caused by a pull on the cable to be placed on the captive strength member and not on the fiber inside the connector/terminus.

n. Cable, Color Coding. Color coding is standard method for organizing and identifying fibers, bundles, ribbons and loose tubes within a cable sheath. There is no one standard color coding scheme used across all aircraft platforms.

o. Cable, Fiber Optic. A cable that contains optical fibers. The cable may be of a tight buffer or a loose tube design.

p. Cable Harness, Multiple Segment (Fiber Optic). Two or more single segment cable harnesses mated together at the fiber optic connectors.

q. Cable Harness, Single Segment (Fiber Optic). Single fiber harnesses consist of cabling with connectors on each end. Different configurations for this cable harness may be multiple termini connector cable harnesses (such as plug-to-plug or plug-to-receptacle configurations) and multiple termini plug/receptacle-to-single fiber connector harnesses.

r. Cable, Loose Tube. A fiber optic cable design is one configured with one or more optical fibers are fitted loosely within a tube, giving the optical fibers freedom to move. This mobility and isolation from the tube minimizes the effects of external forces on the performance of the link. The isolation allows cable expansion and contraction with temperature independent of the optical fibers.

s. Cable, Simplex. A cable containing a single fiber and may be configured as either tight buffer or loose tube construction.

t. Cable, Tight Buffer. A fiber optic cable design is one configured with an additional protective coding (additional buffer layer) is applied directly over a coated (buffered) fiber. Buffer material helps preserve the fiber's inherent strength and provides increased mechanical protection. A tight buffered cable allows cable placement in tighter bends, more roughed handling (such as better crush and impact resistance)

u. Cable Topology (Fiber Optic). An integrated optical fiber distribution system that provides the optical interconnection between end user equipments (such as a WRA). This is typically the fiber optic link without the transmitting device and receiving device.

v. Cladding. The core is surrounded by a layer of material called the cladding. Even though light will propagate along the fiber core without the layer of cladding material, the cladding does perform some necessary functions: Reduces loss of light from the core into the surrounding air, Reduces scattering loss at the surface of the core, Protects the fiber from absorbing surface contaminants, Adds mechanical strength

w. CMQJ. The Commercial Off the Shelf (COTS) Measurement Quality Jumper (CMQJ) is a low loss jumper that is used with test equipment to perform optical loss measurements. The CMQJ must meet stringent optical loss requirements to ensure accuracy of measurements performed. Measurements must be accurate and repeatable. The accuracy and repeatability of your measurement is only as good as your CMQJ. As the CMQJ degrades with use, so does the measurement accuracy. The CMQJ consists of a single fiber cable with a connector at one end that mates to the test equipment and a connector at the other end which mates to the link/segment under test.

x. Connection, Butt-Jointed. Connectors in which the mating ferrule end faces align and bring the two fiber ends into close contact. Depending on polish technique used during connector termination, the fibers may come into physical contact (PC) or are non-contact (NC).

y. Connector, Fiber Optic. A device that permits repeated mating and couples the optical power between two optical fibers or two groups of optical fibers. A fiber optic connector must maintain fiber alignment without significant loss of optical power.

z. Connector, LC. The Lampert connector or Lucent connector (LC) is a single ferrule connector with a 1.25 mm ferrule diameter, a push-pull style attachment configuration to the mating LC-to-LC adapter\patch panel or equipment interface port, and a butt-jointed connector design. The LC connector has a small form factor configuration that has the same footprint as a RJ-45 receptacle.

aa. Connector, SC. The subscriber connector (SC) is a single ferrule connector with a 2.5 mm ferrule diameter, a push-pull style attachment configuration to the mating

SC-to-SC adapter/patch panel or equipment interface port, and a butt-jointed connector design.

ab. Connector, ST. The straight tip (ST) connector is a single ferrule connector with a 2.5 mm ferrule diameter, a bayonet style attachment configuration to the mating ST-to-ST adapter/patch panel or equipment interface port, and a butt-jointed connector design.

ac. Connector, Test Probe. Single ferrule connector that is placed on one end of a CMQJ and used to mate with a terminus inside a multiple termini connector. The test probe connector is mated with the terminus through the use of a connector test probe adapter.

ad. Connector Loss. Optical loss due to interface between two optical connectors caused by reflective losses due to air gaps and polishing imperfections, and scattering and absorption losses due to surface contaminations.

ae. Coupling Loss. Fiber-to-fiber connection loss is affected by intrinsic and extrinsic coupling losses. Intrinsic coupling losses are caused by inherent fiber characteristics. Extrinsic coupling losses are caused by jointing techniques. Fiber-to-fiber connection loss is increased by the following sources of intrinsic and extrinsic coupling loss: Reflection losses, Fiber separation, Lateral misalignment, Angular misalignment, Core and cladding diameter mismatch, Numerical aperture (NA) mismatch, Refractive index profile difference, Poor fiber end preparation

af. Critical Angle. The angle at which total internal reflection occurs. The critical angle of incidence (θ_c) is shown in Figure 2. At any angle of incidence greater than the critical angle, light is totally reflected back into the glass medium. The critical angle of incidence is determined by using Snell's Law. The critical angle is given by:

$$\sin \theta_c = \frac{n_2}{n_1}$$

ag. Decibel (dB). Unit to express differences of power level. Used to express power gain in amplifiers or power loss in passive circuits or cables. Ten times the logarithm(to the base 10) of the ratio of two intensities.

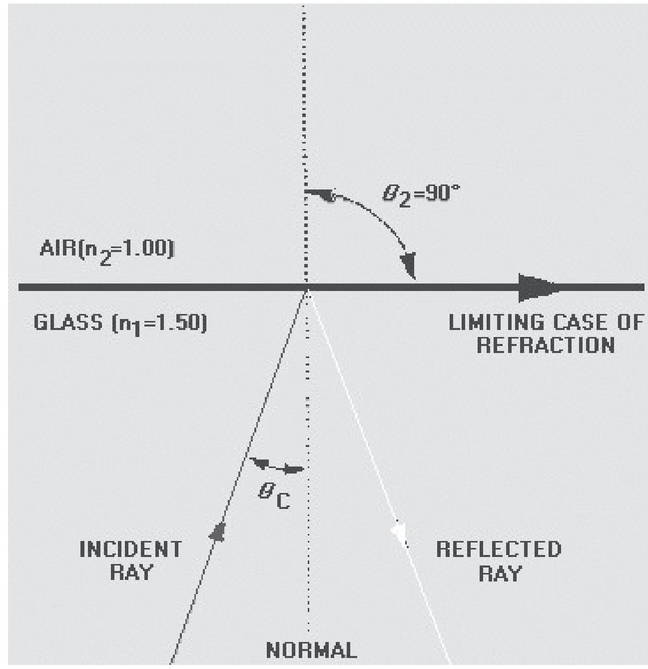


Figure 2. Critical Angle of Incidence

ah. Decibel, dBm. Decibels above or below one milliwatt.

ai. Domed Ferrule. See End Face, Domed.

aj. End Face, Domed. A ferrule in which the mating connection surface has a radius (or domed) shape (see Figure 3).

ak. End Face, Ferrule. Surface of the ferrule that makes contact with the mating ferrule and/or the mating fiber and the surface that is perpendicular to the longitudinal axis of the optical fiber.

al. End Face, Flat. A ferrule in which the mating connection surface has essentially a planar (flat) shape with a very limited degree of tilt.

am. End Face, Geometry. Measurement of the ferrule end face for radius of curvature, measurement of the fiber from a defined surface for fiber height, and measurement of the highest point on the surface contour from the center of the fiber for offset (see Figure 3).

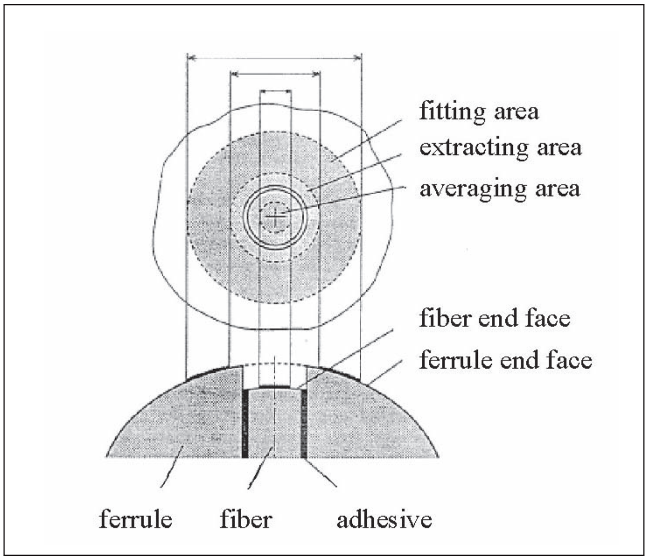


Figure 3. End Face Geometry

an. Exit angle. The angle defined by a ray of light leaving an optical fiber and the fibers axis. See Acceptance Angle.

ao. Ferrule End Face. Surface of the ferrule that makes contact with the mating ferrule and/or the mating fiber and the surface that is perpendicular to the longitudinal axis of the optical fiber.

ap. Ferrule, Flat. See End Face, Flat.

aq. Fiber Height, End Face, Domed. The height of the fiber is compared to the region of the sphere over the fiber that is formed by an ideally polished connector end face. The difference is the fiber height. The fiber height is measured as the degree of fiber protrusion or undercut from this region of the sphere (see Figure 3).

ar. Fiber Height, End Face, Flat. The height of the fiber is compared to the planar surface determined from predetermined distances on the connector end face. The difference is the fiber height. The fiber height is measured as the degree of fiber protrusion or undercut from the planar surface.

as. Fiber Optic Cable Assembly. One segment of fiber optic cable with a connector on each end. Another term for a fiber optic cable harness configured without any intermediary connectors and cable segments.

at. Fiber Optic Cable Harness. Fiber optic cable harnesses come in the follow configurations:

(1) Single Segment Cable Harnesses. This is the configuration for a fiber optic cable assembly. The various single segment, fiber optic cable harnesses include simple single fiber harnesses with single ferrule connectors on each end, multiple termini connector cable harnesses (such as plug-to-plug or plug-to-receptacle configurations) and multiple termini plug/receptacle-to-single fiber connector harnesses.

(2) Multiple Segment Cable Harnesses. Two or more single segment cable harnesses mated together at the fiber optic connectors.

au. Fiber Optic Link. End-to-end communication path that includes the transmitting device, receiving device and one or more single segment, fiber optic cable harnesses.

av. Fiber Optic Cable Topology. See Cable Topology (Fiber Optic).

aw. Fiber Connectors. Fiber optic connectors come in the following configurations:

(1) Single ferrule (light duty) connectors (such as SC, ST and LC connectors) are used to interconnect two optical fiber cable components (OFCCs) at a patch panel or at the WRA optical port.

(2) Multiple terminus (heavy-duty) connectors, such as those in accordance with MIL-DTL-38999 connectors, are used at mating receptacles on the WRA and at intermediary, fiber optic cable harnesses. For single harnesses, plug connectors with inserts configured for pin termini are used on each end of the cable. Receptacle connectors with inserts configured for socket termini are placed on the WRA.

ax. Flat End Face. A ferrule in which the mating connection surface has essentially a planar (flat) shape with a very limited degree of tilt.

ay. Flat Ferrule. See End Face, Flat.

az. FOVIS - The Fiber Optic Video Inspection System. The FOVIS can view the optical fiber on the ferrule end face of a connector or terminus. Different adapters are provided to allow viewing for different ferrule diameters, for termini within a multiple termini connector and for connectors behind various bulkhead adapters. This system consists of a probe (camera with probe tip), display and interconnecting cabling. Single or dual magnification allows for general or fiber inspection. General inspection (200X) is used to view the end face for cleanliness. A larger area of the ferrule is displayed (larger field of view) with the resulting smaller image size. Fiber inspection (400X) is used to view the end face for fiber imperfections. A smaller area of the ferrule is displayed (smaller field of view) with the resulting larger image size.

ba. Index of Refraction. The index of refraction (n) measures the speed of light in an optical medium. The index of refraction of a material is the ratio of the speed of light in a vacuum to the speed of light in the material itself. The speed of light (c) in free space (vacuum) is 3×10^8 meters per second (m/s). The speed of light is the frequency (f) of light multiplied by the wavelength of light (λ). When light enters the fiber material (an optically dense medium), the light travels slower at a speed (v). Light will always travel slower in the fiber material than in air. The index of refraction is given by:

$$n = \frac{c}{v}$$

A light ray is reflected and refracted when it encounters the boundary between two different transparent mediums. For example, Figure 4 shows what happens to the light ray when it encounters the interface between glass and air. The index of refraction for glass (n_1) is 1.50. The index of refraction for air (n_2) is 1.00.

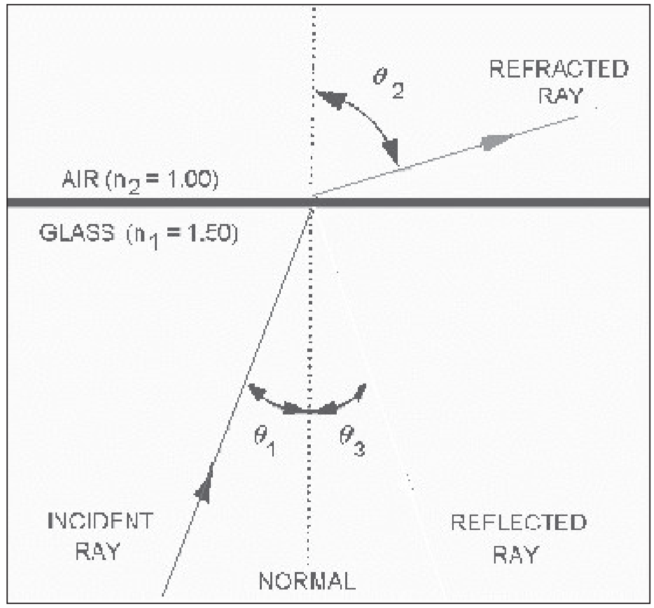


Figure 4. Light Reflection and Refraction at a Glass-Air Boundary

bb. Insertion Loss. The optical power loss resulting from the introduction of an optical coupling or branching component (such as a connector, splice or coupler) into a fiber optic link.

bc. Laser Diode (LD). Semiconductor source that emits coherent light of essentially one wavelength (coherent light) with a narrow spectral width and small output beam angle.

bd. Light Emitting Diode (LED). A light emitting diode is a semiconductor device that emits incoherent light with a wider spectral width and larger output beam angle than found with coherent light.

be. Line Replaceable Unit (LRU). A printed circuit card that slides into a card rack and mates with a backplane connector.

bf. Line Replaceable Module (LRM). Another term for a WRA.

bg. Link (Fiber Optic). End-to-end communication path that includes the transmitting device, receiving device and one or more single segment, fiber optic cable harnesses.

bh. Mandrel. A rod or bar used as a core, around which a fiber optic cable is wound.

bi. Minimum Bend Diameter. See Bend Diameter, Minimum.

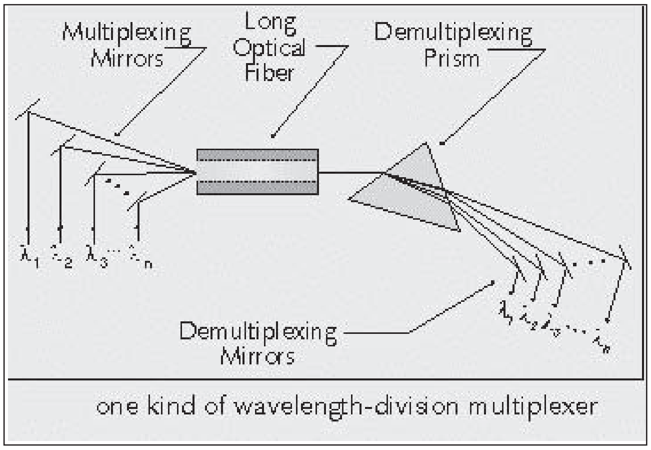


Figure 5. Wavelength Division Multiplexing

bj. Micron. A unit of measure for a micrometer or the distance of one millionth of a meter (1 micron = 0.000001 m).

bk. Microscope, Fiber Optic Connector. An alternative viewing device to the FOVIS. The microscope is less preferred since it is a direct viewing device and can only view connectors with exposed ferrules. A magnified, direct viewing device may be a potential source of laser radiation eye damage if viewing occurs when the transmitter is energized. Ferrules on the other side of bulkheads and termini within a multiple termini connector cannot be viewed with a microscope.

bl. Multiplexing. A method employed to transmit multiple signals simultaneously over a single communications link.

bm. Multiplexing, Wavelength Division. In optical communication, any technique by which two or more optical signals having different wavelengths may be simultaneously transmitted in the same direction over one fiber (see Figure 5).

bn. Music Wire. See Piano Wire.

bo. Non-contact polish. See Polish, NC.

bp. Numerical aperture. The numerical aperture (NA) is a measurement of the ability of an optical fiber to capture light. The NA is also used to define the acceptance and emitting cone of an optical fiber.

bq. Offset. See Polish, Offset.

br. Offset, Angular. The angle between a radial line from the center of the spherical surface to the high point of the polish and a line through the longitudinal axis in the center of the fiber.

bs. Optical Fiber. A Optical fiber is a thin cylindrical dielectric (non-conductive) waveguide used to send light energy for communication. Optical fibers consist of three parts: the core, the cladding, and the coating or buffer. The choice of optical fiber materials and fiber design depends on operating conditions and intended application.

bt. Optical Fiber Cable. See Cable, Fiber Optic.

bu. Optical Fiber Cable Component (OFCC). An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket. It is another term to describe a tight buffed, single fiber cable.

bv. Optical Fiber, Core. The core is located in the center of the optical fiber along the longitudinal axis and is bound by a cladding. It is the region with the highest index of refraction and considered the light conducting part of the fiber.

bw. Optical Fiber, Cladding. One or more layers of material, which surrounds the core of an optical fiber. It has a lower index of refraction when compared to that of the core, thereby causing the transmitted light to be contained within the core.

bx. Optical Fiber, Graded Index (GI). Graded index fibers have a core refractive index that varies gradually as a function of radial distance from the fiber center. For example: A multimode graded-index fiber has a core of radius (a). The value of the refractive index of the core

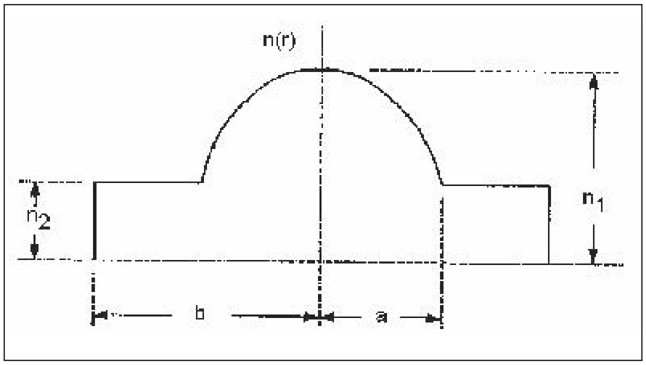


Figure 6. Graded Index Fiber Profile

(n_1) decreases until it approaches the value of the refractive index of the cladding (n_2). The value of n_1 must be higher than the value of n_2 to allow for proper mode propagation. The refractive index profile for a multimode graded-index fiber is shown in Figure 6.

by. Optical Fiber, Multimode. An optical fiber that supports the propagation of more than one bound mode (electromagnetic wave) as shown in Figure 7.

bz. Optical Fiber, Single Mode. A small core optical fiber where one bounded electromagnet wave of light will propagate at the wavelength of interest (see Figure 8).

ca. Optical Loss. The calculated loss in optical power between a known, measured amount of power (through two CMQJs) compared to the measured optical power through a cable assembly (link, harness, etc. under test).

cb. Optical Fiber, Step Index (SI). In a step index fiber, the refractive index of the core is uniform and undergoes an abrupt change at the core-cladding boundary. Step-index fibers obtain their name from this abrupt change called the step change in refractive index (see Figure 9)

cc. Physical Contact (PC) Polish. See Polish, Physical Contact (PC).

cd. Piano Wire. A thin metal wire with a diameter smaller than 125 microns that is used clear obstructions or extract a broken fiber from inside the ferrule of a fiber optic terminus or connector.

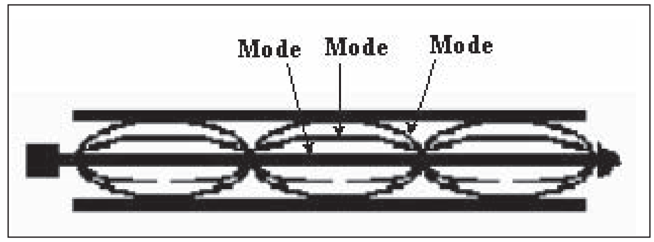


Figure 7. Multiple Modes in a Multimode Fiber

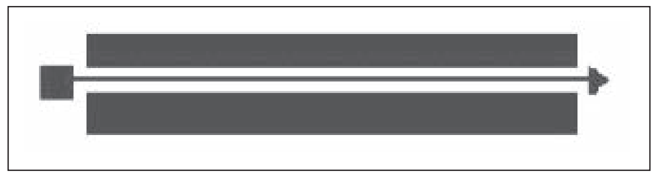


Figure 8. Single Mode in Single Mode Fiber

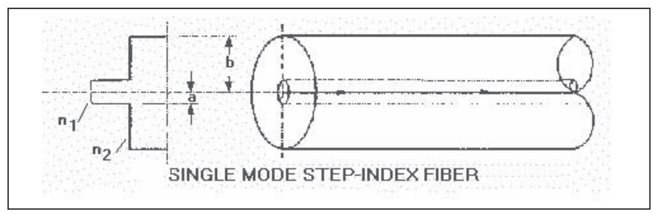


Figure 9. Step Index Fiber Profile

ce. Polish. The process that removes most surface imperfections on the end face of the fiber caused by the cleaving the fiber. This process is performed in multiple steps. In each step, the connector/terminus ferrule is placed into a polishing tool/puck and moved over a specified roughness (grit) abrasive paper, usually in a figure-eight motion. Polishing steps proceed from rough to fine polish. Rough polish uses a 5 micron to 15 micron grit abrasive paper. Likewise, the medium polish uses a 1 micron to 2 micron grit abrasive paper and fine polish uses a 0.1 micron to 0.5 micron grit abrasive paper. For more enhanced return loss results, a slurry polish would be included as the last step in the process.

cf. Polish, Air-Gap. A different term for a NC polish.

cg. Polish, Concave. A different term for a NC polish.

ch. Polish, Non-Contact (NC). Ferrule end face is polished in a manner so that the ferrules are the first to make contact when connection surfaces are mated together without the fibers coming into contact.

ci. Polish, Offset. The polish offset is the distance between the highest point on the connector end face (where the center of the bull's eye pattern is observed) and the center of the fiber. This offset is also referred to as the linear offset, eccentricity or apex offset.

cj. Polish, Physical Contact (PC). Ferrule end face is polished in a manner so that the fibers are the first to make contact when connection surfaces are mated together.

ck. Polishing Tool (Puck). A fixture used in the polishing process to hold the ferrule of a single ferrule connector or a terminus so that ferrule end face is perpendicular to and extends below the fixture's flat bottom.

cl. Polyimide. High temperature thermoplastic resin used to coat optical fiber. Chosen because of its exceptional mechanical, electrical and environmental survivability properties.

cm. Radius of Curvature, Domed End Face. An ideally polished connector end face should have the fiber and the connector form a uniform, spherical surface with the fiber at the highest point (apex). The radius of this sphere formed by the polished connector is called the radius of curvature.

cn. Receiver, Fiber Optic. A fiber optic receiver is an electro-optic device that accepts optical signals from an optical fiber and converts them into electrical signals.

co. Refraction. The change in direction of light wave that occurs when it passes from one medium into a medium having a different velocity of propagation (the speed waves can travel through a medium).

cp. Refractive Index. See Index of Refraction.

cq. Splice. A permanent (as opposed to mateable) fiber joint that connects two optical fibers and exhibits low loss optical performance. A means to repair optical fibers damaged during installation, accident or stress. Two broad types of splices are mechanical and fusion.

cr. Splice, Fusion. Two optical fibers are melted or fused together by means of a fusion splice apparatus using such methods as electric arc, laser or gas flame. During fusion, the surface tension of molten glass tends to realign the fibers on their outside diameter, changing fusion splicer initial alignments performed. As a result, a small core distortion may be present. Fusion splice operators must be highly trained and remain proficient to make low-loss, reliable fusion splices. Fusion splicing yields depend on the strength and loss requirements. Factors affecting splicing yields include condition of the splicing machine, personnel experience and environmental conditions.

cs. Splice, Mechanical. Two optical fibers are held in alignment for an indefinite period without movement by means of a mechanical fixture (such as a tube/ capillary, rods or v-groove substrate). Precision cleaves on the fiber ends and index matching fluid is used as two measures to ensure low optical loss.

ct. Swab. A consumable used to clean the ferrule end face that is configured as an absorbent material placed on the end of a stick or dowel. Absorbent material of a lint free nature that must meet constraints for geometry (such as the cylindrical diameter be smaller than 1.25 mm), abrasion (non abrasive to fiber end face), and cleaning efficacy (sufficient cleaning effectiveness for most common particles and film contaminants and for ability to absorb hydraulic oils, fuels and other aircraft and shipboard fluids).

cu. Termination. The act of placing a fiber optic terminus or connector onto the end of a fiber optic cable.

cv. Termini. A fiber optic connection component that is inserted into one of the insert cavity of a multiple termini connector and terminated onto the end of a simplex, fiber optic cable. Plural form for the word terminus.

cw. Termini, M29504/4 & /5 Style 1. A pin or a socket terminus with a cable strain relief capture mechanism in which the captive strength member of the cable is outside of the barrel (body). A piece of shrink sleeve is placed over the captive strength member.

cx. Termini, M29504/4 & /5 style 2. A pin or a socket terminus with a cable strain relief capture mechanism in which the captive strength member of the cable is inside the barrel (body).

cy. Termini, M29504/4 & /5 style 3. A pin or a socket terminus with a cable strain relief capture mechanism in which the captive strength member of the cable is outside of the barrel (body) and the captive strength member is secured with an internal crimp sleeve.

cz. Terminus. Singular form for the word termini.

da. Terminus, Metal Ferrule with Jeweled Insert. A metal ferrule terminus that uses a watch-jewel with a precision centered hole placed at the ferrule end face.

db. Terminus, Pin. The male configuration of a terminus that consists of a metal barrel (body) and a metal or ceramic ferrule.

dc. Terminus, Socket. The female configuration of a terminus that consists of a metal barrel (body), a metal or ceramic ferrule and an alignment sleeve. The alignment sleeve attaches to the socket terminus ferrule. Fiber alignment occurs when the pin terminus slides into the alignment sleeve of the socket terminus.

dd. Transmitter (Fiber Optic). A fiber optic transmitter is a hybrid device, which converts electrical signals into optical signals and launches the optical signals into an optical fiber.

de. Weapons Replaceable Assembly (WRA). Any replaceable electronics or aviation box within the aircraft.

df. Wipe. A consumable used to clean the ferrule end face that is configured as a sheet of absorbent material. Absorbent material of a lint free nature that must meet constraints for abrasion (non abrasive to fiber end face), and cleaning efficacy (sufficient cleaning effectiveness for most common particles and film contaminants and for ability to absorb hydraulic oils, fuels and other aircraft and shipboard fluids).

Symbols

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

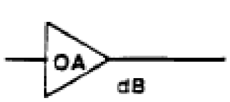
2. This work package lists common symbols (schematic representations) used in the electro-optics, photonics and fiber optic fields. These symbols are based on those listed in TIA-587.

3. SYMBOLS.

NOTE

Indicates the specific change in dB.

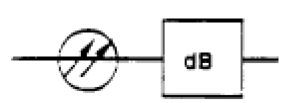
a. Amplifier, Optical.



NOTE

Indicates the specific change in dB.

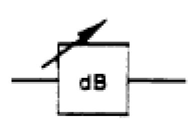
b. Attenuator, Optical.



NOTE

Indicates the specific change in dB.

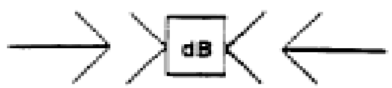
c. Attenuator, Variable, Optical.



NOTE

Indicates the specific change in dB.

d. Attenuator, Within a Connector Assembly, Optical.



NOTE

If no confusion arises, then the symbol denoting fiber optics may be deleted.

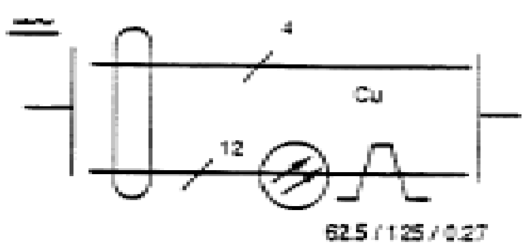
e. Cable, Simplex Fiber Optic (or Optical Fiber).

NOTE

Composite cable shown contains following supplementary information:

4 copper conductors
12 optical fibers with core diameter = 62.5 microns, clad diameter = 125 microns
NA = 0.27 (optional)

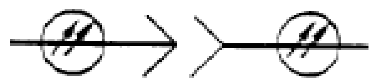
f. Cable, Composite.



NOTE

Male to female connection shown.

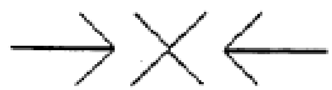
g. Connector, Plug-to-Receptacle Type, Optical.



NOTE

"NC" or "PC" can be added. (NC = non-contact. PC = physical contact).

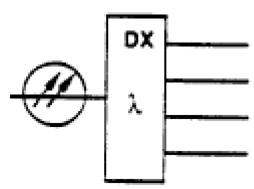
h. Connector, Male-to-Male with Mating Adapter Type, Optical.



NOTE

Four channel configuration shown.

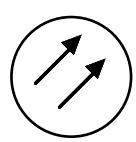
i. Demultiplexer, Wavelength (WDM).



NOTE

Use with other symbols to denote fiber optics.

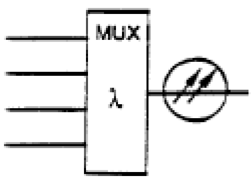
j. Denotation for a Fiber Optic Component.



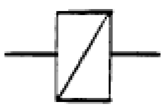
NOTE

Four channel configuration shown.

k. Multiplexer, Wavelength.

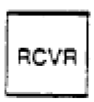


l. Polarizer.



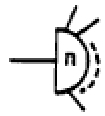
m. Polarization Controller.

n. Receiver.



o. Splice.

p. Splitter, Optical.

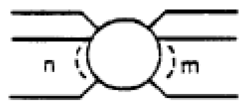


NOTE

n by m star coupler shown.

Change in dB may be placed in circle.

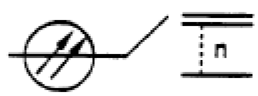
q. Star Coupler.



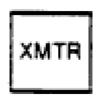
NOTE

1 by n switch shown.

r. Switch, Optical.



s. Transmitter.



THIS PAGE LEFT INTENTIONALLY BLANK

Labels

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This work package lists labels that are approved for common, multi-service usage across aircraft platforms.

3. SAFETY LABELS.

a. WRA Label.

THIS PAGE LEFT INTENTIONALLY BLANK

Safety and HAZMAT

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Safety	004 01	13 August 2004
HAZMAT	004 02	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into two subordinate work packages for safety precautions and HAZMAT. The WP 004 01 for safety precautions lists those that must be observed when working with fiber optics. WP 004 01 is referenced in other work packages for theory, handling, inspection, cleaning, fiber optic termination, testing and troubleshooting, assembly and installation. The WP 004 02 for Hazmat identifies HAZMAT used in the fabrication (including termination) and cleaning of fiber optic cable topologies. WP 004 02 is referenced in other work packages for troubleshooting, testing and installation.

THIS PAGE LEFT INTENTIONALLY BLANK

Safety

Reference Material

ANSI Z136.2

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION. This work package lists the general safety precautions that must be practiced when working with fiber optics. Other work packages will reference this one and may add to or emphasize particular safety precautions.

2. GENERAL SAFETY PRECAUTIONS. The following general safety precautions shall apply:

a. Observe and follow all written safety precautions given in the methods of this and other work packages contained within this manual.

b. Observe and adhere to all Warning/Caution/ Advisory signs on equipment and materials.

c. Observe and adhere to all Warning/Caution/ Advisories/Notes in the applicable Type/ Model/Series aircraft manuals for repair of and operational verification of Fiber Optic repair.

3. LASER SAFETY.

a. Laser Classification Overview: The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operation an optical fiber communication system (OFCS) is inherently an eye safe system, but when an optical fiber connection is broken and an optical viewing instrument is used, it is possible that hazardous laser energy can enter the eye. For this reason four service group hazard classes (Class 1, 2, 3 (a & b), and 4) have been devised to indicate the degree of hazard and required hazard control measures. Refer to ANSI Z136.2 for a full technical definition and preventive measures.

b. Laser Safety Precautions:

(1) Observe and adhere to all Warning/Caution/Advisories/Notes in the applicable Type/Model/Series aircraft manuals for repair of and operational verification.

(2) Ensure personnel are familiar with the degree of hazard and the required control measures for the laser in use.

(3) Light generated by light emitting diodes (LED's) and laser diodes may not be visible, but may still be hazardous to the unprotected eye. Never stare into the end of an optical fiber connected to an LED or laser diode and do not stare into broken, severed or disconnected optical cables.

(4) Do not view the primary beam or a specular reflection from an OFCS with an optical microscope, eye loupe or other viewing instrument. The instrument may create an eye hazard due to its light gathering capability.

4. FIBER OPTICS SAFETY PRECAUTIONS:

a. Keep all food and beverages out of the work area. If fiber particles are ingested they can cause internal injury.

b. Do not smoke while working with fiber optic systems.

c. Always wear safety glasses with side shields. Treat fiber optic splinters the same as you would glass splinters.

d. Never look directly into the end of fiber cables until you are positive that there is no light source at the other end. Use a fiber optic power meter to make certain the fiber is dark.

e. Do not touch the ends of the fiber, as they may be razor sharp. Rinse hands thoroughly under running water to rinse away any glass shards.

f. Contact wearers must not handle their lenses until they have thoroughly rinsed and then washed their hands.

g. In the event glass shards enter the eye or penetrate the skin seek medical attention immediately. **DO NOT** rub your eye. Only authorized medical personnel should attempt removal of glass shards from the eye. **DO NOT** attempt removal of glass from the eye yourself.

h. Do not touch your eyes while working with fiber optic systems until your hands have been thoroughly cleaned.

i. Clean hands thoroughly first by rinsing hands under running water to rinse away any glass shards after handling and repairing fiber. Then wash normally. Wear protective gloves if at all possible.

j. Keep all combustible materials safely away from heat sources.

k. Ultraviolet (UV) safety glasses shall be worn when using the UV curing lamp.

l. Only work in well-ventilated areas.

m. Avoid skin contact with epoxies.

HAZMAT

Reference Material

49 CFR (Code of Federal Regulations), Parts 171-179

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This work package addresses guidelines for the transportation and disposal of two-part epoxy (those currently approved for use on aircraft and ships) and of isopropyl alcohol used in fiber optic connector terminations and cleaning procedures. Guidelines are provided for disposal of fiber ends and consumable materials used while working with epoxy also. This guidance is general and appropriate for most, if not all applications. This guidance and the materials used are not meant to be all-inclusive and must be augmented / tailored for each service being performed (installation or repair) and for variations in Local and State ordinances. Consult your Activity HAZMAT Officer for final guidance.

3. HAZARDOUS MATERIAL TRANSPORTATION.

a. General. Two-part epoxy, as listed under those currently approved for use on aircraft and ships, and isopropyl alcohol may be shipped by air transportation in limited quantities. Proper markings and labels must be present on the package. All shipping and labeling must be in accordance with 49 CFR (Code of Federal Regulations), Parts 171-179. Site/Facility personnel trained for shipment of hazardous materials must complete the hazardous material shipping forms and provide/verify proper markings and labels on the package.

b. Transportation Information on MSDS. The Material Safety Data Sheet written in the last five years may contain transportation information. The USDOT or IATA ID number must be provided to determine allowable methods to ship the material.

c. Waste and Expired Shelf Life Materials. Arrangements must be made to have materials disposed of at the facility where the work is being done.

4. HAZARDOUS MATERIAL WASTE DISPOSAL CONTROL MEASURES.

a. Two-Part Epoxy. Two-part epoxies, as listed under those currently approved for use on aircraft and ships, come in packets separated into two parts, hardener and resin. The hardener is a corrosive material. The gelled epoxy becomes a piece of thermoset plastic and may be disposed of as non-hazardous waste. Leftover epoxy, that has been mixed, may be disposed of with the non-hazardous waste once it is hardened. Some types of two-part epoxies may need to be heated in order to cure. If the hardener goes bad, then the epoxy will not gel and must be disposed of as hazardous waste. Consult your Activity HAZMAT Officer for final guidance.

b. Fiber Ends. Preferred disposal for cleaved ends of optical fiber is to place them in a plastic bottle. An alternative means is to wrap the fiber in a layer of tape. The placement of fiber ends in a bottle is preferred since tape wrapped fiber usually is deposited into local, trash cans. Personnel emptying these trash cans are not aware of the potential fiber hazard to their hands and may compress trash or remove stuck tape by hand. The plastic bottle should have a small neck (so fiber ends do not spill out easily if tipped over). Also, do not use a snap-off cap or cover (so fibers do not launch out of the bottle in the jerking motion of opening the bottle cap).

c. Isopropyl Alcohol. This is a landfill-banned item. Non-used alcohol, such as contaminated bottles, must be disposed of as hazardous waste. Consult your Activity HAZMAT Officer for final guidance.

d. Consumable Material Containing Mixed, Dried Epoxy. Dispose of dirty rags, wipes, syringes and other consumable material containing mixed, dried epoxies by placing them in a waste container.

e. Canned Liquidfied Gas for Microscopic Dusting. Product is under pressure. Do not puncture or incinerate. Disposal must comply with Federal, State and local regulations. Consult your Activity HAZMAT Officer for final guidance.

Theory

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Theory of Fiber Optic Link Operation	005 01	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for fiber optic theory. The first subordinate work package, WP 005 01 addresses theory of fiber optic link operation. Future work packages are planned to address unique techniques to be used for specific configurations.

THIS PAGE LEFT INTENTIONALLY BLANK

Theory of Fiber Optic Link Operation

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. SCOPE. This WP provides basic supplementary information on fiber optic theory relative to the operation, support and maintenance of aircraft fiber optic links. A formal self study course on fiber optics is the Navy Electricity and Electronics Training Series, Module 24, Introduction to Fiber Optics. The scope of this WP is limited to fiber optic interconnect components between fiber optic transmitting units and fiber optic receiving units. This WP does not address internal components of fiber optic transmitter and fiber optic receiver units.

2. BACKGROUND. Aircraft fiber optic links require more rugged components than fiber optic land links. Fiber optic links in tactical aircraft require more rugged components than links installed in pressure compensated aircraft cabins. Individual aircraft platform programs are responsible for choosing fiber optic components suitable for use in expected environments. The components discussed herein are representative of components that have been selected for use in aircraft applications.

3. INTRODUCTION. A simple, one fiber, one direction, box to box fiber optic link is shown in Figure 1. The link consists of four component types. Fiber optic transmitters convert input signals from electrical to optical (EO) and transmit light out. They transmit infrared (IR) light generated from LED or laser diode sources. Fiber optic receivers convert input light from optical to electrical (OE) and transmit electronic signals out. Typically, fiber optic transmitters and receivers are bundled together in one unit called a fiber optic transceiver. Fiber optic cable carries the light in an optical glass channel from one end of the link to the other. Fiber optic connectors provide a mating interface between fiber optic cables and fiber optic enabled devices.

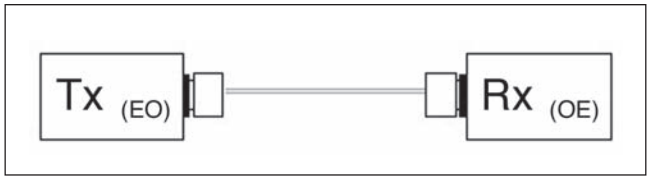


Figure 1. Simple Fiber Optic Link

4. SAFETY. Fiber optic links pose two primary safety concerns.

a. Exposure to Glass. Exposed fiber optic glass is a physical hazard. The exposed glass is easy to break. Once broken, small, sharp splinters can stick to and penetrate the skin. Small chards can then easily be transferred from fingers to other vulnerable body parts like the eyes. Exposure of fiber optic glass by inadvertent cutting of fiber optic cables from tool usage or chafing must be avoided. Aircraft fiber optic cables are constructed with an outer jacket, a protective braided fabric strength member and a buffer material to protect the fiber. It is important to note that the glass inside a fiber cable can be broken without damaging the outer cable construction. This can be done with excessively tight cable clamping and by greatly violating the specified minimum bend radius of a fiber cable. Generally this type of broken fiber is not a physical hazard until a repair is tried that could expose the broken glass.

b. Exposure to IR Radiation. The other primary safety concern posed by fiber optic links, is exposure of eyes to IR radiation. Fiber optic transmitters transmit IR light generated from either LED or laser diode sources. Fiber optic transmitters with laser light sources, and the devices they are embedded in, are required to be labeled with a Laser Hazard Classification if they fall within a laser hazard class. Devices not falling within a laser hazard class, such as LED light sources, may not be labeled as transmitters even though they may be transmitters of IR or visible light.

c. IR Exposure Scenarios. The most likely scenario for eye exposure to occur is with unmated connectors from a fiber optic capable device that is powered up. These devices may include fiber optic test equipment as well as installed WRAs, LRMs and avionics boxes. IR radiation is not visible, so the only condition indicating that an unmated connector may be transmitting is whether an associated unit is powered up. Therefore, maintainers should avoid starring into unmated connectors and should be aware when fiber optic capable devices are powered up. Currently (2004), most if not all, aircraft fiber optic transmitters are rated as Class-1 laser transmitters, or they are safe enough to not require labeled hazard classification. Class-1 laser transmitters are generally exempt from radiation hazard controls during operation and maintenance. Maintainers however, need to be aware of applicable fiber optic transmitter classification ratings for fiber optic capable units.

5. LINK LOSS BUDGET. Fiber optic links are not 100% efficient sending light from a source to a destination. Every interconnect and component that the light passes through has some scattering loss and absorption loss associated with it. Digital fiber optic links are generally designed to work within a link loss budget including known losses (e.g. due to connectors, aging and environmental factors) and some unknown losses. A link's "margin" is designed to cover unknown losses. A link margin of 3 dB is a reasonable design value that would allow a link to function if half of the light is lost due to an unexpected condition. An unexpected condition might be degraded performance of a defective transmitter, receiver, cable or connector.

6. CHARACTERISTICS OF AIRCRAFT LINKS. Aircraft fiber optic links have several distinguishing characteristics. They are short (typically less than 300 feet). They generally contain less than 5 cables in series. Fiber optic cable(s) may be bundled with the copper wire cable(s). The link loss (optical loss) of a "healthy" aircraft fiber optic link is dominated by the number of series connectors in the link rather than the losses due to cable lengths. For comparison purposes, the optical loss incurred passing through one mated connector is higher than the loss incurred passing through a 500 foot length of fiber optic cable.

7. COMPONENTS OF FIBER OPTIC LINKS.

a. Fiber Optic Transmitters. Fiber optic transmitters are embedded within WRAs, LRMs, avionics units and test equipment. Their purpose is to modulate the light they emit with a signal (digital or analog) they are to transmit. Within fiber optic transmitters, LED or laser diode photo-emitters emit IR radiation. The photo-emitters within fiber optic transmitters are chosen for the specific applications they are intended. Simple point-to-point or switched digital fiber optic links are more cost effectively implemented as multimode links. Wavelength multiplexed and high bandwidth analog links are implemented as single mode links. Multimode and single mode fiber optic applications will use different photo-emitters. Primary differences of photo-emitters include: type (laser diode or LED), IR wavelength (near IR to mid IR), output power (microwatts to milliwatts) and optical launch (restricted to overfilled).

(1) Fiber Optic Transmitters in Test Equipment. Test equipment functioning as fiber optic transmitters are called Optical Sources. Optical sources are used to test fiber optic links for optical loss measurements. These measurements are generally invalid or inconclusive when made with optical sources that do not have the appropriate characteristics for the link they are used to measure. Appropriate characteristics include: fiber type (multimode or single mode), fiber core/clad size (various), source type (laser diode or LED), source wavelength (near IR to mid IR), source power (microwatts to milliwatts) and optical launch (restricted to overfilled). Extreme care must be taken in choosing appropriate optical sources for making optical measurements of aircraft fiber optic links.

b. Fiber Optic Receivers. Fiber optic receivers are also embedded within WRAs, LRMs, avionics units and test equipment. Within fiber optic receivers, photodetectors convert received light into electrical energy. The photodetectors within receiving equipment are chosen for the specific applications they are intended. Multimode and single mode fiber optic applications will likely use receivers with different photodetectors. Photodetectors vary by the size of their photosensitive active areas and their wavelength sensitivity (near IR to mid IR).

(1) Fiber Optic Receivers in Test Equipment. Test equipment with fiber optic receivers include power meters for optical loss measurements. Fiber optic receiver characteristics must be appropriate for both the optical source used and the fiber optic link being measured. These measurements are generally invalid or inconclusive when made with power meters that do not have the appropriate characteristics for the fiber optic link they are used to measure and for the optical source in which they are used. Appropriate characteristics include: source wavelength (near IR to mid IR), and source power (microwatts to milliwatts). Extreme care must be taken in choosing appropriate power meters for making optical measurements of aircraft fiber optic links.

c. Fiber Optic Connectors. The most common connector chosen for use with aircraft fiber optic links is the MIL-DTL-38999 Series-III connector. Figure 2 depicts an eight fiber, fiber optic link with MIL-DTL-38999 Series-III bulkhead and plug connectors. These connectors are compatible with both electronic and fiber optic pins and sockets. Fiber optic pins and sockets are called fiber optic termini. Dirt, wear, or inadequate connector tightening can interfere with the precise alignment requirements of fiber optic termini in fiber optic connectors.

(1) Fiber Optic Termini. Fiber optic termini provide a low-loss, light transparent termination for fiber optic cable (see Figure 3). To be low-loss, the glass in a fiber optic termini is polished to be smooth, scratch free and chip free. The surface topology or geometry is also precisely controlled. Maintaining these polished surface characteristics and keeping them clean is essential to keeping a fiber optic link operational. Fiber optic termini consist of a ferrule and a metal housing. When mated, in a connector, fiber optic termini are butted together against their ferrule end faces. The ferrule has a precision central hole to hold the glass fiber. The glass fiber is bonded to the ferrule with an epoxy that is rated to withstand an expected airborne environment. The metal housing is bonded to the fiber optic cable. Socket termini have a guide (alignment) sleeve that covers their ferrule. The fiber optic termini used in MIL-DTL-38999 Series-III connectors are MIL-PRF-29504 termini. Two styles of these termini are shown in Figure 3. A primary differentiation between styles is the cable strength member capture method.

(2) Termini End Face. The polished end of a fiber optic termini is called an end face. Handheld tools (such as FOVIS) allow two dimensional, magnified inspection of fiber optic end faces, right at a fiber optic connector. Three end face images from such a tool are shown in Figure 4. The lighted central area indicates the fiber core region. Note the core diameters. The diameter of human hair (about 70 microns) is comparable to the core sizes shown in the two end face images on the left.

(3) Termini Topography. The elevation dimension of an end face can not be witnessed in the Figure 4 images. The elevation dimension describes the surface elevation topography of the glass and the ferrule surfaces (alternately called end face geometry). The ferrule surface elevation topography is usually domed (convex) but can be flat. Figure 5 shows two domed ferrule end faces butted up against one another as they would be in a mated connector. The glass (core and cladding) surface elevation topography can be domed (convex), or non-contact (concave).

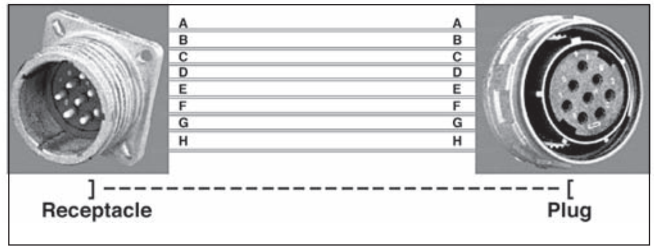


Figure 2. 38999 Series-III Connectors, Part of an Eight Fiber, Fiber Optic Link

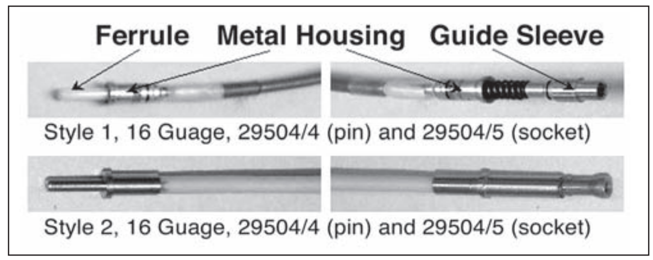


Figure 3. Sample MIL-PRF-29504 Fiber Optic Termini, Pin and Socket Samples for 38999 Series-III Connectors

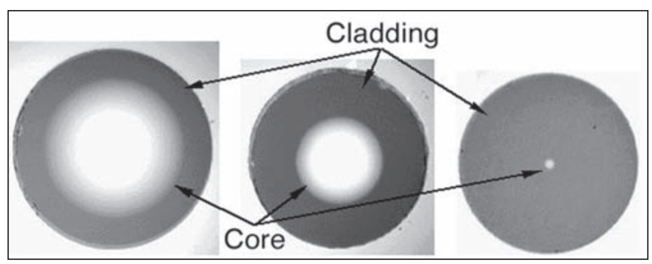


Figure 4. Fiber End Face Images with Light in the Cores From Left to Right (Core/Clad Sizes in Microns) 100/140(multimode), 62.5/125(multimode) and 9/125(single-mode)

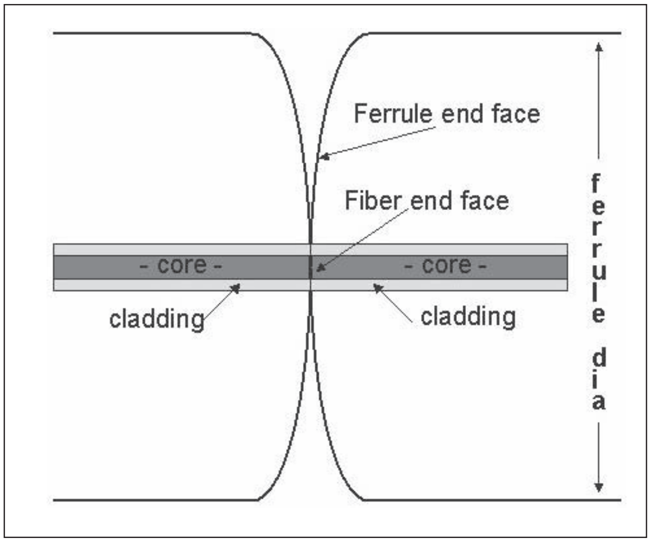


Figure 5. Physical Contact of Two Fiber Optic Termini (Note Glass and Ferrule Are in Contact)

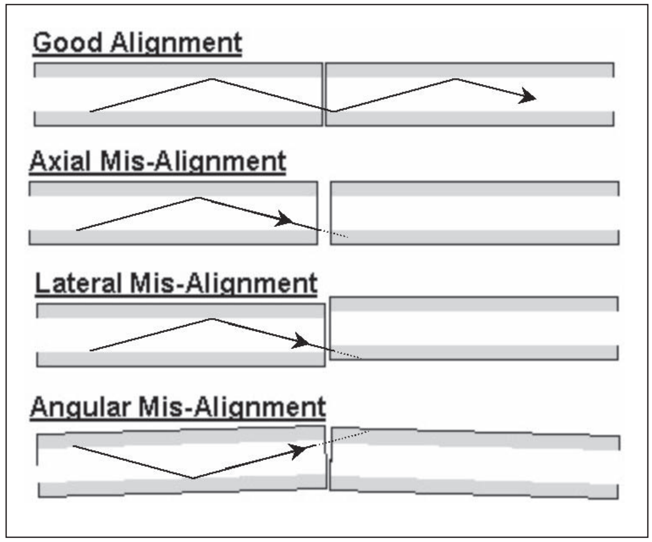


Figure 6. Examples of Good and Poor Alignment in Fiber Optic Connectors

(4) Polish. The surface elevation topography of the glass is set when a termini is polished. Physical Contact (PC) or Non-Contact (NC) may be specified for the fiber polish. The design intent of a PC polish is for the glass cores of connectorized, mated termini to be in physical contact. The PC polish is the dominant type across land, sea and air applictaions, however both types are specified for use in aircraft today. Mating a PC polished termini to a termini with a non-contact polish is a dissimilar configuration that is not recommended. Mated non-contact polished termini result in ferrule to ferrule contact with a slight gap (typically less than 1 micron) between the glass surfaces.

(5) Polishing Proceedure Controls. Polishing fiber end faces requires procedures with controls in them to guarantee the resulting surface elevation topography profile is within specification and the two dimensional, magnified images show acceptably smooth, scratch free and chip free surfaces. This is typically a multi step process with strict, reliability and reproducibility requirements.

(6) Problem Areas. Fiber optic connectors perform critical alignment tasks of minimizing axial, lateral and angular misalignment of fibers in mated connectors. Examples of these three misalignment types are depicted in Figure 6. Fiber optic termini are also very succeptable to accumulating dirt while connectors are unmated (due to humidity, aerosols and airborne particulate). This makes connectors a likely place to look when a problem with a fiber optic link is suspected.

(a) Alignment. Axial misalignment (see Figure 6) is most likely to occur when connectors are not tightened properly. It leaves a gap between fibers that lets light leak out and scatter away. The resulting loss will increase as the width of the gap increases. With MIL-DTL-38999 Series-III connectors a visible red inspection ring indicates an inadequitely closed connector. A small gap ($^1/_{16}$ of an inch) can cause a 20 dB loss which will fail any fiber optic link. A 20 dB loss is equivelent to an attenuation factor of $^1/_{100}$. Lateral and angular misalignment are likely to be caused by aging of mechanical parts within connectors.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(b) Dirt. Dirty fiber optic end faces on termini and improperly tightened connectors are expected to be the most likely causes of an intermittent or failed fiber optic link on aircraft. Dirt can rapidly accumulate on termini of an unmated connector due to moisture, aerosols and particulate in the air. A piece of dirt completely covering a half moon section of a core will cause a loss of 3 dB (or half the light). While all of the light travels in the core of a fiber, most of the light travels in the center of the core. Therefore a spot covering much less than half the area of the core can also cause a 3 dB loss, if it is in the center of the core. A 3 dB loss can possibly fail a fiber optic link, if some aging has occurred and if the link's design margin is small. Dirt is important to eliminate when it is discovered. Since connectorized, mated termini are always in compression, dirt left on an end face will become more difficult to remove (and possibly cause damage) if connectors are re-mated without cleaning the dirt away.

d. Fiber Optic Cables. Fiber optic cables carry light from fiber optic transmitters to fiber optic receivers. A thin optical fiber is packaged in larger diameter fiber optic cable to make it more rugged and easier to handle.

(1) Fiber Construction. The optical transport component of aircraft fiber optic cable is a glass strand consisting of a glass core region that is concentrically surrounded by a glass cladding region. Figure 4 shows fiber end face images with clearly distinct core and cladding regions for three different fiber size configurations.

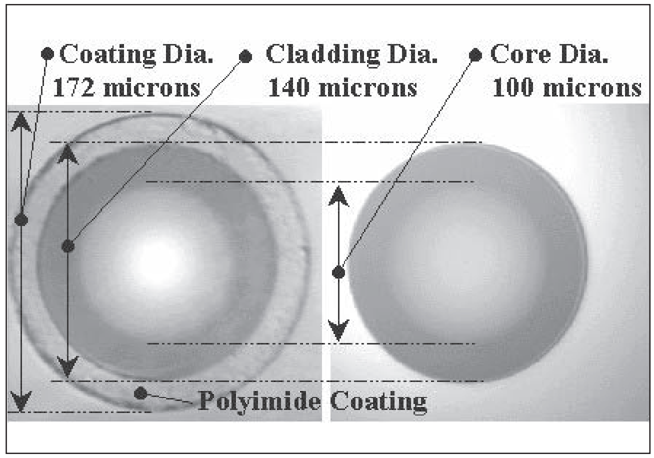


Figure 7. Diameters: Core, Cladding and Coating, 100/140 Fiber With and Without Polyimide Coating

(a) Optical Fiber Coating. Optical fiber in tactical aircraft interconnect cables typically has a 10 to 20 micron thick protective polyimide coating. The coating tolerates extreme temperatures and protects the glass fiber from penetration by moisture and other contaminants. The coating is softer than the glass fiber and the ceramic ferrule. Optical fiber cables in avionics units or in pressurized aircraft installations may not have this polyimide coating. Figure 7 shows a 100/140 micron fiber with and without the coating. This permanent protective coating increases the overall fiber diameter of a 100/140 micron fiber to 172 microns.

(2) TIR. Light is kept in the fiber core and continually reflected forward by maintaining a condition called Total Internal Reflection (TIR). The conditions required for TIR depend on a critical angle α_c which is determined by the index of refraction property of the core and clad materials. TIR fails when incident rays of light impact the core/clad boundary at an angle less than the critical angle (See α_c in Figure 9). Violation of a fiber optic cable's bending specification and localized external stress on a fiber optic cable are the primary reasons for TIR to fail.

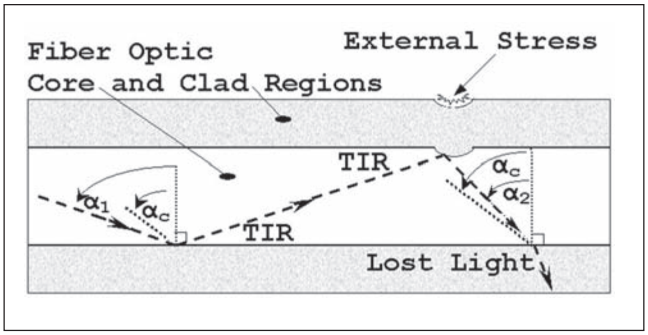


Figure 8. Total Internal Reflection (TIR) in a Fiber Core (α_c is the Critical Angle)

(3) Light Leaks (Bend Loss). External stress on a fiber cable or bending beyond a cable's specified minimum bend radius causes rays to impact at angles less than the critical angle. When this occurs light exits the fiber core and is lost. Figure 8 shows TIR in a fiber core and lost light when the TIR condition is not met. Localized external stresses on a fiber cable that cause light to deflect out of the core are called microbends. Microbends are caused by excessively tight cable clamps, strangling string ties and improper routing. Extreme cases of overtight cable clamps and string ties can break the glass fiber.

(4) Acceptance and Exit Angle**.** Optical fibers can only accept and emit light over very narrow input and output angles called the acceptance and exit angles. The acceptance and exit angles of a fiber are equal, and are determined from the the index of refraction property of the core and clad materials. Typical values range from 8 to 16 degrees (See α_a and α_e in Figure 9). The fiber specification that describes the acceptance and exit angles of a fiber is called Numerical Aperature (NA). The mathematical relationship between NA and acceptance angle is: NA = Sine α_a. The acceptance and exit angles of a fiber are important in understanding the high loss incurred when an unexpected gap exists between mated fiber termini in a connector. When a gap exists, the projected cone of light from the transmitting fiber rapidly exceeds the core size of the receiving fiber, causing a high loss.

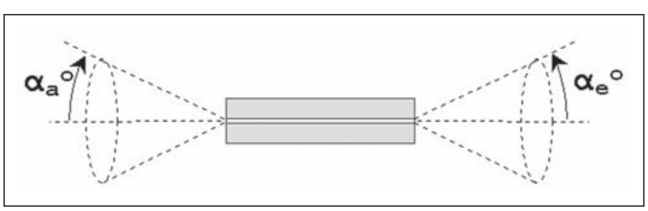


Figure 9. Acceptance and Exit Angles of a Fiber

(5) Bending Specifications. Manufacturers and suppliers specify a safe minimum bend radius or minimum bend diameter for fiber cable (typically an inch or two for single fiber cable). Exceeding this specification causes a high loss condition where light leaks out of the fiber core. Greatly exceeding this specification will result in breaking the glass fiber, which will fail a fiber optic link. Bending losses and breakage are caused by improper cable routing or improper cable clamping. Glass broken by excessive bending will remain contained inside the fiber optic cable's protective covering.

CAUTION

There is no common standard color coding scheme used across all aircraft platforms.

(6) Color Coding. There is no common standard color coding scheme used across all aircraft platforms.

8. LINK LOSS MEASUREMENT**.** Generally a fiber optic link's loss (or optical loss) is specified in units of dB. A link loss measurement in dB, describes how much more loss the fiber optic link has than a high quality, pristine fiber optic reference cable. High quality, pristine fiber optic reference cables are called COTS Measurement Quality Jumpers (CMQJ). A fiber optic link's loss is calculated in three steps.

a. Calculating Fiber Optic Link Loss.

(1) Measure optical power (dBm) transmitted through a CMQJ. Call it P_1.

(2) Measure optical power (dBm) transmitted through the CMQJ and the test link. Call it P_2.

(3) Calculate Loss.

Loss (dB) = $P_2 - P_1$

Table 1. Loss dB and Attenuation Factor

Loss (dB)	Attenuation Factor
-3	1/2
-6	1/4
-9	1/8
-10	1/10
-20	1/100
-30	1/1000

b. Units. Units of dB are power measurement units relative to any stable power level as the reference level. Negative units indicate loss. Positive units indicate gain. All fiber optic link components are passive and have no gain or amplification associated with them. Therefore loss measurement numbers should be negative numbers. Positive loss numbers generally indicate a bad measurement setup. Units of dB should not be confused with units of dBm. Units of dBm are power measurement units relative to a one milliwatt power level. An alternative way to describe loss is as an attenuation factor that is always less than 1. Table 1 is presented as a comparison of loss in dB versus an equivalent attenuation factor. The conventional way to specify the loss of a fiber optic link is in units of dB.

c. CMQJ Types. COTS Measurement Quality Jumpers (CMQJs) are used to make optical loss measurements. CMQJ characteristics must be appropriate for both the fiber optic link being measured and the test equipment used (optical source and power meter). These measurements are generally invalid or inconclusive when made with CMQJs that do not have the appropriate characteristics for the fiber optic link they are used to measure and for the test equipment used. Appropriate CMQJ characteristics include: fiber type (multimode or single mode), fiber core/clad size (various), polish type (PC, NC), connector type (test probe, MIL-DTL-38999, ST, FC) and connector ferrule tolerance (STD or tight). Extreme care must be taken in choosing appropriate CMQJs for making optical measurements of aircraft fiber optic links.

9. REPAIR, FIBER OPTIC CABLES. Fiber optic cables need repair when connectors malfunction, when fiber end faces are dirty or damaged, when bending and microbending losses are excessive or when the glass has been broken.

a. Non-catastrophic Damage. Non-catastrophic damage to fiber optic cable is damage that can be repaired without installation of new fiber optic cable. The following are listed in an order of expected likelihood. All of these can cause a link to become inoperative due to excessive optical loss.

(1) Loose Connector. Loose connectors result in an excessive gap between mated fiber termini inside connectors. Connectors must be inspected for proper tightening.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(2) Dirty Fiber Optic Termini. Dirty termini end faces must be inspected and cleaned with approved materials and procedures. If dirt is left and connectors are re-mated, the dirt will become more difficult to remove and may become permanent damage. See WP 008 02.

(3) Excessive Bending Losses. Excessive bending losses due to poor cable routing and excessively

tight clamping (microbends), must be remedied by cable rerouting and adjustments to cable clamping. See WP 006 01 and WP 012 01.

(4) Unseated Fiber Optic Termini. Unseated pin or socket termini result in an excessive gap between mated fiber termini inside connectors. Termini must be reseated with the appropriate insertion tool.

(5) Damaged Connector. Damaged connectors can cause misalignment of mated termini inside connectors (See Figure 6). Connector damage due to aging and wear requires replacement of the connector plug or receptacle.

b. Catastrophic Damage. Catastrophic damage requires some new fiber cable to be installed. All of the following can cause a link to become inoperative due to excessive optical loss.

(1) Broken Glass Fiber. Repair is currently limited to installing a single replacement fiber optic cable. See WP 012 01 and WP 013 01.

(2) Scratched, Chipped End Face. Repair is currently limited to installing a single replacement fiber optic cable. See WP 012 01 and WP 013 01.

(3) Permanent Dirty End Face. Repair is currently limited to installing a single replacement fiber optic cable. See WP 012 01 and WP 013 01.

THIS PAGE LEFT INTENTIONALLY BLANK

Handling

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
General Handling Practices for Fiber Optic Harnesses	006 01	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for different types of handling guidance. The first subordinate work package, WP 006 01, addresses general guidance for handling fiber optic cable harnesses and components. Future work packages are planned to address unique techniques to be used for specific configurations.

THIS PAGE LEFT INTENTIONALLY BLANK

General Handling Practices for Fiber Optic Cable Harnesses

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

2. This work package provides general guidance for handling fiber optic cable harnesses and components. The guidance includes cable bend diameter considerations, handling practices within the aircraft, placement with electrical cable, connector/termini terminations, handling do's and don'ts, and transporting.

3. GENERAL HANDLING PRACTICES.

a. General Summary. Fiber optic cable harnesses and components must be handled with care. There is much similarity between the handling of optical fiber cable and standard copper wiring harnesses. However, there are some unique differences requiring attention when working in and around optical fiber cables. The degree of care involved in this handling is listed in this WP. The next few statements are the key considerations for proper handling of optical fiber cables. They should be taken into consideration whenever working on or around cables containing optical fibers.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(1) Never bend fiber optic cables in excess of the minimum bend diameter.

(2) Always seek the largest possible bend diameter, when bending is necessary.

(3) Never fold fiber optic cable, or connectors on the cable, back over themselves.

(4) Never kink fiber optic cables. This will break the fiber.

(5) Never place fiber optic cable onto sharp bends.

(6) Always inspect and clean (see WP008 02) the connections prior to mating.

(7) Never excessively tighten or clamp fiber optic cable. The degree of tightness must be snug.

(8) Never pry from clamps/straps, use as a hanger for tools/implements, or use as a hand hold/foot hold any installed cable, cable bundle or cable harness.

(9) Always cover connectors/termini with protective covers (ESD or dust caps) immediately after unmating (for any reason such as interval maintenance or just to gain access).

b. Cable Bend Diameter Considerations.

(1) Minimum Bend Diameter. The minimum bend diameter is the diameter at which a cable or cable harness can be bent without degrading optical performance or the diameter at which a loose tube cable, convoluted tube or conduit can be bent without kinking (tube collapse causing fiber breakage). Two types of minimum bend diameters, short-term and long-term bend diameters, must be considered.

(2) Short-term bend diameter. The short-term bend diameter applies during handling and installing. When the short-term bend diameter is not specified:

(a) Use a value of eight times the cable diameter for simplex, tight buffer cable (e.g. 2 mm diameter for simplex type buffer cable results in a 16 mm cable diameter. Also note that four times the cable diameter if working in terms of cable bend radius).

(b) Use a value of 20 times the cable diameter for simplex, loose tube cable (e.g. 2 mm diameter loose tube cable results in a 40 mm cable bend diameter).

(c) Use a value of 20 times the tube diameter for convoluted tube or conduit (e.g. 0.5 inch convoluted tubing results in a 10 inch cable bend diameter).

(3) Long-Term Bend Diameter. The long-term bend diameter applies to the completed installation. When the long-term bend diameter is not specified:

(a) Use a value of 16 times the cable diameter for simplex, tight buffer cable (i.e., eight times the cable diameter if working in terms of cable bend radius).

(b) Use a value of 20 times the cable diameter for simplex, loose tube cable.

(c) Use a value of 20 times the tube diameter for convoluted tube or conduit.

c. Handling Practices Within the Aircraft.

(1) General Practice Tips.

(a) Bend diameter. Secure cables, cable bundles or cable harnesses as close as possible to the equipment without violating the long-term bend diameter.

(b) No external loading. Do not place any tension, compressive or bending force during handling and placement of the cable, cable bundles or cable harness.

(c) Use of protective sleeve. Use protective sleeves in locations where rubbing or sharp surfaces cannot be avoided and rerouting is not practical. Do not use protective sleeves in lieu of good routing practices.

(d) Use of Conduit. Guidance addressing installation of fiber optic cables and use of conduit is covered in WP 011.

(e) Use of Over-braiding. Guidance addressing installation of fiber optic cables and use of over-braid is covered in WP 011 01.

(f) Cable repair, remove and replace. Do not route replacement cable over any topology or obstruction that will place microbends into the cable. Microbends cause added loss.

(2) Placement in Cable Clamps.

(a) Insert cable into a cable clamp without damaging the cable structure, excessively bending the cable, and without using excessive force. If possible, open the cable clamp and lay the portion of the cable, cable bundle or cable harness into the cable clamp. If the clamp can not be opened, pull the cable through the clamp applying the minimum amount of force and without damaging the cable structure. Do not push fiber optic cable through a cable clamp.

NOTE

If a cushioned clamp (clamp with rubber channel or insert) is used, then no sliding should be evident when a moderate force is applied. Tighten cable, conduit and convoluted tube to constrain without constricting. This is to ensure that no deformation, kink or pinch will occur. Tighten cable wrap until constriction is observed, but no deformation, kink or pinch is evident.

(b) Tightening of cable clamp. Tighten cable clamps to the degree that the cable is snug, but to the extent that cable does not deform, kink or pinch. Ensure that the cable, cable bundle or cable harness will slide in the clamp when a moderate force is applied.

1 Conduit and non-metallic conduit. Tighten to constrain without constricting. Constricting the conduit or non-metallic conduit will kink the tube structure resulting in potential fiber breakage.

2 Cable wrap. Cable wrap may be tightened to point of constriction since the constriction does not create a hard point at which a kink will occur.

(3) Cable Slack.

(a) Ensure sufficient slack and strain relief between equipment and the last point of cable support for cable, cable bundles or cable harness entering hard-mounted equipment.

(b) Ensure an additional slack between equipment and the last point of cable support for cable, cable bundles or cable harness entering resilient or shock-mounted equipment that exceeds the travel distance of the resilient or shock-mount.

(c) Ensure sufficient slack between multiple termini connectors (such as the MIL-DTL-38999) attached to equipment and the last point of cable support for cable, cable bundles or cable harness.

(4) Placement with Electrical Cable.

(a) Supporting Cable. Ensure that optical cables do not support electrical cables.

(b) Cable Position. Place fiber optic cables, cable bundles or cable harnesses on top of electrical cables where the two types are to be mixed in the same cable clamps.

(c) Installation Sequence. Install fiber optic cables, cable bundles or cable harnesses last when mixed with electrical cables in the same cable clamp.

(d) Protective Coverings. Use protective coverings over the fiber optic cable, cable bundles or cable harness where the installation of electrical cables over fiber optic cable, cable bundles or cable harness cannot be avoided. Monitor the fiber optic cable during the electrical cable pull as an alternative to the use of protective coverings. Ensure that the fiber optic cable, bundles or cable harness does not support the electrical cable.

d. <u>Connector/Termini Terminations</u>.

(1) Stress at Termination Points. Handle cable, cable bundles or cable harnesses so as to prevent placing stresses on the connector/termini terminations. The rears of termini tend to be susceptible to breakage from mishandling such as sharp bends.

(2) Ferrule Protection. Keep dust covers or protective caps on termini and connectors whenever possible after unmating a connector.

(3) Connector Removal from Harness. Do not remove connectors during any operation involving cable, cable bundle or cable harness handling whenever possible (this prevents cables within bundles from relaxing to a different length). Additionally, connector removal may result in an additional inspect and clean operation (see WP008 02) and the corresponding time it takes.

(4) Pulling on Connector. Do not pull a fiber optic cable harness using the connectors as a handle to pull the cable. Take hold of the cables behind the backshell with one hand and pull gently. Support the connector with the other hand.

(5) Pulling on Cable in Direction Opposite of Connector. Do not pull on the cable immediately after the backshell in the direction opposite to the connector. Such pulls cause terminus misalignment and cable shifts resulting in increased optical loss. Instead, first release the connector on the end of the fiber optic cable and then support the connector as in (4) while pulling on the cable.

(6) Pulling on Termini. Do not pull a fiber optic cable bundle by the termini. Instead, take hold of the cables behind the termini with one hand and pull gently.

(7) Inserting Termini into Connector. Do not permit cable immediately after termini to be bent, kinked, or folded over while inserting termini into connector. This is likely if insertion is attempted without use of the proper insertion tool.

(8) MIL-DTL-38999 connector mating. Verify that the red inspection ring is covered (not visible) as one measure for proper mating and that the connector is tightened down completely.

e. <u>Handling Do's and Don'ts</u>.

(1) Do's.

(a) Do wear proper clothing and safety equipment (gloves, eye protection, etc.) as appropriate while performing handling operations.

(b) Do use a step ladder properly (reposition versus leaning over) to conveniently access fiber optic cables and connectors.

(c) Do pull slowly enough when installing cables so that you can readily notice if the cable gets caught.

(d) Do inspect and remove sharp edges, (including debris, burrs, etc. from bulkhead penetrations and other items) along the route in which the cable will be handled then placed.

(e) Do allow sufficient slack for ease of mating connectors and adequate strain relief.

(f) Do keep ferrules/termini covered once connectors are unmated.

(g) Do inspect and clean (see WP008 02) ferrules/termini before mating connectors.

(h) Do use an insertion tool when inserting termini into a connector.

(i) Do cover connectors/termini with protective covers (ESD or dust caps) immediately after unmating (for any reason such as interval maintenance or just to gain access).

(2) Don'ts.

(a) Don't exceed the minimum bend diameter.

(b) Don't subject cables, cable bundles or cable harnesses to sharp bends.

(c) Don't permit cables, cable bundles or cable harnesses to contact sharp edges.

(d) Don't permit cables, cable bundles or cable harnesses to be kinked, folded over or crushed.

(e) Don't permit cable immediately after termini to be bent or folded over while inserting termini into connector.

(f) Don't permit cables or cable harnesses to be stretched for mating connectors.

(g) Don't pry cables, cable bundles or cable harnesses.

(h) Don't support your work items (tools, lamps, etc.) from cables, cable bundles or cable harnesses.

(i) Don't use cables, cable bundles or cable harnesses as foot rests, steps or handholds.

(j) Don't use any pointed object (like a pencil) to count or otherwise contact ferrules/termini on/inside connectors. Similarly, don't bring sharp tools in contact with cables.

(k) Don't clean ferrule end faces without inspecting them before and after cleaning.

f. Transporting.

(1) Place the cable, cable bundle or cable harness in a coil that does not exceed the minimum bend diameter. Avoid bends, kinks and twisting.

(2) Support termini/connector ends and breakout segments. Place on a backing material and tie down. Tie the connectors and breakout segments to the coil when no backing material is available.

(3) Wrap the cable, cable bundle or cable harness in bubble paper.

(4) Place the cable, cable bundle or cable harness in container large enough so that the cable, cable bundle or cable harness will lay flat without altering the shape of the coils.

(5) Pick up the cable, cable bundle or cable harness by the coil, never by the connector or breakout segment.

(6) Isolate wrapped cable, cable bundle or cable harness during transportation to extent that no parts or equipment are stacked on top.

Troubleshooting

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Troubleshooting Strategy	007 01	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for troubleshooting. The first subordinate work package, WP 007 01 addresses Troubleshooting Strategy. Future work packages are planned to address unique troubleshooting techniques to be used for specific configurations.

THIS PAGE LEFT INTENTIONALLY BLANK

Troubleshooting Strategy

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. SCOPE. The scope of this troubleshooting strategy is limited to passive fiber optic links (and their components) between avionics boxes. This strategy does not address active components such as fiber optic transceivers. Fiber optic transceivers typically reside within avionics units. This WP provides intuitive guidance to supplement other troubleshooting tools of individual aircraft platforms.

2. BACKGROUND. Limitations of system designs (Built-In-Test) and automated troubleshooting tools may only provide isolation of a fiber optic communication failure to a specific, single channel, box to box, fiber optic link. This level of isolation does not distinguish between failures of the fiber optic transmitting unit, the fiber optic interconnect hardware or the fiber optic receiving unit. Troubleshooting is required determine whether the fiber optic link is at fault or whether associated WRAs, LRMs or avionics units are at fault. If the fiber optic link is at fault, further troubleshooting can isolate a fiber optic fault to a specific connector, terminus or cable. If the fiber optic link is not at fault the maintainer will need to consider whether the fault lies within an avionics unit.

3. INTRODUCTION. The handling of fiber optic cables requires a high level of care similar to that used with coaxial Radio frequency (Rf) cables. Connectors need to be mated properly and cable bending must be regulated. Failures of fiber optic links will often be attributable to handling practices. Appropriate handling practices are covered in WP 006 01, which may be superceded by the Platform maintenance manual. A fiber optic link has multiple possible failure sites and modes. Efficiently narrowing down these possibilities to the specific cause of a failure, requires a troubleshooting strategy that considers failure likelihood and the capabilities and effectiveness of troubleshooting tools.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

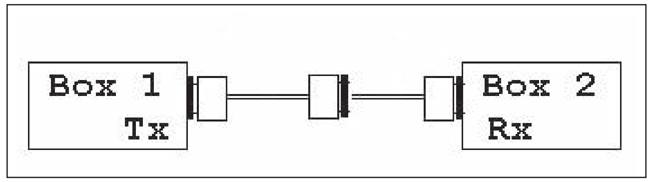


Figure 1. Failure Sites (A Single Channel, Box to Box, Fiber Optic Link)

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

4. FAILURE SITES. Every interconnect and cable in a fiber optic link is a possible failure site. This includes box mounted interconnects, intermediate cable interconnects and every cable in a link (See Figure 1). Failures at these sites will likely be related to physical disturbances due to maintenance actions, either related or unrelated to the link with the reported problem. Unrelated maintenance actions may have disconnected a fiber optic connector or pushed a fiber optic link cable just to gain access to unrelated equipment. This can result in dirt accumulating on exposed fiber optic termini, gapping between termini from inadequate connector re-tightening and broken optical fiber in a cable. Similarly, these same results can occur with the removal and reinstallation of fiber optic enabled WRAs, LRMs and avionics units. The handling of fiber optic link components requires vigilant adherence to appropriate handling practices. Appropriate handing practices are covered in WP 006 01 which may be superceded by the Platform maintenance manual.

a. Interconnects. Connectors are probably the most likely sites for fiber optic link failures. The most likely connector related problems that can cause a fiber optic link failure are gapping between termini from inadequate connector re-tightening and dirt accumulating on exposed fiber optic termini. When a

Table 1. Summary of Failure Modes with Likelihood, Expected Optical Loss Range and Corrective Action

Failure Sites	Failure Modes		Likelihood	Corrective Action
	Mechanical	Optical Loss(dB)		
Multiple Termini Connector (38999)	Insufficiently tightened connector	0.1 to open	High	Inspect & clean per WP 008 01, WP 008 02 then remate
	Dirty ferrule end face	0.1 to 10	High	Inspect & clean per WP 008 01, WP 008 02 then remate
	Damaged ferrule end face	0.1 to 30	Low	Repair optical fiber. See WP 012 01 and WP 013 01.
	Unseated termini	1 to open	Low	Reseat; Inspect & clean per WP 008 01, WP 008 02 then remate.
	Misaligned termini, worn connector parts	0.1 to 10	Low	Replace connector
Cable	Cable routing: Bend diameter violated	0.1 to 3	Medium	Reroute. See WP 012 01.
	Cable clamping: Excessively tight	0.1 to 3	Medium	Redo clamping: make snug. See WP 012 01.
	Broken optical fiber	30 to open	Low	Repair optical fiber. See WP 012 01 and WP 013 01.
	Broken optical fiber adjacent to production splice strain relief	30 to open	Low	Repair optical fiber. See WP 012 01 and WP 013 01.

loose fiber optic connector is found, all fiber optic termini shall be inspected and cleaned per WP 008 01 and WP 008 02 before re-tightening.

b. Cables. Fiber optic Cables are susceptible to degraded performance and damage when appropriate handling practices (see WP 006 01) are not followed. Fiber optic cables will become optically lossy as bending exceeds bending specifications. The optical fiber in cables will break when bending greatly exceeds bending specifications.

(1) Splices. Fiber optic splices installed in production manufactured cables are also possible failure sites. Prior to approval of a rugged, long-term use splice, temporary fiber optic splices may be found in some aircraft. Fiber optic splices change cable characteristics because they are more rigid and have a larger diameter than aircraft fiber optic cable. These changed cable characteristics make the fiber optic cable immediately adjacent to the splice somewhat more susceptible to breakage.

5. FAILURE MODES. Each failure site has multiple failure modes. Fiber optic termini inside connectors can become unseated, dirty or damaged. Connectors may be insufficiently tightened. Fiber optic termini may be misaligned due to worn or aged connectors. Cables can become optically lossy due to excessive bending or clamping. The optical fiber inside cables can be broken from excessive bending or clamping. The various failure modes each have ranges of expected optical loss that they could cause. These ranges are notable for their narrowness, wideness, maximums and minimums. The loss ranges estimated here are values that optical loss (link loss) test equipment can measure. Optical loss equipment can typically measure losses greater than fifty dB. Operational fiber optic links in comparison may typically only be able to handle a few to ten dB of loss. Table 1 Summarizes failure modes by likelihood, expected loss range and corrective action. A discussion of each failure mode follows.

a. Connector Failure Modes. Failure modes of connectors at WRAs, LRMs and avionics units as well as intermediate connectors in a fiber optic link must be considered. Connectors at box interconnects must be evaluated on the box side as well as the cable plug end. Similarly, intermediate connectors, such as through bulkhead connections, must be evaluated on the plug and receptacle sides.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

NOTE

Fiber optic terminus shall be inspected and cleaned per WP 008 01 and WP 008 02, unless superceded by the Platform maintenance manual.

(1) Insufficiently Tightened Connector. This mode is likely to occur whenever a connector is reconnected for any reason. When a loose fiber optic connector is found, its fiber optic termini shall be inspected and cleaned per WP 008 01 and WP 008 02 before re-tightening, unless superceded by the Platform maintenance manual. A loose connector causes a gap between mated fiber optic termini. With a gap, the projected cone of light from the transmitting fiber rapidly exceeds the core size of the receiving fiber. Loosening a connector behaves like a variable attenuator on the light sent from a transmitting termini to a receiving termini. The loss attributed to this mode can be anything from insignificant to greater than 50 dB (i.e. "open circuit"). When the full width of the red inspection line on a MIL-DTL-38999 connector is visible, the resulting gap for mated fiber optic termini pair could easily be a loss of 20 dB (See Figure 2).

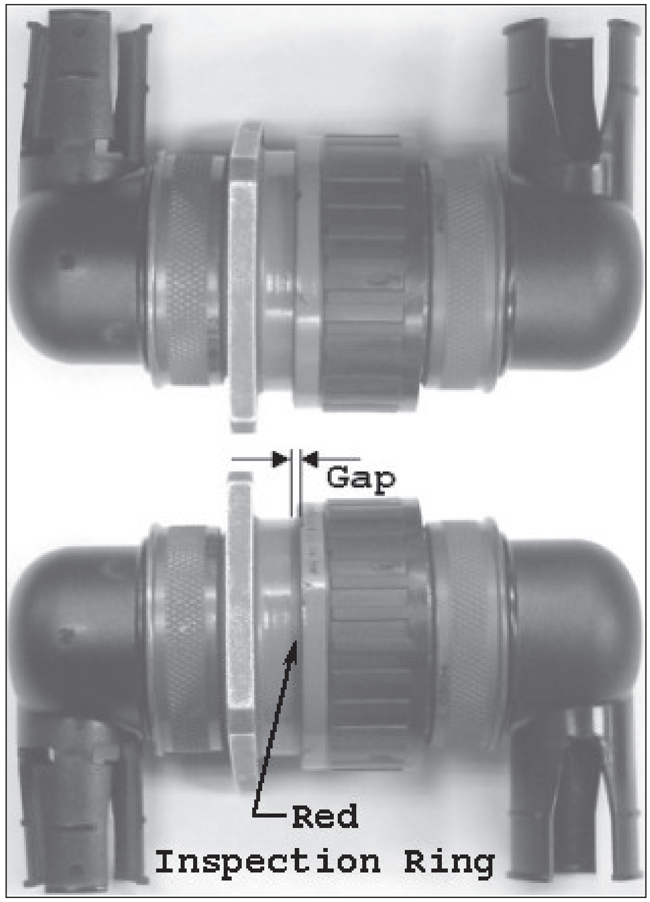


Figure 2. A Connector Gap With Full Width of the Inspection Line Visible (Top: Properly Closed Connector, Bottom: Improperly Closed Connector)

(2) Dirty Fiber Optic Terminus/Ferrule. See Figure 3. When dirty fiber optic termini are found, they shall be inspected and cleaned per WP 008 01 and WP 008 02, unless superceded by the Platform maintenance manual. A dirty terminus end face presents an optical loss condition similar to dirt on a window. Dirt on a window scatters light (making an image blurry) and

absorbs light (making an image dim). Dirt on mated fiber optic termini, scatters light away from the receiving core and absorbs light going from core to core. The result is a loss that increases with the area, thickness and density of the pollutant. Thick pollutants also cause gaps between mated termini. Gaps allow light to escape before it can be collected by the core of a receiving fiber. The loss attributed to dirt on terminus end faces can typically be anything from insignificant to 10 dB for one mated termini pair. The inspection and cleaning of fiber optic link components requires vigilant adherence to appropriate inspection and cleaning practices. Appropriate inspection and cleaning practices are covered in WP 008 01 and WP 008 02.

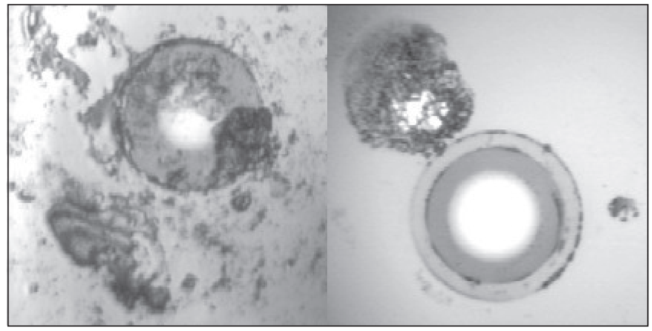


Figure 3. Dirty End Faces

(3) Damaged Fiber Optic Terminus/Ferrule. See Figure 4. Damaged terminus end faces result from inadequate inspection and cleaning practices. Damaged terminus end faces require repair. Appropriate installation and repair practices are covered in WP 012 01 and WP 013 01, which may be superceded by the Platform maintenance manual. Damaged terminus end faces can result when dirty termini are remated. Termini in fiber optic interconnects are always in compression. Soft dirt will tend to become permanent the longer it is left. Hard dirt can cause permanent damage like chips, scratches and cracks the first time a connector is reconnected. The loss attributed to damaged terminus end faces can vary widely from insignificant to easily 30 dB for one mated termini pair. The inspection and cleaning of fiber optic link components requires vigilant adherence to appropriate inspection and cleaning practices. Appropriate inspection and cleaning practices are covered in WP 008 01 and WP 008 02.

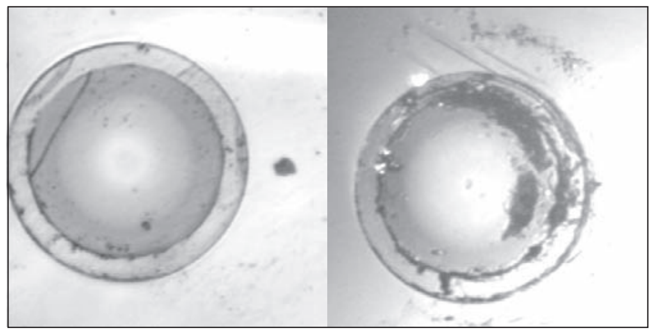


Figure 4. Damaged End Faces (Left: Crack in Cladding, Right: Permanent Dirt)

(4) Unseated Fiber Optic Terminus/Ferrule. Unseated termini that have been reseated, shall be inspected and cleaned prior to remating the connector. Unseated fiber optic termini can result from broken retaining parts within connectors (See Figure 5) and of the termini assemblies themselves. An unseated termini can also be the result of an improper insertion of a terminus into a connector. The result of an unseated terminus will be a gap between mated termini with additional angular and lateral misalignment between the mated termini (see Figure 6). The loss attributed to an unseated terminus will typically be large and may range from 10 dB to greater than 50 dB (i.e. "open circuit").

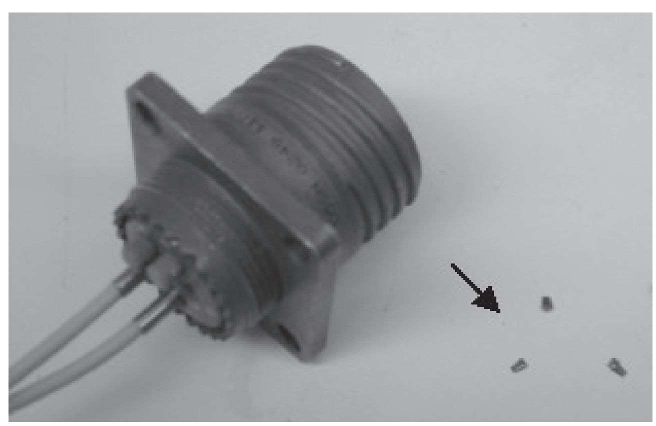


Figure 5. Damaged Retaining Parts From Within a MIL-DTL-38999 Connector

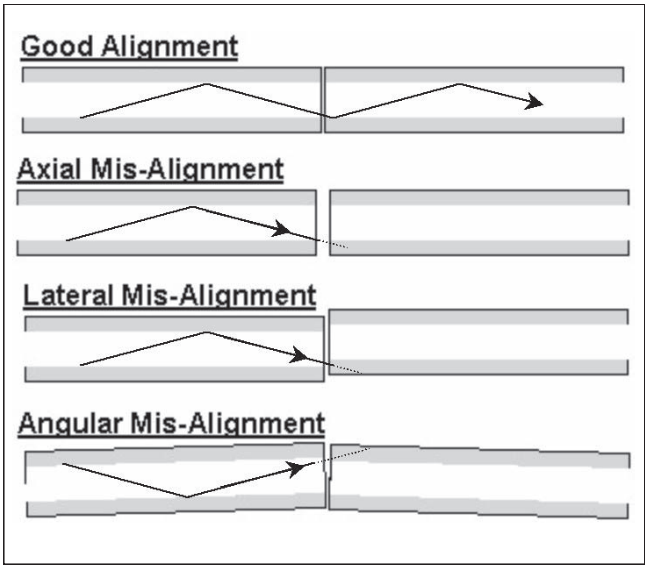


Figure 6. Fiber Alignment in Mated Connectors

(5) Misaligned Termini/Ferrule. Misaligned fiber optic termini can result from worn, aged or defective retaining parts within connectors and of the termini assemblies themselves. The result of a misaligned terminus can be axial misalignment (a gap) between mated termini with additional angular and lateral misalignment between the mated termini (See Figure 6). The gapping, angular and lateral misalignment will typically be much less than that of an unseated terminus. The loss attributed to a misaligned terminus will typically be small and may range from insignificant to 10 dB for one mated termini pair.

b. Cable Failure Modes. The failure modes of fiber optic cables will often be attributable to handling practices. The handling of fiber optic cables requires a level of care similar to that used with coaxial Rf cables. Fiber optic cables are approximately as susceptible to degraded performance and damage as coaxial Rf cables. Fiber optic cables will become optically lossy as bending exceeds bending specifications. The optical fiber in cables will break when bending greatly exceeds bending specifications. Fiber optic cable handling practices, including bending, are covered in WP 006 01 which may be superceded by the Platform maintenance manual. The handling of fiber optic cables requires vigilant adherence to appropriate handling practices.

(1) Bending Losses. Bending losses occur in a fiber optic cable when the cable's bending specification is violated. Losses will increase as the cable bend radius is decreased. Bending beyond the cable's bending specification causes the incident angles of light rays hitting the fiber's core boundary to become less than the critical angle. This causes the Total Internal Reflection (TIR) condition to fail which lets light exit the fiber's core.

(a) Cable Routing. Proper installation practices are in WP 012 01. Proper handling practices, including bending, are covered in WP 006 01. These practices must be followed unless superceded by the Platform maintenance manual. Bending losses due to cable routing occur wherever a fiber optic cable's bending specification is violated. Bending losses occur along the length of cable where the specification is violated. If the specification is violated for a six inch length, then bending losses occur over that six inch length. Losses due to cable bending are small when compared to losses associated with many other failure modes. Expected loss values may range from insignificant to 3 dB.

(b) Cable Clamping. Proper installation practices are covered in WP 012 01. Proper handling practices, including bending, are covered in WP 006 01. These practices must be followed unless superceded by the Platform maintenance manual. Bending losses due to cable clamping and tying occur wherever cable clamps and ties are excessively tight. Excessively tight cable clamping deforms the optical fiber locally and causes the cable's bending specification to be violated over the short length impacted by the cable clamp or tie (See External Stress in Figure 7). This type of excessive bending is called a microbend. Losses due to microbending are small when compared to losses associated with many other failure modes. Expected loss values may range from insignificant to 3 dB.

(2) Broken Optical Fiber. Cable breakage requires repair. Appropriate installation and repair practices are covered in WP 012 01 and WP 013 01, which may be superceded by the Platform maintenance manual. The optical fiber in a cable will break when excessive bending is well beyond the cable's minimum bend radius specification. Figure 8 shows a fault finder

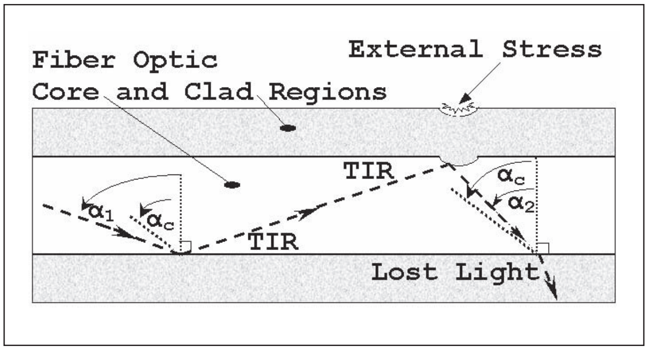


Figure 7. Cable Clamping Causes Microbending Losses When External Stress Deforms the Fiber

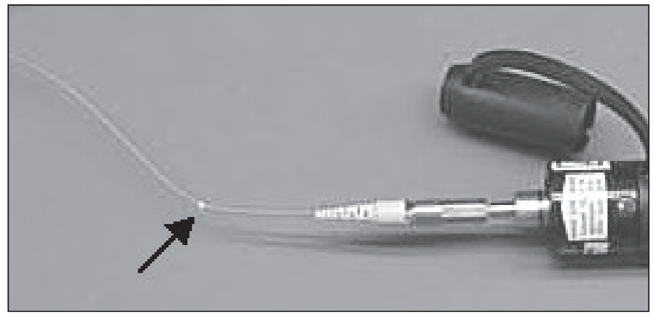


Figure 8. Fault Finder and an Illuminated Break in a Fiber

illuminating such a break. A fiber break is likely to occur when a cable's routing path changes with a sharp angle instead of smooth radius. A fiber optic cable's routing path should change in a smooth radius path and never as a sharp angle. Fiber optic cable handling practices, including bending, are covered in WP 006 01, which may be superceded by the Platform maintenance manual. The handling of fiber optic cables requires vigilant adherence to appropriate handling practices. The loss attributed to a broken fiber optic cable will typically be large but may range from 30 dB to greater than 50 dB (i.e. "open circuit").

(a) Production Splice. Fiber optic splices installed in production manufacturing are also possible failure sites. Prior to approval of a rugged, long-term use splice, temporary fiber optic splices may be found in some aircraft. Optical fiber breakage is more likely to occur near a fiber optic splice. Fiber optic splices change cable characteristics because they are more rigid and have a larger diameter that the fiber optic cable. These changed cable characteristics make the fiber optic cable immediately adjacent to the splice somewhat more susceptible to breakage of the optical fiber.

5. FAILURE MODES, LIKELIHOOD. Connector failure modes are expected to be the most likely with fiber optic links. This characteristic is similar to connector related failures with electronic links. Connector failures will be much more likely than cable and transceiver failures. Fiber optic cable failures are expected to be as likely as with coaxial Rf cable links. In Table 1, Likelihood is a relative estimate of probability of occurrence. Optical loss is an estimate of expected typical loss range values. Fiber optic links may be designed with operational link loss margins of less than 3 dB. Preserving this margin will require vigilant adherence to appropriate handling, inspection and cleaning practices. Appropriate handling practices are covered in WP 006 01. Appropriate inspection and cleaning practices are covered in WP 008 01 and 008 02.

6. TROUBLESHOOTING TOOLS. Troubleshooting fiber optic links requires several troubleshooting tools sets. Inspection will find the most common problems. Optical loss (link loss) measurement tools will determine whether the fiber optic link is at fault for almost any reason. The OTDR and fault finder are most effective in isolating and localizing suspected faults indicated by the use of other tools.

a. Inspection Tools. Inspection tools are highly effective in detecting and isolating the high probability failure modes. Inspection tools include the eyes of fleet maintainers as well as magnifying video inspection tools.

(1) Eyes, Maintainer's. The maintainer's eyes will be highly effective at identifying the highly probable loose connector failure mode (See Figure 2). The use of an inspection mirror will be necessary to inspect connectors out of the direct line of sight.

(2) Magnifying Video Inspection Tools. Magnifying video inspection tools are the only tools that can determine whether dirty or damaged end faces are at fault in a fiber optic link. Inspection before cleaning determines if cleaning is necessary. Inspection after cleaning verifies cleaning effectiveness. Inspection before reconnecting a replacement WRA, LRM or other avionics unit avoids transferring dirt and possibly damaging a mating connector. Inspection criteria for cleanliness and damage are covered in WP 008 01. A set of video inspection tools is shown in Figure 9.

b. Optical Loss Tools. Optical loss (link loss) tools are excellent at determining whether the fiber optic link is at fault. Isolating and localizing a detected problem to a particular failure mode of a link may require several loss measurements or the use of other tools. Given access to all connectors in a series of fiber optic cables, optical loss tools can determine which cable (if any) is at fault. Optical loss and inspection tools are a highly productive combination for isolating and localizing the great majority of failure modes. The usage of optical loss tools are covered in WP 009 01. A set of optical loss tools is shown in Figure 10.

c. Fault Finder. The fault finder is at best only moderately effective in locating an expected break of the optical fiber in a cable (See Figure 8). Locating a break to within a few inches is a prerequisite to performing a splice repair. Cable access, cable over-braiding and ambient light conditions all limit the effectiveness of the fault finder (See Figure 11). The use of a fault finder tool is covered in WP 009 06.

d. OTDR. The Optical Time Domain Reflectometer (OTDR) is very effective in locating a break in a fiber optic cable. Generally, back reflections from each cable interconnect show up as narrow pulses on the OTDR display (See Figure 12). When the distance between all cable interconnects are known, unexpected narrow pulses indicate a fiber break. Its primary drawback is limited availability due to its high cost. A secondary concern is that the user interface can be cumbersome, leading to ineffective usage.

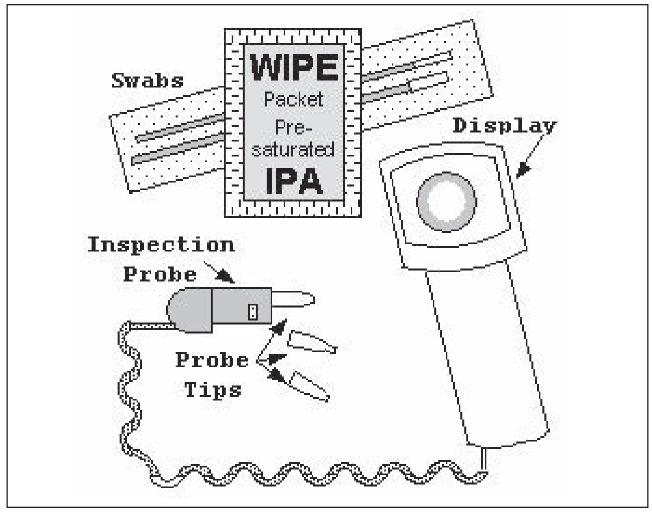


Figure 9. Inspection Tools, Wipes and Swabs

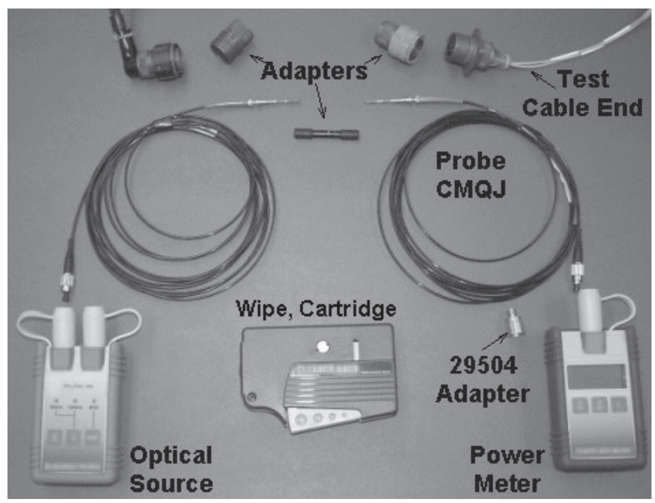


Figure 10. Optical Loss Measurement Tools

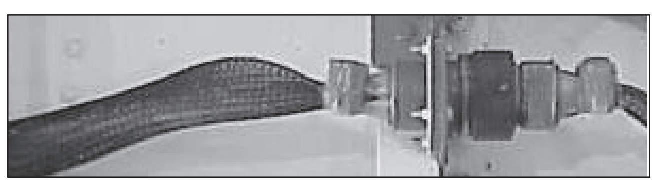


Figure 11. Over-Braid Limits Effectiveness of Fault Finder

7. TROUBLESHOOTING TOOL EFFECTIVENESS. Table 2 ranks various troubleshooting tools for effectiveness in detecting and localizing various fiber optic link failure modes. To score "High" a tool must be effective at detecting that a problem exists and effective in localizing a problem. Generally a score of "Low" indicates a very limited effectiveness.

8. STRATEGY FLOW CHART. The flow chart in Figure 13 presents a troubleshooting strategy for evaluating a fiber optic link that has been indicated as a possible failure.

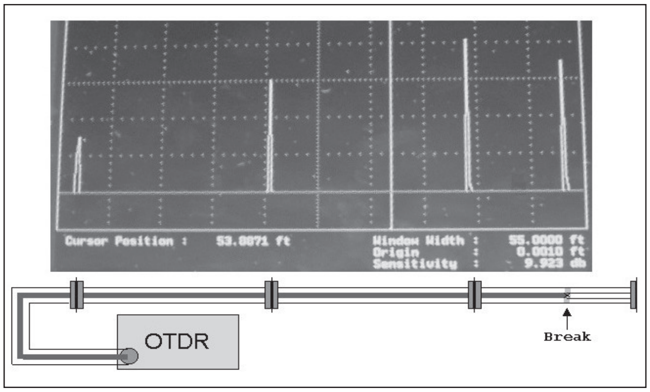
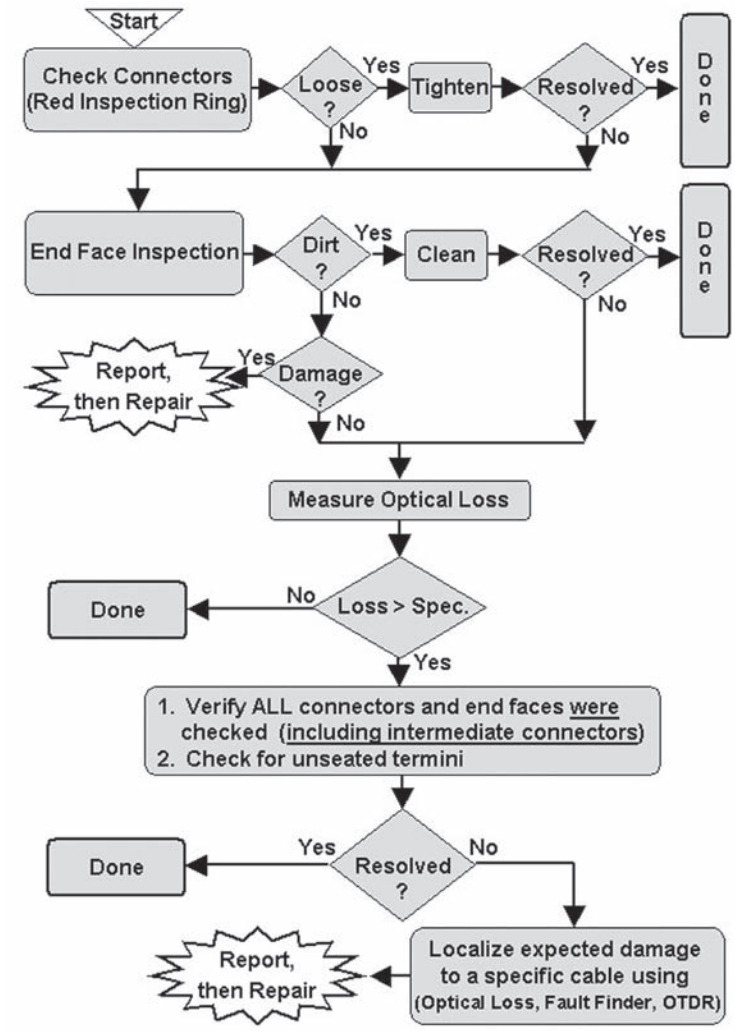


Figure 12. OTDR Showing Back Reflection Pulses from Three of Four Interconnects and an Optical Fiber Break in a FO Link

Table 2. Ranking of Troubleshooting Tool Effectiveness

Characterization of Troubleshooting Tool Effectiveness in Detecting and/or Localizing FO Link Failure Modes					
Failure Mode	Optical Loss Tools	Magnified Video Insp.	Maintainer's Eyes	Fault Finder	OTDR
Loose Mated Connector	High	None	High	None	Medium
Dirty Terminus End Face	High	High	None	None	Low
Damaged Terminus End Face	High	High	None	None	Low
Unseated Terminus	High	Low	Medium	None	Medium
Misaligned Termini	High	None	None	None	Low
Cable Routing Bending Losses	High	None	None	None	Low
Cable Clamping Bending Losses	High	None	Low	None	Low
Broken Fiber in a Cable	High	None	None	Medium	High



LEGEND	
Resolved	Determined to be acceptable by an appropriate procedure: • Inspection • Optical Loss • Approved Functional Test (Platform maintenance manual)
Tighten	Inspect and Clean per WP 008 01 and WP 008 02, then tighten
Dirt	No = No pollutants found within a diameter of 200% of the cladding diameter See Inspection Criteria, Pollutants (WP 008 01)
Clean	See Inspection and Cleaning Procedures (WP 008 01, WP 008 02)
Damage	See Inspection Criteria, Damage (WP 008 01)
>	Greater than
Spec.	The loss specification applicable to the FO link cable segment being measured (see Platform maintenance manual)
Done	No further troubleshooting required
Repair	A repair found in the applicable Platform maintenance manual

Figure 13. Troubleshooting Strategy FlowChart for a Fiber Optic Link

General Inspection and Cleaning

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Inspection	008 01	13 August 2004
Manual Cleaning Procedures	008 02	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for inspection and different types of cleaning processes and techniques. The first subordinate work package, WP 008 01, addresses inspection of ferrule end faces and presents criteria for cleanliness determination and damage determination. The second subordinate work package, WP 008 02, addresses manual techniques using hand cleaning procedures. These manual techniques are the ones in common use today. Future work packages are planned to address "powered" cleaning techniques, such as on using a small, hand-held cleaning machine/device. This equipment is anticipated to reduce cleaning cost and time while providing more consistent and better results.

THIS PAGE LEFT INTENTIONALLY BLANK

Inspection

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/

Item	Description	Quantity	Cage Code	Part or Identifying No. 2/
CLEANING INSPECTION/TEST EQUIPMENT				
	FERRULE END FACE INSPECTION			
117	Video Inspection System Kit w/ probe tips w/o case (kit includes items below)	1		
	200X/400X Video inspection probe, no tips or display	1		
	2.5” hand held video display	1		
	Probe tip for M29504/4 pin terminus	1		
	Probe tip for M29504/5 socket terminus	1		
	Patch cord probe tip for 2.5 mm dia. ferrule	1		
	Patch cord probe tip for 1.25 mm dia. ferrule	1		
	Adapter probe tip, vu thru ST-to-ST adapter	1		
	Adapter probe tip, vu thru SC-to-SC adapter	1		
	Adapter probe tip, vu thru FC-to-FC adapter	1		
	Adapter probe tip, vu thru LC-to-LC adapter	1		
	Adapter probe tip, M38999 connector probe adapter	1		
1/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for this drawing.			
2/	Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicabiltiy to be determined through the applicable supply system process.			

Materials Required 1/

Item	Description	Quantity	Cage Code	Part or Identifying No. 2/
STANDARD CLEANING SUPPLIES (FOR CONNECTORS)				
D101	Canned liquefied gas (microscopic dusting) NSN: 6850 01 346 9144 NSN: 6830 01 498 7119	N/A		
D102	Wipes, cloth cleaning, white NSN: 7920 01 321 6791	N/A		
D103	Dispenser, solvent 4 oz., leak proof (for alcohol) NSN: 8125 01 439 5367	N/A		
	Alcohol, Isopropyl, 99% pure anhydrous NSN: 6505 00 205 6513	N/A		
D104	Cleaning swab, 1.25 mm	50	54700	2316-50
		40	0LN21	CCPS-12-0900
D105	Cleaning swab, 2.5 mm	50	54700	2317-50
		40	0LN21	CCPS-25-0900
		N/A	K1479	14100400
D106	Wipes, Isopropyl alcohol, pre-saturated packets (50) NSN: 6810 01 414 6659	N/A		
D107	Wipes, cartridge reel	1	1WEB4	6227
D191	Foreign Object Debris (FOD) pouch	6		
SUPPLEMENTAL/ALTERNATE CLEANING SUPPLIES				
D202	Replacement cleaning tape (for item D107)	N/A	1WEB4	6232
D203	Electrical contact cleaner, CFC free	N/A	66724	03116
1/ 2/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for this drawing. Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicabiltiy to be determined through the applicable supply system process.			

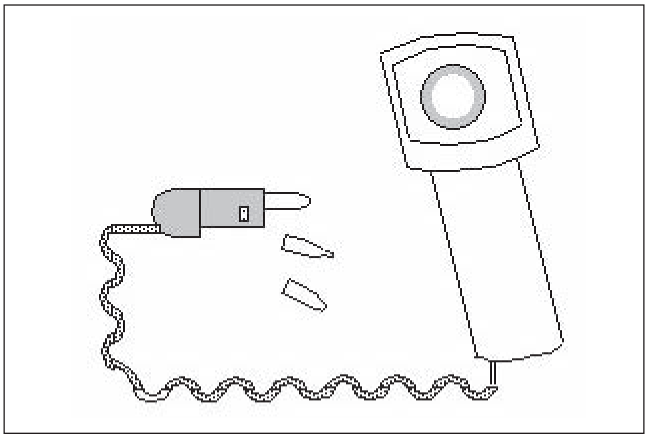


Figure 1. Fiber Optic Video Inspection System (FOVIS)

1. INTRODUCTION.

2. This work package is for inspection of the ferrule end face of a fiber optic connector or the ferrule end face of each terminus in a fiber optic, multiple termini connector. Inspection is accomplished using a Fiber Optic Video Inspection System (FOVIS) as shown in Figure 1. A FOVIS with 200X magnification will show approximately a 600 micron wide x 450 micron high area. Appropriate inspection criteria are presented that may be superceded by requirements of specific aircraft platforms.

3. PURPOSE. The purpose of inspecting ferrule end faces is to look for pollutants and damage that may affect the passage of light between the cores of mated fiber optic termini. Inspections should cover the fiber core area, the fiber cladding area surrounding the core and some of the ferrule surface area surrounding the cladding. Found damage, such as scratches, cracks or chips should be reported so that a repair can be initiated. Found pollutants should be cleaned using appropriate cleaning practices. Appropriate cleaning practices are covered in WP 008 02, which may be superceded by the Platform maintenance manual.

4. BACKGROUND. Pollutants on and damage to ferrule end faces cause optical loss conditions that can fail a fiber optic link. Pollutants found on the core would cause an optical loss condition due to absorption and scattering of light. Pollutants found near the core could also cause an optical loss condition because of their thickness. Thick pollutants cause gaps between mated termini. These gaps allow light to escape before it can be collected by the core of a receiving fiber. Pollutants found near the core also present a risk of causing an optical obstruction the next time the fiber optic termini are disturbed (see Figure 6, View C). A disturbance, such as the next disconnect/re-connect event, may be enough to move a pollutant from near the core to over the core. The glass core, glass cladding and ceramic ferrule areas are susceptible to scratches, cracks and chips. Scratches, cracks or chips in the core area cause an optical loss condition due to scattering of light. Exposing cracked or chipped glass cores, glass cladding and ceramic ferrule surfaces to flight conditions may result in sudden end face degradation resulting in a sudden operational failure of the fiber optic link.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

5. WHEN TO INSPECT. Inspection should always be done before mating any connector to verify all mating fiber optic ferrule end faces are clean and free of damage. Inspection detects ferrule end face pollutants and damage. Existing pollutants and damage on an unmated connector (plug or receptacle) can easily be transferred to the mating connector.

a. Before and After Cleaning. Inspection is required before and after cleaning any ferrule end face (unless superceded by the Platform maintenance manual). Cleaning an end face is not risk free. Cleaning materials (such as swabs and wipes) can easily become contaminated with particulate. Contaminated cleaning materials used on a clean end face may leave it spotted. Inspection must always determine when termini cleaning is required and inspection must verify that every cleaning attempt was successful.

NOTE

Inspection and cleaning of ferrule end faces on replacement WRA, LRM or other avionics units should be done prior to carrying replacement units out to an aircraft (especially on the flight deck or flight line). This is highly important when conditions (wind, rain, etc.) on the flight deck or flight line may prohibit performance of inspection and cleaning.

ESD caps or dust caps should be left on all fiber optic connectors until cables are ready to be connected to the replacement WRA, LRM or other avionics unit.

Always cover connectors (with ESD or dust caps) immediately after unmating. Never use tape to cover connectors with fiber optic termini in them.

b. Avionics Box Installation. Inspection should be performed when replacing a WRA, LRM or other avionics unit. Ferrule end faces on the replacement unit and the mating plug(s) must be inspected for pollutants and damage prior to mating connectors with fiber optics.

c. Troubleshooting Fiber Optic Link. Inspection should be performed in the process of troubleshooting a suspected fiber optic link problem. For example, before connecting any test equipment (such as CMQJs), the end faces on the equipment and the suspected cable ends must be inspected.

6. INSPECTION ZONES. Damage inspection and pollutant inspection require the definition of several zones of a ferrule end face image. A FOVIS ferrule end face image with 200X magnification will show an area several times larger than the fiber core and cladding of a 100/140 micron fiber. Figure 2 shows a ferrule end face with a polyimide coated 100/140 micron fiber. The full fiber diameter including the polyimide coating is

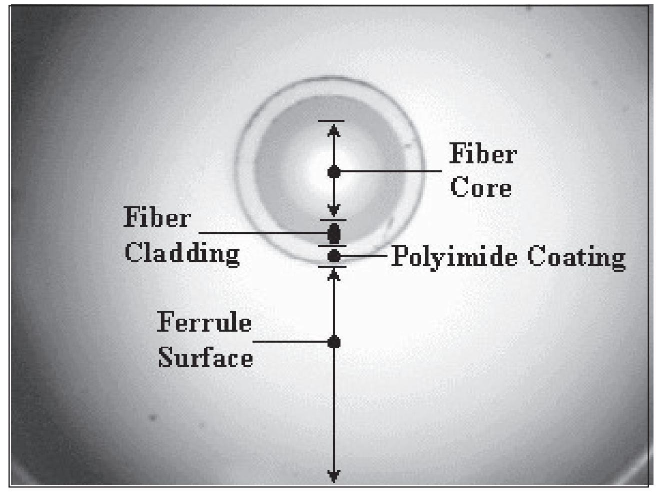


Figure 2. 200X FOVIS Ferrule End Face with a Polyimide Coated 100/140 Fiber

172 microns. Optical fiber cables installed in tactical aircraft or in unpressurized compartments will typically have polyimide coated fiber. Optical fiber cables within avionics units or within pressurized aircraft cabins may not have this polyimide coating.

a. Damage Inspection. Inspection for damage should consider the full viewable area that the FOVIS shows. Inspection must consider the glass core, glass cladding, polyimide coating (if present) and the viewable surface area of the ceramic ferrule. The glass core, glass cladding and ceramic ferrule areas are susceptible to scratches, cracks and chips, which are primary concerns. A polyimide coating is softer than the glass fiber or the ceramic ferrule. Minor scratches, cracks and chips in the polyimide coating (if present) are not a concern. The primary concern with a polyimide coating is that its general structural integrity remains intact, providing support all around the fiber. Loose pieces of the polyimide coating are a pollution inspection concern.

(1) Damage Inspection Zone. The gross zone for damage detection is the full viewable area that the FOVIS shows.

b. Pollutant Inspection. Inspection for pollutants should prioritize the fiber core area. Optical fiber is designed to transport light through the core. Pollutants on the core area will generally cause more loss than pollutants found elsewhere. Pollutants found outside

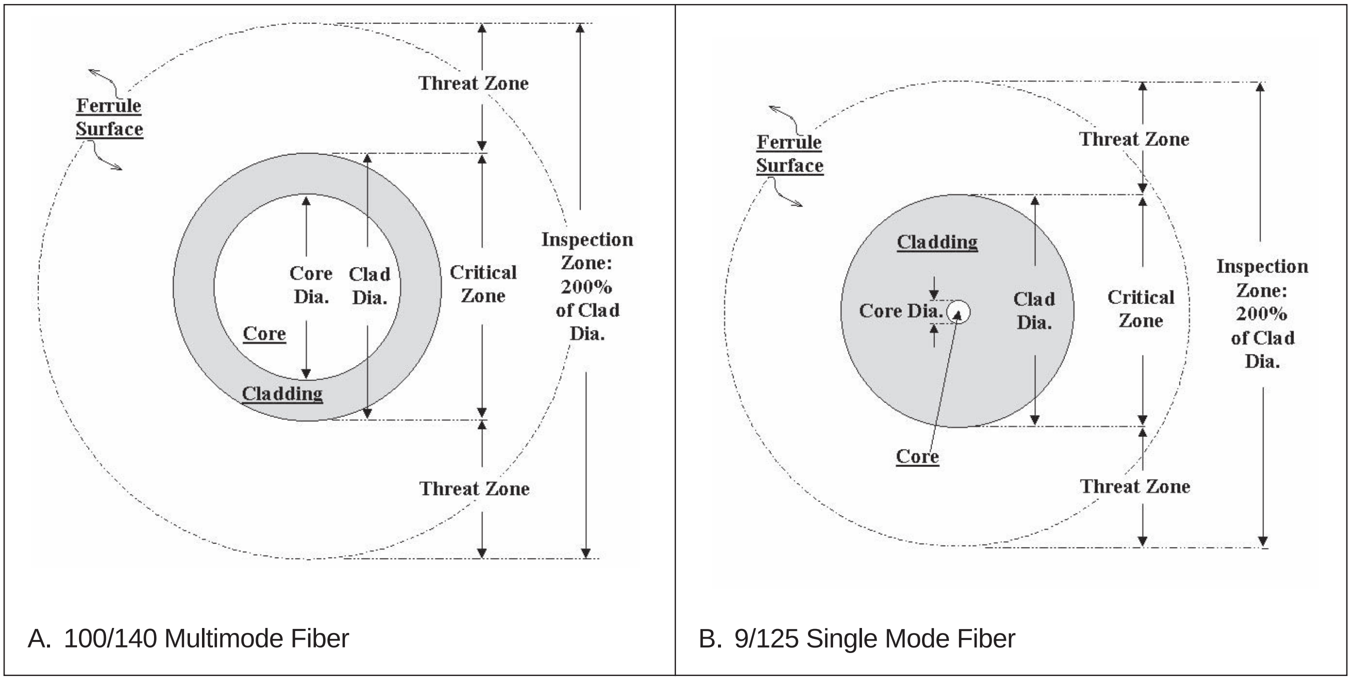


Figure 3. Critical and Threat Zones of the Inspection Zone (Core/Clad Sizes in Microns)

the core area, and within a circle of diameter equal to 200% of the cladding diameter are also a concern. These can cause gapping between mated termini and these could also be shifted onto the core area with the next reconnection event.

(1) Pollutant Inspection Zone. The gross zone for pollutant inspection is a concentric circle with a diameter equal to 200% of the cladding diameter (280 microns for multimode and 250 microns for single mode fiber). The pollutant inspection zone is subdivided into the critical zone and threat zone (see Figure 3).

(a) Critical Zone. The critical zone is defined as the full core and cladding area of the glass fiber. It includes nothing outside of the cladding diameter. The critical zone excludes a polyimide coating (if present).

(b) Threat Zone. The threat zone is defined as a donut shaped zone that extends from the critical zone out to a concentric circle with a diameter equal to two times (200%) the critical zone diameter. The threat zone includes the fiber's polyimide coating (if present).

1 Polyimide Coating. The polyimide coating (if present) is within the threat zone (see Figure 4).

7. INSPECTION CRITERIA, POLLUTANTS. Criteria are discussed below.

a. Clean. This criterion describes a clean end face: No pollutants found within the inspection zone. This is typical of a newly polished end face. This is also typical of an end face from a connector that has rarely been unmated.

(1) Criterion. No pollutants found within a diameter of 200% of the cladding diameter.

b. Acceptable. This is a condition that is worse than "Clean". This will likely be the classification of the great majority of inspected end faces. This condition allows for the presence of minor spots that a previous approved cleaning attempt has failed to remove.

(1) Criteria. To be classified as acceptable, the following **three** criteria must be true.

(a) Criteria 1: An appropriate cleaning attempt must have resulted in an end face condition worse than Clean. Appropriate cleaning practices are covered in WP 008 02, which may be superceded by the platform maintenance manual.

Table 1. Illustrative Circular Obstruction Sizes

Max Obstruction Diameters for an Illustrative Circular Obstruction Based on 5% and 50% Core Area Obstructions				
Fiber Core/Clad Dia. (microns)	Critical Zone Dia. (microns)	Critical Zone Max Illustrative Obstruction (25% of Core Dia.) Dia. (microns)	Threat Zone Dia. (microns)	Threat Zone Max Illustrative Obstruction (70% of Core Dia.) Dia. (microns)
100/140	140	25	280	72
62.5/125	125	16	250	44
50/125	125	12.5	250	36
9/125	125	2.25	250	6

(b) Criteria 2: No pollutants are found within the critical zone, that **by themselves or cumulatively**, would obstruct more than 5% of the core area. A circular 5% core area obstruction would have a diameter equal to 25% of the core diameter. Table 1 and Figure 5 present obstruction size reference information. Pollutant obstructions are not expected to be circular, however a circular illustration provides a practical basis for evaluating obstructed area.

(c) Criteria 3: No individual pollutants are found within the threat zone, that by themselves could obstruct more than 50% of the core area (if moved onto the core). This condition allows more than one pollutant, as long as none of them would obstruct more than 50% of the core area. A circular 50% core area obstruction would have a diameter equal to 70% of the core diameter. Figure 5 and Table 1 present obstruction size reference information. Pollutant obstructions are not expected to be circular, however a circular illustration provides a practical basis for evaluating obstructed area.

(2) Illustrative Areas. Table 1 presents diameter sizes of illustrative circular areas that individually would block 5% of the core area (25% of the core diameter) and 50% of the core area (70% of the core diameter) for typical fiber core diameters. A 5% core area obstruction could result in an approximate 0.25 dB loss. A 50% core area obstruction could result in an approximate 3 dB loss.

(3) Illustrative Examples. Figure 5 shows scaled 5% core area obstructions inside various core sizes.

c. Unacceptable. Unacceptable is defined as anything worse than that described as "acceptable". Any inspection classified as unacceptable, because of a

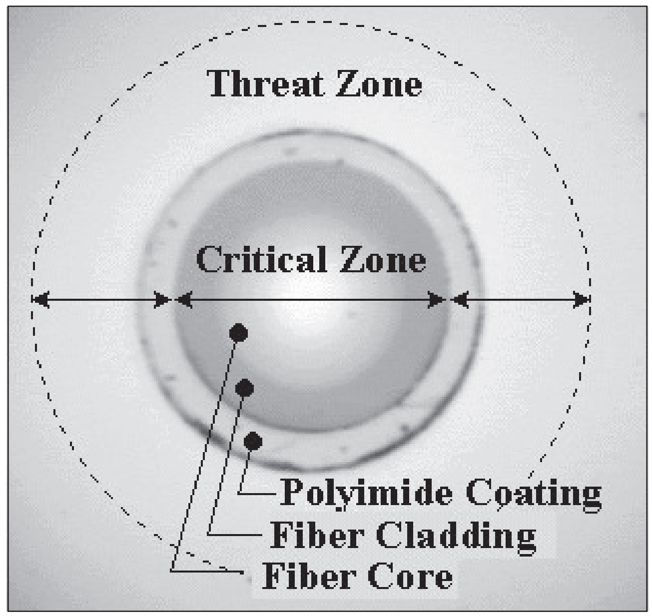


Figure 4. Polyimide Coating is in the Threat Zone

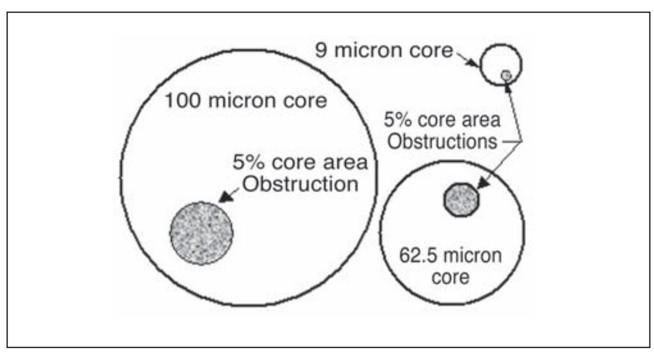
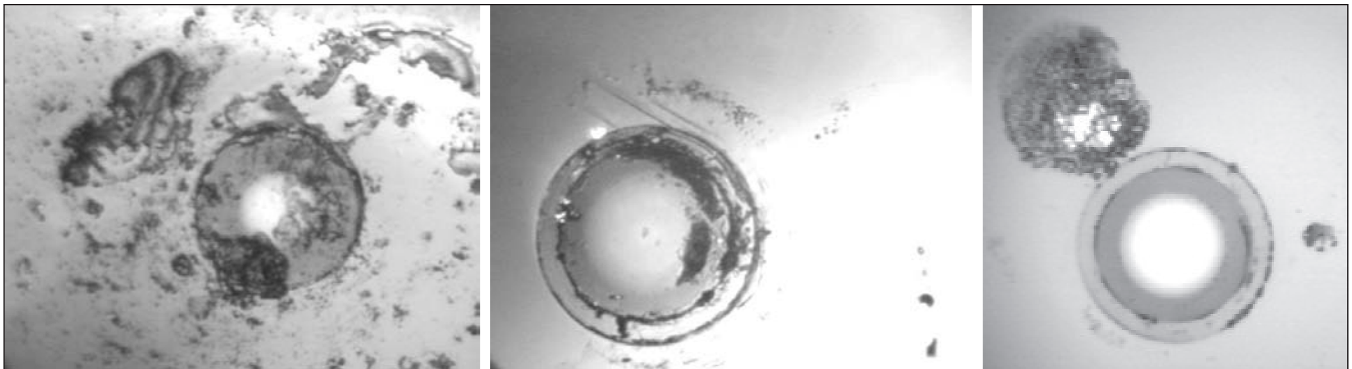


Figure 5. Scaled 5% Core Obstructions Shown inside Cores of 100/140, 62.5/125 and 9/125 End Face Sizes



A. Pollutants in Critical & Threat Zones   B. Pollutants in Critical Zone   C. Pollutants in Threat Zone

Figure 6. Unacceptable Polluted Samples (Pollutants Larger Than Maximum Size Allowed)

core obstruction, requires a loss measurement or approved functional test (see Platform maintenance manual) to ultimately determine the acceptability of the end face condition. Any inspection classified as unacceptable indicates additional cleaning should be tried.

(1) Unacceptable Polluted Samples (see Figure 6, Views A, B, and C).

8. INSPECTION CRITERIA, DAMAGE. Any inspection detecting a crack or chip in the core area, cladding area or viewable ferrule surface area is unacceptable. In addition, scratches in the core area and cladding area are unacceptable as well. This damage must be reported so that a repair can be initiated. Exposing cracked or chipped glass cores, glass cladding and ceramic ferrule surfaces to flight conditions may result in sudden end face degradation resulting in a sudden operational failure of the fiber optic link. Minor scratches, cracks and chips in the polyimide coating (if present) are not a concern. The primary concern with a polyimide coating is that its general structural integrity remains intact, providing support all around the fiber. Figure 7 presents sample sketches of some damage types.

a. Unacceptable Damage Samples. See Figure 8, View A, B, and C.

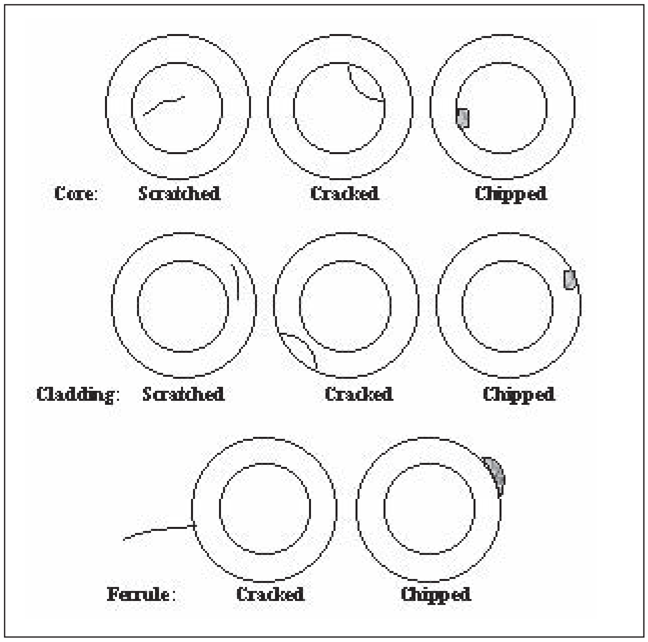
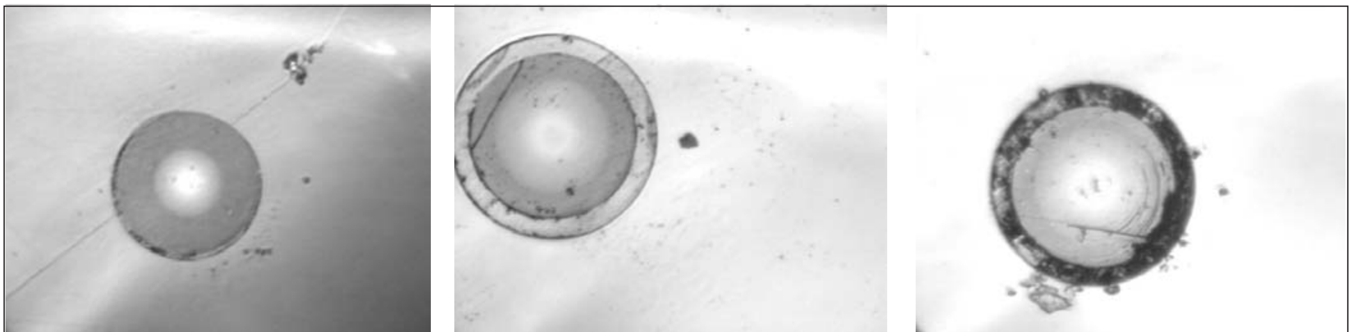


Figure 7. Examples of Scratched, Cracked and Chipped End Faces Shown in Core, Cladding and Ferrule Surface Areas



A. Ferrule Crack

B. Cladding Crack

C. Crack Into the Core & Deep Scratches in the Cladding

Figure 8. Unacceptable Damage Samples

9. INSPECTION, INSTRUMENT INTERFACE PORTS. fiber optic test equipment has optical source transmit ports and detector receive ports. FOVIS inspection of these ports often presents images dissimilar to that of a ferrule end face of a cable harness connector.

NOTE

Optical sources should not be energized when inspecting transmit ports with a FOVIS.

To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this.

a. Inspection of an Optical Source Transmit Port. A transmit port on fiber optic test equipment will often present a FOVIS image similar to that shown in Figure 9. The image of a ferrule end face, from a fiber pigtail connected to an LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. The inspection zones are the same and inspection criteria are nearly the same for transmit ports as with ferrule end faces on cables. The exception is that chips, cracks and scratches of the ferrule surface are acceptable, when the test equipment

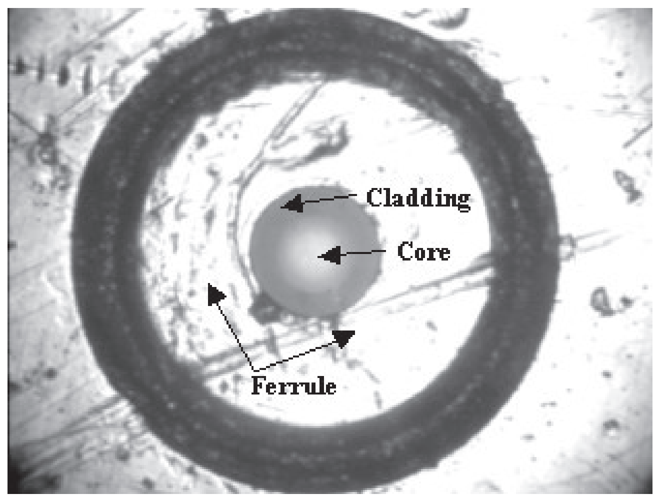


Figure 9. FOVIS 200X Inspection of Test Equipment FO Transmit Port

is used as ground support equipment. The damage and pollutant criteria for the critical zone (fiber core and cladding) are the same. Chips, cracks and scratches are unacceptable in the critical zone.

NOTE

To inspect an optical receiver port, the FOVIS must be focused until some distinguishable features are observed on the photodetector or surrounding surface.

To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this.

b. Inspection of an Optical Receive Port. A receive port (typically a power meter) on fiber optic test equipment will present a FOVIS image similar to that shown in Figure 10. There is a photodetector behind the optical connection port on an optical power meter or the port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Surrounding the photodetector, some of the optical port backing / mounting panel may be observed.

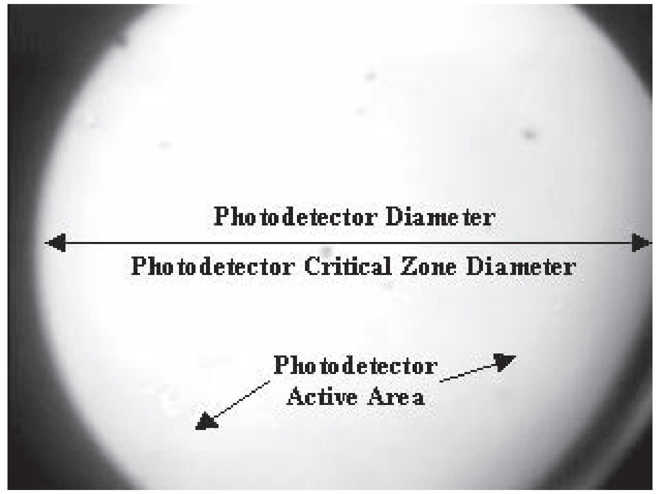


Figure 10. FOVIS 200X Inspection of Test Equipment Receive Port

Here the entire photodetector surface is the photodetector critical zone. Chips, cracks and scratches are unacceptable in this critical zone. This critical zone should be clean such that no pollutants are found, that **by themselves or cumulatively**, would obstruct more than 5% of the photodetector area (photodetector critical zone).

Manual Cleaning Procedures

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/

Item	Description	Quantity	Cage Code	Part or Identifying No. 2/
CLEANING INSPECTION/TEST EQUIPMENT				
	FERRULE END FACE INSPECTION			
117	Video Inspection System Kit w/ probe tips w/o case (kit includes items below)	1		
	200X/400X Video inspection probe, no tips or display	1		
	2.5” hand held video display	1		
	Probe tip for M29504/4 pin terminus	1		
	Probe tip for M29504/5 socket terminus	1		
	Patch cord probe tip for 2.5 mm dia. ferrule	1		
	Patch cord probe tip for 1.25 mm dia. ferrule	1		
	Adapter probe tip, vu thru ST-to-ST adapter	1		
	Adapter probe tip, vu thru SC-to-SC adapter	1		
	Adapter probe tip, vu thru FC-to-FC adapter	1		
	Adapter probe tip, vu thru LC-to-LC adapter	1		
	Adapter probe tip, M38999 connector probe adapter	1		
1/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for this drawing.			
2/	Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicabiltiy to be determined through the applicable supply system process.			

Materials Required 1/

Item	Description	Quantity	Cage Code	Part or Identifying No. 2/
STANDARD CLEANING SUPPLIES (FOR CONNECTORS)				
D101	Canned liquefied gas (microscopic dusting) NSN: 6850 01 346 9144 NSN: 6830 01 498 7119	N/A		
D102	Wipes, cloth cleaning, white NSN: 7920 01 321 6791	N/A		
D103	Dispenser, solvent 4 oz., leak proof (for alcohol) NSN: 8125 01 439 5367	N/A		
	Alcohol, Isopropyl, 99% pure anhydrous NSN: 6505 00 205 6513	N/A		
D104	Cleaning swab, 1.25 mm	50	54700	2316-50
		40	0LN21	CCPS-12-0900
D105	Cleaning swab, 2.5 mm	50	54700	2317-50
		40	0LN21	CCPS-25-0900
		N/A	K1479	14100400
D106	Wipes, Isopropyl alcohol, pre-saturated packets (50) NSN 6810 01 414 6659	N/A		
D107	Wipes, cartridge reel	1	1WEB4	6227
D191	Foreign Object Debris (FOD) pouch	6		
SUPPLEMENTAL/ALTERNATE CLEANING SUPPLIES				
D202	Replacement cleaning tape (for item D107)	N/A	1WEB4	6232
D203	Electrical contact cleaner, CFC free	N/A	66724	03116
1/ 2/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for this drawing. Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicabiltiy to be determined through the applicable supply system process.			

1. INTRODUCTION.

2. This work package is for manual cleaning the ferrule end face of a fiber optic connector or the ferrule end face of each terminus in a fiber optic, multiple termini connector. The manual techniques listed use hand cleaning procedures without any "powered" cleaning devices. The criteria defining a clean condition with respect to ferrule end faces are covered in WP 008 01.

3. CLEANING TECHNIQUES. A swab/wipe cleaning technique and a compressed gas cleaning technique are covered below. In addition, guidance on the usage of swabs and wipes is covered.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per this work package, WP 008 02.

NOTE

The criteria defining a clean condition with respect to ferrule end faces are covered in WP 008 01. The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection and cleaning of ferrule end faces on replacement WRA, LRM or other avionics units should be done prior to carrying replacement units out to the flight deck or flight line. This is highly important when conditions (wind, rain, etc.) on the flight deck or flight line may prohibit performance of inspection and cleaning.

Always cover connectors (with ESD or dust caps) immediately after unmating. Never use tape to cover connectors with fiber optic termini in them.

Internal surfaces (other than ferrule end faces) of MIL-DTL-38999 type connectors may be cleaned with wipes to remove excess particulate/debris during interval maintenance or general servicing.

a. Cleaning with Swabs and/or Wipes. This is the preferred technique for cleaning end faces. Inspection before and after cleaning is a requirement of this technique (unless superceded by the platform maintenance manual). Cleaning an end face is not risk free. Cleaning materials (such as swabs and wipes) can easily become contaminated with particulate. Contaminated cleaning materials used on a clean end face may leave it spotted. Therefore, inspection must always determine when cleaning is required and inspection must always verify the result of a cleaning event. Inspection before and after cleaning also provides efficient use of consumables. The flow chart in Figure 1 summarizes the steps of this technique. The technique consists of the following steps:

(1) Step 1. Inspect Ferrule End Face.

(a) If it is clean, the procedure is done. If not proceed to Step (2).

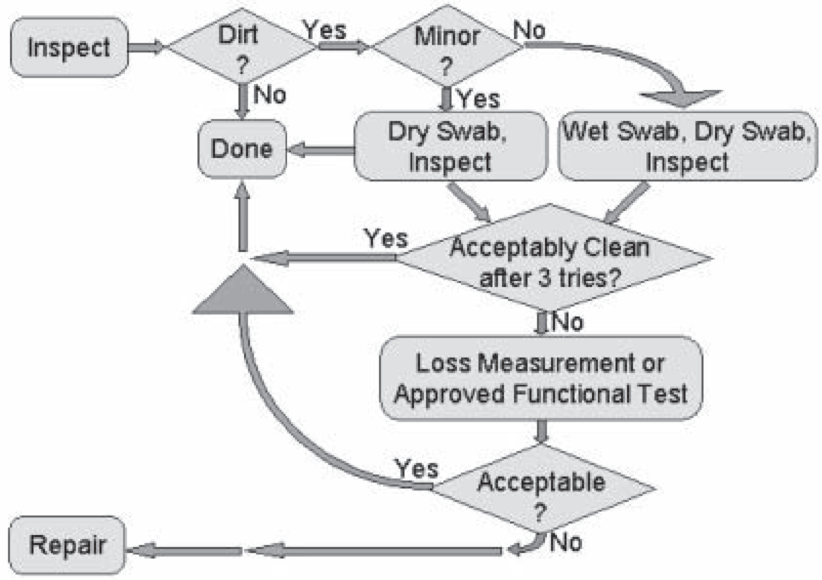
(2) Step 2. Clean Ferrule End Face.

(a) If small particles and/or small liquid spots were observed: Clean with a dry swab or wipe. Go to Step (3).

NOTE

To dampen a fiber optic swab for cleaning, approved alcohol presaturated wipes should be used to transfer alcohol to the swab. This avoids saturating the swab and "flooding" the end face.

Alcohol on and end face will leave a film or residue if it is left to evaporate. After cleaning with alcohol , a dry swab/wipe must be used to dry the alcohol .



Flow Chart Legend	
Dirt ?	No = No pollutants found within a diameter of 200% of the cladding diameter. See "Clean" in; Inspection Criteria, Pollutants (WP 008 01)
Minor ?	Yes = Pollutants found are generally sparse with none larger than 5 % of core area (see Table-1 and Figure-5 in WP 008 01 for 5% core area size reference).
Acceptably Clean ?	See "Acceptable" in; Inspection Criteria, Pollutants (WP 008 01).
Approved Functional Test	Apprpriate functional test from the Platform maintenance manual
Repair	A repair found in the applicable aircraft Platform maintenance manual

Figure 1. Flow Chart: Recommended Cleaning Technique for Ferrule End Face(s) of a Fiber Optic Connector

Avoid touching swab head with fingers or pressing swab head with finger to transfer alcohol from a presaturated wipe.

Leave presaturated alcohol wipes in their opened package to prevent rapid evaporation.

Follow appropriate safety precautions when using alcohol.

(b) If other than small particles or spots were observed: Clean with a damp swab or wipe. Then, within a few seconds, dry the end face with a dry swab or wipe to dry the end face . Go to Step (3).

(3) Step 3. Inspect Ferrule End Face.

(a) If it is clean, the procedure is done.

(b) If not, repeat Steps (2) and (3) until an acceptable result (see WP 008 01) is observed. If the first repeat cleaning fails, successive repeat cleaning should be with a damp swab/wipe per Step 2. No more than two repeat attempts are required. More cleaning attempts are recommended while cleanliness is observed to be improving.

(c) If the end face remains unclean, the acceptability of the end face condition must be determined with either a loss measurement or an approved functional test. Loss measurement is covered in WP 009 01.

b. Swab and Wipe Usage. These handling practices help to avoid damaging end faces, avoid cross contamination of swabs and wipes, and generally improve cleaning efficiency.

(1) Swab Usage. Fiber optic swabs are of a low-lint design. Care must be exercised to avoid contaminating them with any particulate or fluids before they are used. Once taken out of a storage package the cleaning tip end must not contact anything but the ferrule end face to be cleaned.

(a) Life of Swabs (Single use versus multiple usage). The job of a swab is to accumulate dirt. Swabs have very limited reusability. One swab per cleaning event is recommended.

NOTE

After using a swab, deform it by bending. This can help to avoid the mistaken use of a dirty swab.

1 Recommended Practice. Use one swab per contact with the ferrule, then discard. This is industry practice. This practice ensures maximum particle removal capability of the swab.

2 Economy Practice. Use the same swab until retention of particles on the ferrule is observed during inspection after the last cleaning.

(b) Applied Pressure. Applied pressure should always be light. Light pressure minimizes the risk of scratching an end face by dragging a hard particle across the end face.

NOTE

This technique addresses alignment sleeves in single terminus adapters (such as ST-to-ST adapters), multiple termini connector adapters (MIL-DTL-38999 adapters) and loose alignment sleeves of disassembled socket termini.

The job of a swab is to accumulate dirt. Swabs have very limited reusability. One swab per cleaning event is recommended.

Avoid pulling swab back through alignment sleeve with the opposite rotation.

Table 1. Swab Size Recommendations for Cleaning Applications

Swab Tip Size (mm)	Cleaning Application
1.25	• Socket configured ferrules in MIL-DTL-38999 connectors • Alignment sleeves in MIL-DTL-38999 connectors and connector adapters. • Recessed ferrules in connector adapters, bulkhead or female configured LC connectors
2.5	• Pin configured ferrules in MIL-DTL-38999 connectors • Exposed ferrules of any connector (such as ST, FC, SC, LC, etc.) • Recessed ferrules and alignment sleeves in connector adapters, bulkhead or female configured ST, FC and SC connectors

(c) Cleaning Alignment Sleeves in Connector Adapters. Alignment sleeves are found in various single terminus adapters (such as ST-to-ST adapters) and multiple termini connector adapters (MIL-DTL-38999 adapters).

1 Technique: Use a swab to clean alignment sleeves. Insert swab, rotate 1 revolution while passing through, rotate 1 revolution (same direction) while extracting (see Table 1).

NOTE

The job of a swab is to accumulate dirt. Swabs have very limited reusability. One swab per cleaning event is recommended.

(d) Cleaning Pin Termini. Use 2.5 mm fiber optic swabs to clean exposed ferrules of pin termini.

1 Recommended Technique: Lightly press the swab tip against the ferrule end face. Then wipe with one straight-line movement across the ferrule end face. Do not repeatedly wipe with the same section of the swab. Dirt that has been picked up by the swab can be transferred back.

2 Alternate Techniques:

a Lightly press swab tip against the ferrule end face one to two times.

b Lightly press swab tip against the ferule end face and rotate 1/2 to 1 revolution.

NOTE

The job of a swab is to accumulate dirt. Swabs have very limited reusability. One swab per cleaning event is recommended.

Alignment sleeve surfaces of recessed ferrules in socket configured termini, will accumulate pollutants that need cleaning.

(e) Cleaning Socket Termini. Use 1.25mm fiber optic swabs to clean recessed ferrules and alignment sleeves of socket termini.

1 Recommended Technique: Insert swab. Rotate swab 1 revolution as swab approaches the ferrule end face. Once contact is made press lightly and rotate 1/2 to 1 revolution. Lift swab off the ferrule and remove in a straight outward movement.

2 Alternate Techniques: Two alternate techniques are presented.

a Insert and rotate the swab 1 revolution down the alignment sleeve. Once contact is made with the ferrule, press, straight down, against the ferrule a couple of times (lifting swab slightly off the ferrule after each press). Lift swab off the ferrule and remove in a straight outward movement.

b Insert and push straight down until light contact is made with the ferrule. Rotate the swab for three revolutions (3 x 360°), then pull out straight.

(2) Wipe Usage. Wipes are only effective in cleaning exposed ferrules of single ferrule connectors (such as found on CMQJs and fiber optic test equipment). Fiber optic wipes are of a low-lint design. Care must be exercised to avoid contaminating them with particulate or fluids before they are used. Fiber optic wipes are available in several forms: presaturated with alcohol, cartridge containers with a replaceable reel of dry wipe cloth, and as dry loose cloth.

NOTE

Wipes should never be used to clean multiple ferrule connectors. Cross contamination among ferrules is uncontrollable when using a wipe on a multiple ferrule connector.

When using wipes presaturated with alcohol, care must be taken to use the wipe before the alcohol evaporates and leaves the wipe dry.

Leave presaturated alcohol wipes in their opened package to prevent rapid evaporation.

Alcohol on and end face will leave a film or residue if it is left to evaporate. After cleaning with alcohol, a dry wipe must be used to dry the alcohol.

When using loose cloth fiber optic wipes, use several (at least four) wipes in a stack to avoid skin contaminants leaching through from hands to the fiber optic ferrule being cleaned.

When using loose cloth fiber optic wipes, and cleaning is finished, remove and discard bottom wipe/cloth before placing remainder of wipes/cloths back into their storage package. This avoids skin contaminants leaching through from the handled cloth to rest of the stack.

(a) Life of Wipes The job of a wipe is to accumulate dirt. Reuse of wipes requires extreme care to avoid reusing a previously used section of a wipe cloth.

1 Recommended Practice. Use one clean section of cloth per contact with the ferrule.

(b) Applied Pressure. Applied pressure should always be light. Light pressure minimizes the risk of scratching an end face by dragging a hard particle across the end face.

(c) Cleaning Exposed Ferrules. Move ferrule across the wipe in a gentle 1/2 to 1 inch linear motion. Use a different area of the wipe for each cleaning event.

c. Cleaning with Compressed Gas. Cleaning with compressed (liquefied) gas is not recommended on or near aircraft. This technique is recommended for cleaning connector adapters and single ferrule connectors in relatively clean environments. Cleaning with compressed gas is also recommended for cleaning WRA, LRU or other avionics units before installation (provided that ESD or dust caps are covering the fiber optic connectors). This technique may only be used on aircraft if the Platform maintenance manual does not restrict its use. However, if the Platform maintenance manual does not restrict its use, it is still not recommended for the reasons noted below. Inspection before and after cleaning is a requirement of this technique when used on termini (unless superceded by Platform maintenance manual). Cleaning an end face is not risk free. Ambient particulate and compressed gas propellant can leave the target termini and neighboring termini spotted. Therefore, inspection must always determine when termini cleaning is required and inspection must always verify the result of a termini cleaning event. Inspection of termini before and after cleaning also provides efficient use of consumables. A practice to follow if compressed gas is authorized as part of a cleaning procedure follows:

NOTE

Canned compressed gas or canned liquefied gas intended for use in microscopic dusting applications is often incorrectly referred to as canned air. These items may contain halogenated hydrocarbons or 1,1,1,2 tetrafluoroethane and usually contain no air.

Use of compressed gas is not recommended to clean ferrule end faces on or near aircraft. Ambient conditions (including particulate and aerosols) on and near aircraft are not compatible with efficient and effective cleaning using compressed gas.

Use of compressed gas is not recommended to clean ferrule end faces of multiple termini connectors. Transfer of ambient pollutants to the target and neighboring termini is a risk. The post cleaning inspection requirement applies to every end face of a multiple termini connector, when one end face is cleaned with compressed gas.

Use of compressed gas to clean ferrule end faces requires extreme care to avoid expelling liquid propellant. The can must be held upright.

Use of compressed gas for any cleaning requires the exit nozzle or extension tube is clean and free of pollutants that could transfer to the item being cleaned.

Use only the compressed gas type designated for this application. Generic duster cans may not be adequately filtered to remove particulate that can deposit on ferrule end faces.

(1) Cleaning Alignment Sleeves in Connector Adapters. Connector adapters and connector ports have hollow alignment sleeves that accumulate pollutants. To clean these alignment sleeves or loose alignment sleeves, blow directly through the alignment sleeve. Hold the gas can upright. Hold the gas tube tip from the can of compressed gas at least four inches away from the sleeve. This orientation is done to minimize liquid propellant contact with the sleeve. Blow a steady stream of gas (not short bursts) through the alignment sleeve.

(2) Cleaning Pin Termini. To clean exposed ferrules of pin termini, blow across (parallel to) the ferrule end face. Hold the gas can upright. Hold the gas tube tip from the can of compressed gas at least four inches away from the end face. This orientation is done to minimize liquid propellant contact with the end face. Blow a steady stream of gas (not short bursts) across the ferrule end face.

(3) Cleaning Socket Termini. To clean recessed ferrules of socket termini, blow nearly directly at (almost perpendicular to) the ferrule end face. Hold the gas can upright. Hold the gas tube tip from the can of compressed gas at least four inches away from the end face. This orientation is done to minimize liquid propellant contact with the end face. Blow a steady stream of gas (not short bursts) at the ferrule end face.

Testing

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Optical Loss Measurement, One Jumper Method	009 01	13 August 2004
Optical Loss Measurement, Two Jumper Method	009 02	13 August 2004
CMQJ Field Check Method (ST-to-ST CMQJ)	009 03	13 August 2004
Optical Return Loss Measurement Method	009 04	13 August 2004
Fault Location Isolation Method Using OTDR	009 05	13 August 2004
Fault Location Isolation Method Using Fault Finder	009 06	13 August 2004
Test Probe CMQJ Insertion and Removal	009 07	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for different types of test and troubleshooting procedures. Work packages are provided for acceptance and verification tests (for optical loss and optical return loss, quality conformance (CMQJ field check), and troubleshooting (fault isolation using both an OTDR and a fault finder).

THIS PAGE LEFT INTENTIONALLY BLANK

Optical Loss Measurement, Two Jumper Method

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/, 2/

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL LOSS TEST EQUIPMENT				
	CMQJ (select proper configuration) Note: Other CMQJ types found in Peculiar Sets			
	ST CONNECTOR CMQJ			
101A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01080-5
101B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01080-7
101	Use to check single mode 9/125 micron fiber size	2	06324	FO01080-9
			08RC6	KFO3000
102A	Use to check multimode 50/125 micron fiber size	1	06324	FO00238-50
			08RC6	KFO3001
102B	Use to check multimode 50/125, restricted launch	1	06324	FO01081-50RL
102C	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00238-62
			08RC6	KFO3002
102D	Use to check multimode 62.5/125, restricted launch	1	06324	FO01082-62RL
102	Use to check multimode 100/140 micron fiber size M38999 ST-to-test probe CMQJ	2	06324	FO00238-100
			08RC6	KFO3003
	M38999 ST-TO-TEST PROBE CMQJ			
106A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01086-5
106B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01086-7
106	Use to check single mode 9/125 micron fiber size	2	06324	FO01086-9
107A	Use to check multimode 50/125 micron fiber size	1	06324	FO00240-50
107AR	Use to check multimode 50/125, restricted launch	1	06324	FO01087-50RL
107B	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00240-62
106	Use to check multimode 62.5/125, restricted launch	1	06324	FO01088-62RL
107BR	Use to check multimode 100/140 micron fiber size	2	06324	FO00240-100
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)			
103	SC-to-ST hybrid adapter	2		
104	SC-to-FC hybrid adapter	2		
105	FC-to-ST hybrid adapter	2		
108	M38999 test probe-to-test probe	1	06324	180-043C
108A	Stepped alignment sleeve, 2.5 mm to 1.25 mm	1	06324	087-037
108B	Stepped alignment sleeve, 2.5 mm to 0.0625 inch	1	06324	087-036
108C	Stepped alignment sleeve, 1.25 mm to 0.0625 inch	1	06324	087-035

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL LOSS TEST EQUIPMENT (cont.)				
	OPTICAL SOURCES & ACCESSORIES			
109	Optical source (LED, 850 nm & 1300 nm, full fill)	1	0XY53	252A-AS100
109A	Optical source (LD, 1310 & 1550 nm)	1		
110	FC adapter (narrow key)	1		
111	ST adapter	1		
	OPTICAL POWER METER & ACCESSORIES			
112	Optical power meter (+3to -60dBm,1mm InGaAs)	1		
113	FC adapter, Snap-On Connector interface (SOC)	1		
114	ST adapter, SOC	1		
115	Test probe adapter, M38999, SOC	1		
CONNECTOR PROBE ADAPTERS 3/				
	COMMON M38999 CONNECTOR PROBE ADAPTERS			
118	M3-11P-2P, dwg no. 7612821-M3-11P-2P	1	06324	180-044NF06-11-2P
119	M3-11R-2S-N, dwg no. 7612821-M3-11R-2S-N	1	06324	180-044NF07-11-2S
120	M3-13P-4P, dwg no. 7612821- M3-13P-4P	1	06324	180-044NF06-13-4P
121	M3-13R-4S-N, dwg no. 7612821- M3-13R-4S-N	1	06324	180-044NF07-13-4S
122	M3-15P-5P, dwg no. 7612821- M3-15P-5P	1	06324	180-044NF06-15-5P
123	M3-15R-5S-N, dwg no. 7612821- M3-15R-5S-N	1	06324	180-044NF07-15-5S
124	M3-17P-8P, dwg no. 7612821- M3-17P-8P	1	06324	180-044NF06-17-8P
125	M3-17R-8S-N, dwg no. 7612821- M3-17R-8S-N	1	06324	180-044NF07-17-8S
126	M3-19P-11P, dwg no. 7612821- M3-19P-11P	1	06324	180-073NF06-19-11P
127	M3-19R-11S-N, dwg no. 7612821-M3-19R-11S-N	1	06324	180-073NF07-19-11S
128	M3-25P-37P, dwg no. 7612821- M3-25P-37P Note: Two adapters are included with this item no.	1	06324	180-073NF06-25-37AP 180-073NF06-25-37BP
129	M3-25R-37S-N, dwg no. 7612821- M3-25R-37S-N Note: Two adapters are included with this item no.	1	06324	180-073NF07-25-37AS 180-073NF07-25-37AS
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS			
207	M3-17P-8S-A, dwg no. 7612821- M3-17P-8S-A	1	06324	180-044NF06-17-8S
208	M3-17R-8P-A, dwg no. 7612821- M3-17R-8P-A	1	06324	180-044NF07-17-8PA
209	M3-21P-16P, dwg no. 7612821- M3-21P-16P	1	06324	180-072NF06-21-16P
210	M3-23P-54P, dwg no. 7612821- M3-23P-54P	1	06324	180-073NF06-23-54P

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
CONNECTOR PROBE ADAPTERS 3/ (cont.)				
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS (cont.)			
211	M3-23R-54S-N, dwg no. 7612821- M3-23R-54S-N	1	06324	180-073NF07-23-54S
212	M3-23R-54P-N, dwg no. 7612821- M3-23R-54P-N	1	06324	180-073NF00-23-54P
213	M3-25R-29S-C, dwg no. 7612821- M3-25R-29S-C	1	06324	180-044NF07-25-29SC
214	M3-25P-43P, dwg no. 7612821- M3-25P-43P	1	06324	180-044NF06-25-43P
215	M3-25R-43S-N, dwg no. 7612821- M3-25R-43S-N	1	06324	180-044NF07-25-43S
ADAPTERS, SINGLE FERRULE, (MATE 2 SINGLE FERRULE CONNECTORS OF THE SAME TYPE)				
STA01	ST-to-ST adapter, single mode, COTS, Ruggedized	1		
STA02	ST-to-ST adapter, multimode, 125 micron, COTS, ruggedized	1		
SCA01	SC-to-SC adapter, single mode, COTS, simplex	1		
SCA02	SC-to-SC adapter, multimode, 125 micron, COTS, simplex	1		
LCA01	LC-to-LC adapter, single mode, COTS, duplex	1		
LCA02	LC-to-LC adapter, multimode, COTS, duplex	1		
SUPPLEMENTAL TOOLS				
	TOOLS TO INSERT & REMOVE TERMINI IN M38999 CONNECTORS			
141	Insertion & extraction tool for M29504/4 & /5 (plastic)	3	81349	M81969/14-03
142	Insertion tool M29504/4 & /5 (metal)	1	81349	M81969/8-207
143	Extraction tool M29504/4 & /5 (metal)	1	81349	M81969/8-208
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Cleaning (WP 008 02)			

1/ Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. The CMQJ, connector probe adapters and reference adapters in this table are those specified per NAVSEA Drawing 7612821, COTS Measurement Quality Jumpers (CMQJ), For test Equipment, Fiber Optic. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for these drawings.

2/ Inspection equipment for connector cleaning are listed under Cleaning in this volume. Recommend cleaning inspection equipment includes a Fiber Optic Video Inspection System (FOVIS) with applicable inspection probe tips.

3/ Connector probe adapter designations (for use with the MIL-DTL-38999 connector):
Designations in description (such as M3-11R-2S-N) are as follows:
M3 = Type of multiple termini connector compatible with the connector probe tip
11R = Connector probe adapter shell size and body type (P =plug, R = receptacle)
2S = Number of insert cavities and termini type for insert cavity (P = pin, S = socket)
N = keying position (N = normal, also A through F are applicable, for receptacle type probe adapters only. Plug type connector probe adapters can fit any keyed M38999 receptacles).

4/ Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. **INTRODUCTION**.

2. This work package is the method to be used by personnel for performing optical loss measurements on aircraft platforms. Measurements P_2 and P_3 of this test are for the optical loss measurement on the entire cable harness (P_3 - P_2). This method conforms to the optical power loss measurement of TIA/EIA-526-14 Method A. Measurements P_1 and P_2 of this test are for a field-check of the CMQJ (P_2-P_1). The measurement value obtained in measurement P_1 is not included in the optical loss measurement. Measurements P_1 and P_2, for the field check on the CMQJ, differs from measurements P_2 and P_3, for the optical loss test done on installed cable harnesses. The CMQJ test (field check) is done at one connector interface. Optical loss test is done on entire cable harness (two or more interfaces). This method may be generalized to apply to other connector configurations such as FC-to-Test Probe CMQJ's by replacing the word "ST" with "FC" or other connector type and performing the steps listed below.

3. Optical Loss Measurement, Two Jumper Method.

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

During handling, all the cables shall be protected from kinks, twists, crushing and sharp bends bends (see Handling Practices WP 006 01).

Ensure the test equipment calibration is current.

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

Always cover connectors (with ESD or dust caps) immediately after unmating. Never use tape to cover connectors with fiber optic termini in them.

For measurements on aircraft, or wherever tool control and FOD are a concern, the P_1 (see Figure 1) and P_2 (see Figure 2) measurements of this procedure can be done in a work center after access to the cable harness to test has been accomplished. Then the optical loss tools can be left all connected as shown in Figure 2 (with optical source and power meter energized) and taken out to the cable harness to test. Inspection and cleaning (WP 008 02) will still need to be performed at the cable harness to test.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. First power measurement (P_1).

NOTE

Before making loss measurements, make sure that both the light source and the power meter have been energized for at least 5 minutes to have stable performance.

CMQJ(s) used must be compatible with applicable requirements specified in Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC or NC/NC) should be mated together. Generally, if the fiber size in the cable harness being tested is multimode 50/125 micron or 62.5/125 micron, then ensure that CMQJ1 is the one with the restricted launch condition (CMQJ that states usage is for launch end only).

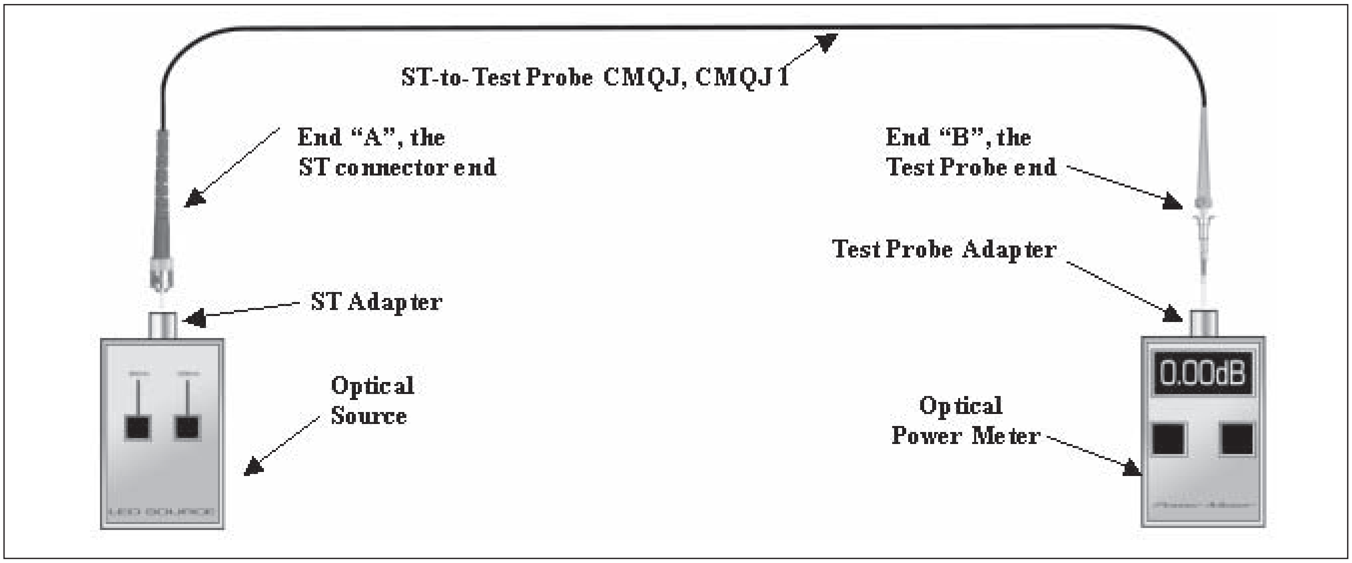


Figure 1. First Power Measurement (P_1) Setup

Test probe CMQJ insertion and removal is covered in WP 009 07.

Different types of CMQJs may be used in this procedure. Step (1) assumes that a MIL-DTL-38999 connector is on each end of the cable harness. CMQJ selection is provided based on the type of connector on the cable harness. For testing a cable harness with a MIL-DTL-38999 connector, the ST-to-Test probe CMQJ is used For testing a cable harness with a ST connector, a ST-to-ST CMQJ is used for the end of the cable harness. For testing a cable harness with other types of single ferrule connectors, a ST-to-applicable single ferrule connector CMQJ is used for the end of the cable harness with the applicable single ferrule connector pigtail.

The light source and optical power meter must be compatible with applicable requirements specified in Platform maintenance manual (such as operating wavelength). If Platform requirements are not applicable, a laser light source is recommended for use with single mode optical fiber cable assembly, link loss measurements.

The source and power meter should be stable (power meter reading not changing by more than +/- 0.05 dBm) over a measurement. If this stability is not observed; check batteries, CMQJs and general test setup.

(1) Turn light source and power meter on. Let them stabilize for at least 5 minutes before making any measurements.

(2) Set power meter display units to dBm.

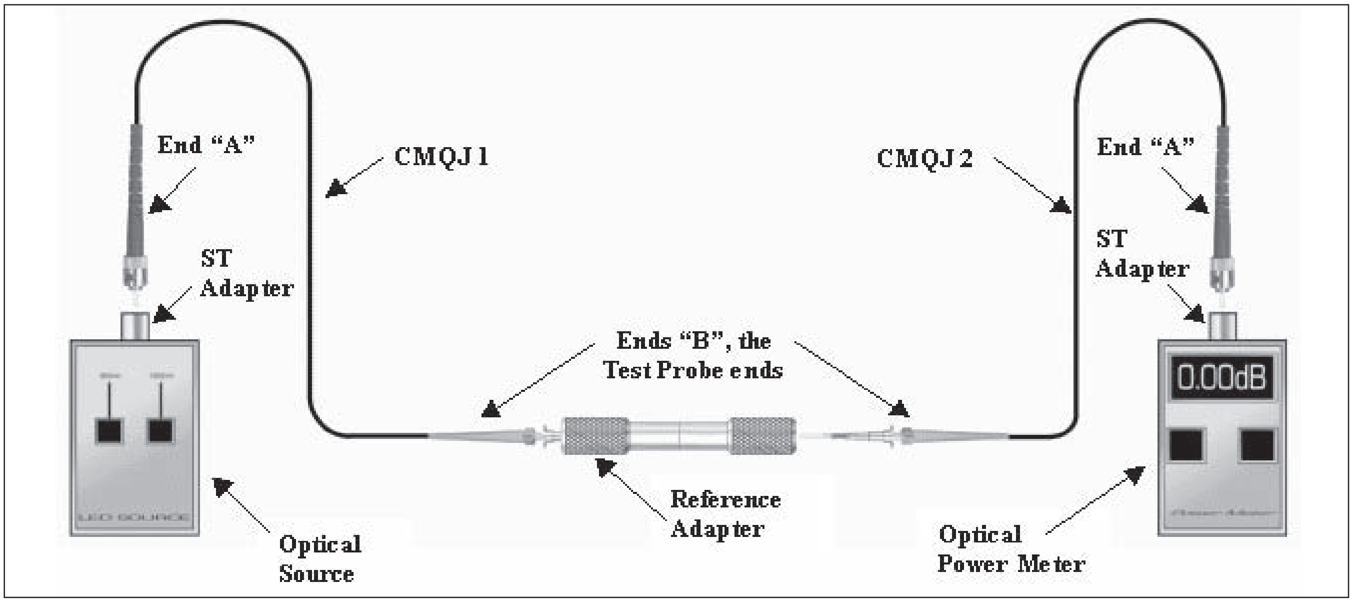


Figure 2. Second Power Measurement (P_2) Setup and CMQJ Field Check (P_2-P_1)

(3) Set light source wavelength (λ) to match applicable Platform maintenance manual requirements and make sure any source modulation is off.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(4) Designate one of the ST-to-Test Probe CMQJ's as CMQJ1 (see Figure 1 for setup).

(5) Designate the ST end of the ST-to-Test Probe CMQJ as "A" and the Test Probe end as "B".

(6) Place a ST adapter on the optical source.

(7) Place a Test Probe adapter on the power meter.

(8) Connect end "A" of CMQJ1 immediately to the optical source.

(9) Connect end "B" of CMQJ1 immediately to the power meter.

(10) Observe power meter reading. When reading is stable (not changing by more than +/- 0.05 dBm), note the value as P_1. If the value is below the specification of the light source (see operator manual), by more than 0.5 dBm , check the batteries in the light source and check CMQJ1.

(11) "Zero out" the power meter (see operator manual). When properly "Zeroed-out" the power meter will read a value of zero dB (within +/- 0.05 dB).

c. Second Power Measurement (P_2) and CMQJ Field Check (P_2-P_1).

NOTE

From this point forward, the power meter should be displaying values in units of dB and not dBm.

The time delay between the measurement of P_1 and P_2 shall be kept to a minimum (less than 10 minutes) to prevent inaccurate measurements.

The value obtained for the second power measurement, P_2 should be consistent from test to test. When making multiple cable harness loss measurements, the P_2 measurement can be repeated to verify the test setup is still valid. Generally, this P_2 value should not change by more than +/- 0.1 dB. Changes in the second power measurement greater than +/- 0.1 dB indicate either a dirty/defective CMQJ, a defective light source or an unstable power meter. If changes in the second power measurement greater than +/- 0.1 dB occur, clean or replace the CMQJ and repeat the second power measurement.

The value obtained for the second power measurement (P_2), should be less than the value obtained for the first power measurement (P_1). A value of the second power measurement (P_2) greater than the value of the first power measurement (P_1) indicates that either a defective or dirty CMQJ was used for the first power measurement (P_1). If a value for the second power measurement (P_2) greater than the value of the first power measurement (P_1) is obtained, clean or replace CMQJ1 and repeat the first power measurement (P_1) and the second power measurement (P_2).

Select the appropriate type of reference adapter based on the two connectors/test probe CMQJs being connected. A test probe to test probe adapter is used when probe CMQJs are used. A hybrid adapter is used when each CMQJ has a different connector type on the end. For instance, a test probe-to-1.25 mm adapter is used to connect the CMQJ ends together of a test probe to a single ferrule connector CMQJ and one ST-to-test probe CMQJ.

Test probe CMQJ insertion and removal is covered in WP 009 07.

(1) Designate another one of the ST-to-Test Probe CMQJ's as CMQJ2 (see Figure 2 for setup).

(2) Designate the ST end of CMQJ2 as "A" and the Test Probe end as "B".

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(3) Detach end "B" of CMQJ1 from the power meter (see Figure 1).

(4) Connect end "B" of CMQJ1 immediately into one end of the reference adapter (see Figure 2).

(5) Remove the Test Probe adapter from the power meter.

(6) Place a ST adapter on the power meter.

(7) Connect end "A" of CMQJ2 immediately to the power meter.

(8) Connect end "B" of CMQJ2 immediately into the other end of the reference adapter.

(9) Observe power meter reading. When reading is stable (not changing by more than +/- 0.05 dB), note the value as P_2. If this stability is not observed; check batteries, CMQJs and general test setup. P_2 should be a value within +0.1 to -0.5 dB range (if not check setup for dirty/worn components).

(a) If P_2 is within the +0.1 dB to -0.5 dB range, continue (the P_2 measurement is acceptable).

(b) If P_2 is higher than +0.1 dB (e.g. +0.3 dB), or If P_2 is lower than -0.5 dB (e.g. -0.7 dB); then check setup for dirty/worn components and repeat P_1 and P_2 measurements.

NOTE

The "zeroing-out" of the power meter after measuring P2, is the difference between the two jumper and one jumper optical loss measurement methods.

(10) "Zero-out" the power meter. When properly "Zeroed-out" the power meter will read a value of zero dB (within +/- 0.05 dB).

NOTE

For measurements on aircraft, or wherever tool control and FOD are a concern, the P_1 (see Figure 1) and P_2 (see Figure 2) measurements of this procedure can be done in a work center after access to the cable harness to test has been accomplished. Then the optical loss tools can be left all connected as shown in Figure 2 (with optical source and power meter energized) and taken out to the cable harness to test. Inspection and cleaning (WP 008 02) will still need to be performed at the cable harness to test.

d. <u>Test Measurement (P_3) and Cable Harness Measurement (P_3-P_2)</u>.

CAUTION

Make sure that the proper connector probe adapter is used before attaching it to a MIL-DTL-38999 connector with fiber optic termini. Incorrect connector probe adapter may result in damage to the connector termini.

NOTE

Use the adapter that matches the connectors on the cable harness to be tested. For cable harnesses under test terminated with MIL-DTL-38999 connectors, a connector probe adapter is used at each end to connect the test probe end of the CMQJ to the MIL-DTL-38999 connector. For cable harnesses under test terminated with ST connector pigtails at one end, a ST-to-ST adapter is required to connect the CMQJ to the ST connector pigtail end of the cable harness under test. For cable harnesses under test terminated with SC or other single ferrule, fiber optic connectors on one end, a hybrid adapter is required to connect the CMQJ to the pigtail end of the cable harness under test.

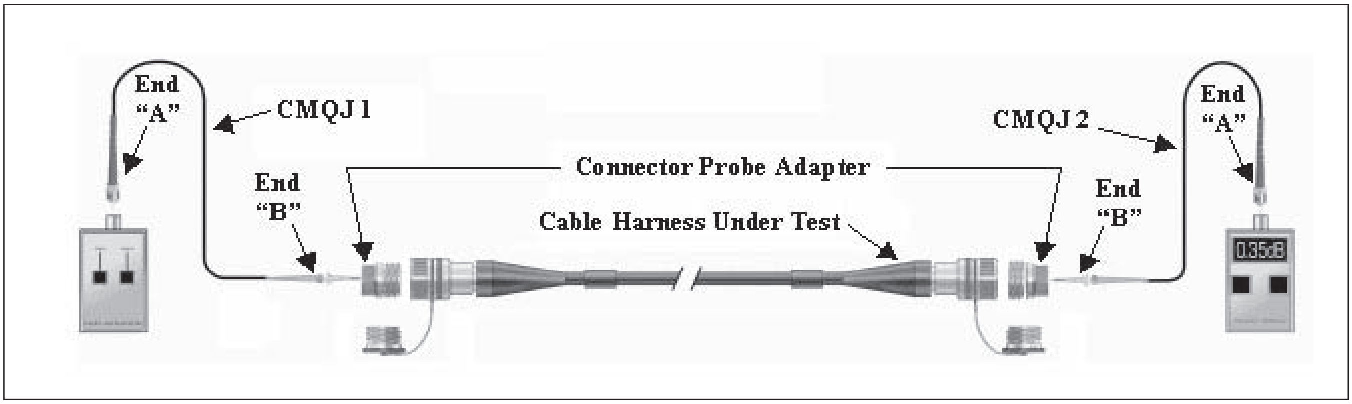


Figure 3. Test Measurement (P_3) and Cable Harness Optical Loss (P_3-P_2)

The value obtained for the test measurement (P_3), should be less than the value obtained for the second power measurement (P_2). A value of the test measurement power (P_3) greater than the value of the second power measurement (P_2) indicates that either a defective or dirty CMQJ was used for the second power measurement (P_2). If a value for the test measurement (P_3) greater than the value of the second power measurement (P_2) is obtained, clean or replace CMQJ1 and repeat the second power measurement (P_2) and the test measurement (P_3).

(1) Identify mating connector probe adapters for each end of the cable assembly/harness under test.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(2) Attach the connector probe adapters to the connectors on each end of the cable harness under test (see Figure 3 for setup).

(3) Remove end "B" of CMQJ1 from the reference adapter, and immediately place end "B" of CMQJ1 into the proper position of the connector probe adapter.

(4) Remove end "B" of CMQJ2 from the reference adapter, and immediately place end "B" of CMQJ2 into the proper position of the second connector probe adapter.

(5) Observe power meter reading. When the reading is stable (not changing by more than +/- 0.05 dB), note the value as P_3. If this stability is not observed; check batteries, CMQJs and general test setup. Record optical power measurement P_3.

NOTE

If optical loss is unacceptable, and the test setup is valid, check connectors for proper mating and inspect/clean(if necessary) all ferrule end faces of the cable under test and CMQJs (see WP 008 02).

(6) Record optical loss. Generally, optical loss is acceptable if P_3 is less than or equal to the specified maximum acceptable optical loss for the cable harness. See specific Platform maintenance manual for the maximum acceptable optical loss value. Optical loss values will be specified in units of dB not dBm.

NOTE

When making multiple measurements, for multiple connector positions, inspect/clean (WP 008 02) ends "B" of the two CMQJs and the next selected termini of the cable under test.

Verification of the test setup integrity may be done after any measurement by rechecking the P_2 measurement with the reference adapter. Changes in the second power measurement greater than +/- 0.1 dB indicate either a dirty/defective CMQJ, a defective light source or an unstable power meter. If changes in the second power measurement greater than +/- 0.1 dB occur, clean or replace the CMQJ and repeat the P_1 and P_2 measurements.

Verification of a CMQJ may be done after any measurement by following the CMQJ field check (WP 009 03), or by following the steps first for the first power measurement (P_1), then for the second power measurement (P_2).

(7) For each connector/terminus position to be tested, remove ends "B" of the two CMQJs then connect them at the next position to be tested and redo step (6).

NOTE

Specific Platform requirements may not require an additional loss measurement of multimode fiber in the opposite direction.

General practice is to also measure multimode fiber cables in the opposite direction. General practice does not measure single-mode fiber cables in the opposite direction. Swapping the connections of the CMQJs connected to the cable harness under test, accomplishes this directionality change (if the CMQJs are not detached from the optical source and power meters).

(8) Redo step (6) for each connector/terminus position to be tested in the opposite direction. Inspecting/cleaning (WP 008 02) ends "B" of the two CMQJs and the termini is required.

(9) Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

e. Determinations for Acceptance of Optical Loss.

(1) Optical loss is acceptable (in each direction for multimode cable harness), if the measured optical loss does not exceed the maximum acceptable optical loss specified for the cable harness. Specific Platform requirements may not require an additional loss measurement of multimode fiber in the opposite direction. See Platform maintenance manual for the acceptable optical loss value(s). Optical loss values will be specified in units of dB not dBm.

(2) If the measured optical loss (in **either** direction for multimode cable harnesses) is above the maximum acceptable optical loss, then inspect and

clean (WP 008 01, and WP 008 02) all the connections and retest. If the optical loss (in either direction for multimode cable harnesses) is still unacceptable, then repair/replacement of cable is needed. (See WP 012 01, and WP 013 01).

(3) If the maximum acceptable optical loss for the cable harness is not specified, record the length of the cable from the vendor's data or as measured. If the cable length is less than 10 meters, then a value of 0 may be recorded. If the cable length is unknown a value of "0/unknown" may be recorded.

NOTE

The term B_{CA} = Total cable harness optical loss in dB. Here, $B_{CA} = P_3$ (recorded previously).

The term MAL= Maximum Acceptable Loss. The term Aca = Maximum Attenuation of the Cable. The term L = Length of the Cable. The term Ns = Number of Splices. The term Ls = Loss of a splice (max.). The term Nco = Number of connectors. The term Lco = Loss of a connector (max.).

(a) Determine if the measurement is acceptable. Compare the measured optical loss (in each direction for multimode cable harness) to the maximum allowable optical loss. The maximum allowable optical loss is calculated from the maximum specified component optical loss values using the formula;

$$MAL = A_{ca}L + N_{co}L_{co} + N_sL_s$$

1 The cable harness is considered acceptable if the measured optical loss (in each direction for multimode cable assemblies) is equal to or less than the maximum acceptable optical loss.

2 If the measured optical loss (in **either** direction for multimode cable harnesses) is above the maximum acceptable optical loss, then inspect and clean (WP 008 01, and WP 008 02) all the connections and retest. If the optical loss (in either direction for multimode cable harnesses) is still unacceptable, then repair/replacement of cable is needed. (See WP 012 01, and WP 013 01).

THIS PAGE LEFT INTENTIONALLY BLANK

Optical Loss Measurement, One Jumper Method

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/, 2/

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL LOSS TEST EQUIPMENT				
	CMQJ (SELECT PROPER CONFIGURATION)			
	Note: Other CMQJ types found in Peculiar Sets			
	ST CONNECTOR CMQJ			
101A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01080-5
101B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01080-7
101	Use to check single mode 9/125 micron fiber size	2	06324	FO01080-9
			08RC6	KFO3000
102A	Use to check multimode 50/125 micron fiber size	1	06324	FO00238-50
			08RC6	KFO3001
102B	Use to check multimode 50/125, restricted launch	1	06324	FO01081-50RL
102C	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00238-62
			08RC6	KFO3002
102D	Use to check multimode 62.5/125, restricted launch	1	06324	FO01082-62RL
102	Use to check multimode 100/140 micron fiber size M38999 ST-to-test probe CMQJ	2	06324	FO00238-100
			08RC6	KFO3003
	M38999 ST-TO-TEST PROBE CMQJ			
106A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01086-5
106B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01086-7
106	Use to check single mode 9/125 micron fiber size	2	06324	FO01086-9
	Use to check multimode 50/125 micron fiber size	1	06324	FO00240-50
	Use to check multimode 50/125, restricted launch	1	06324	FO01087-50RL
	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00240-62
106	Use to check multimode 62.5/125, restricted launch	1	06324	FO01088-62RL
107	Use to check multimode 100/140 micron fiber size	2	06324	FO00240-100
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)			
103	SC-to-ST hybrid adapter	2		
104	SC-to-FC hybrid adapter	2		
105	FC-to-ST hybrid adapter	2		
108	M38999 test probe-to-test probe	1	06324	180-043C
108A	Stepped alignment sleeve, 2.5 mm to 1.25 mm	1	06324	087-037
108B	Stepped alignment sleeve, 2.5 mm to 0.0625 inch	1	06324	087-036
108C	Stepped alignment sleeve, 1.25 mm to 0.0625 inch	1	06324	087-035

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL LOSS TEST EQUIPMENT (cont.)				
	OPTICAL SOURCES & ACCESSORIES			
109	Optical source (LED, 850 nm & 1300 nm, full fill)	1	0XY53	252A-AS100
109A	Optical source (LD, 1310 & 1550 nm)	1		
110	FC adapter (narrow key)	1		
111	ST adapter	1		
	OPTICAL POWER METER & ACCESSORIES			
112	Optical power meter (+3to -60dBm,1mm InGaAs)	1		
113	FC adapter, Snap-On Connector interface (SOC)	1		
114	ST adapter, SOC	1		
115	Test probe adapter, M38999, SOC	1		
CONNECTOR PROBE ADAPTERS 3/				
	COMMON M38999 CONNECTOR PROBE ADAPTERS			
118	M3-11P-2P, dwg no. 7612821-M3-11P-2P	1	06324	180-044NF06-11-2P
119	M3-11R-2S-N, dwg no. 7612821-M3-11R-2S-N	1	06324	180-044NF07-11-2S
120	M3-13P-4P, dwg no. 7612821- M3-13P-4P	1	06324	180-044NF06-13-4P
121	M3-13R-4S-N, dwg no. 7612821- M3-13R-4S-N	1	06324	180-044NF07-13-4S
122	M3-15P-5P, dwg no. 7612821- M3-15P-5P	1	06324	180-044NF06-15-5P
123	M3-15R-5S-N, dwg no. 7612821- M3-15R-5S-N	1	06324	180-044NF07-15-5S
124	M3-17P-8P, dwg no. 7612821- M3-17P-8P	1	06324	180-044NF06-17-8P
125	M3-17R-8S-N, dwg no. 7612821- M3-17R-8S-N	1	06324	180-044NF07-17-8S
126	M3-19P-11P, dwg no. 7612821- M3-19P-11P	1	06324	180-073NF06-19-11P
127	M3-19R-11S-N, dwg no. 7612821-M3-19R-11S-N	1	06324	180-073NF07-19-11S
128	M3-25P-37P, dwg no. 7612821- M3-25P-37P Note: Two adapters are included with this item no.	1	06324	180-073NF06-25-37AP 180-073NF06-25-37BP
129	M3-25R-37S-N, dwg no. 7612821- M3-25R-37S-N Note: Two adapters are included with this item no.	1	06324	180-073NF07-25-37AS 180-073NF07-25-37AS
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS			
207	M3-17P-8S-A, dwg no. 7612821- M3-17P-8S-A	1	06324	180-044NF06-17-8S
208	M3-17R-8P-A, dwg no. 7612821- M3-17R-8P-A	1	06324	180-044NF07-17-8PA
209	M3-21P-16P, dwg no. 7612821- M3-21P-16P	1	06324	180-072NF06-21-16P
210	M3-23P-54P, dwg no. 7612821- M3-23P-54P	1	06324	180-073NF06-23-54P
211	M3-23R-54S-N, dwg no. 7612821- M3-23R-54S-N	1	06324	180-073NF07-23-54S
212	M3-23R-54P-N, dwg no. 7612821- M3-23R-54P-N	1	06324	180-073NF00-23-54P

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
CONNECTOR PROBE ADAPTERS 3/ (cont.)				
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS (cont.)			
213	M3-25R-29S-C, dwg no. 7612821- M3-25R-29S-C	1	06324	180-044NF07-25-29SC
214	M3-25P-43P, dwg no. 7612821- M3-25P-43P	1	06324	180-044NF06-25-43P
215	M3-25R-43S-N, dwg no. 7612821- M3-25R-43S-N	1	06324	180-044NF07-25-43S
ADAPTERS, SINGLE FERRULE, (MATE 2 SINGLE FERRULE CONNECTORS OF THE SAME TYPE)				
STA01	ST-to-ST adapter, single mode, COTS, Ruggedized	1		
STA02	ST-to-ST adapter, multimode, 125 micron, COTS, ruggedized	1		
SCA01	SC-to-SC adapter, single mode, COTS, simplex	1		
SCA02	SC-to-SC adapter, multimode, 125 micron, COTS, simplex	1		
LCA01	LC-to-LC adapter, single mode, COTS, duplex	1		
LCA02	LC-to-LC adapter, multimode, COTS, duplex	1		
SUPPLEMENTAL TOOLS				
	TOOLS TO INSERT & REMOVE TERMINI IN M38999 CONNECTORS			
141	Insertion & extraction tool for M29504/4 & /5 (plastic)	3	81349	M81969/14-03
142	Insertion tool M29504/4 & /5 (metal)	1	81349	M81969/8-207
143	Extraction tool M29504/4 & /5 (metal)	1	81349	M81969/8-208
144	Termini assist removal tool (optional)	1	08RC6	0721-1150
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Cleaning (WP 008 02)			
1/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. The CMQJ, connector probe adapters and reference adapters in this table are those specified per NAVSEA Drawing 7612821, COTS Measurement Quality Jumpers (CMQJ), For test Equipment, Fiber Optic. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for these drawings.			
2/	Inspection equipment for connector cleaning are listed under Cleaning in this volume. Recommend cleaning inspection equipment includes a Fiber Optic Video Inspection System (FOVIS) with applicable inspection probe tips.			
3/	Connector probe adapter designations (for use with the MIL-DTL-38999 connector): Designations in description (such as M3-11R-2S-N) are as follows: M3 = Type of multiple termini connector compatible with the connector probe tip 11R = Connector probe adapter shell size and body type (P =plug, R = receptacle) 2S = Number of insert cavities and termini type for insert cavity (P = pin, S = socket) N = keying position (N = normal, also A through F are applicable, for receptacle type probe adapters only. Plug type connector probe adapters can fit any keyed M38999 receptacles).			
4/	Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.			

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. **INTRODUCTION**.

2. This work package has an alternate method that is used by personnel for performing optical loss measurements on non-aircraft platforms such as surface ship and submarine platforms. This is a valid method and is presented in this work package for aircraft personnel familiarization when involved with "cross-platform" efforts. Measurements P_1 and P_3 of this test are for the optical loss measurement on the entire cable harness (P_3-P_1). This method conforms to the optical power loss measurement of TIA/EIA-526-14, Method B. Measurements P_1 and P_2 of this test are for a field-check of the CMQJ (P_2-P_1). The measurement value obtained for measurement P_2 is not included in the optical loss measurement. Measurements P_1 and P_2, for the field check on the CMQJ, differs from measurements P_1 and P_3, for the optical loss test done on the cable harnesses. The CMQJ test (field check) is done at one connector interface. Optical loss test is done on entire cable harness (two or more interfaces). This method may be generalized to apply to other connector configurations such as FC-to-Test Probe CMQJ's by replacing the word "ST" with "FC" or other connector type and performing the steps listed below.

3. Optical Loss Measurement, One Jumper Method.

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

During handling, all the cables shall be protected from kinks, twists, crushing and sharp bends (see Handling Practices WP 006 01).

Ensure the test equipment calibration is current.

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

Always cover connectors (with ESD or dust caps) immediately after unmating. Never use tape to cover connectors with fiber optic termini in them.

For measurements on aircraft, or wherever tool control and FOD are a concern, the P_1 (see Figure 1) and P_2 (see Figure 2) measurements of this procedure can be done in a work center after access to the cable harness to test has been accomplished. Then the optical loss tools can be left all connected as shown in Figure 2 (with optical source and power meter energized) and taken out to the cable harness to test. Inspection and cleaning (WP 008 02) will still need to be performed at the cable harness to test.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. First Power Measurement (P_1).

NOTE

Before making loss measurements, make sure that both the light source and the power meter have been energized for at least 5 minutes to have stable performance.

CMQJ(s) used must be compatible with applicable requirements specified in the Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC or NC/NC) should be mated together. Generally, if the fiber size in the cable harness being tested is multimode 50/125 micron or 62.5/125 micron, then ensure that CMQJ1 is the one with the restricted launch condition (CMQJ that states usage is for launch end only).

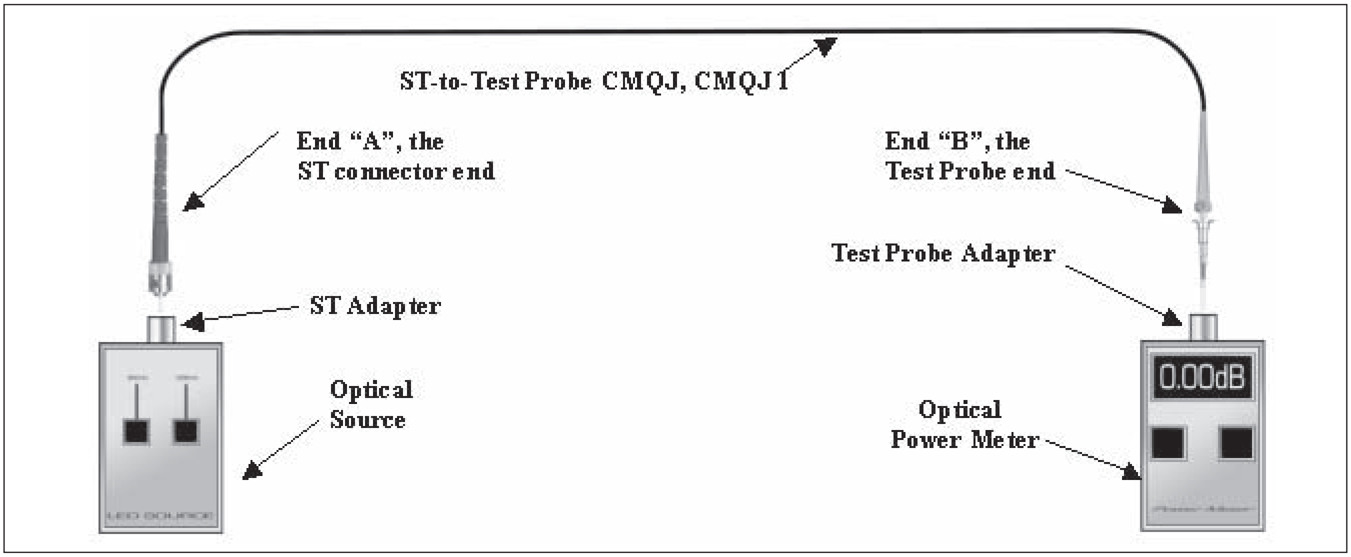


Figure 1. First Power Measurement (P_1) Setup

Test probe CMQJ insertion and removal is covered in WP 009 07.

Different types of CMQJs may be used in this procedure. Step (1) assumes that a MIL-DTL-38999 connector is on each end of the cable harness. CMQJ selection is provided based on the type of connector on the cable harness. For testing a cable harness with a MIL-DTL-38999 connector, the ST-to-Test probe CMQJ is used For testing a cable harness with a ST connector, a ST-to-ST CMQJ is used for the end of the cable harness. For testing a cable harness with other types of single ferrule connectors, a ST-to-applicable single ferrule connector CMQJ is used for the end the cable harness with the applicable single ferrule connector pigtail.

The light source and optical power meter must be compatible with applicable requirements specified in Platform maintenance manual (such as operating wavelength). If Platform requirements are not applicable, a laser light source is recommended for use with single mode optical fiber cable assembly, link loss measurements.

The source and power meter should be stable (power meter reading not changing by more than +/- 0.05 dBm) over a measurement. If this stability is not observed; check batteries, CMQJs and general test setup.

(1) Turn light source and power meter on. Let them stabilize for at least 5 minutes before making any measurements.

(2) Set power meter display units to dBm.

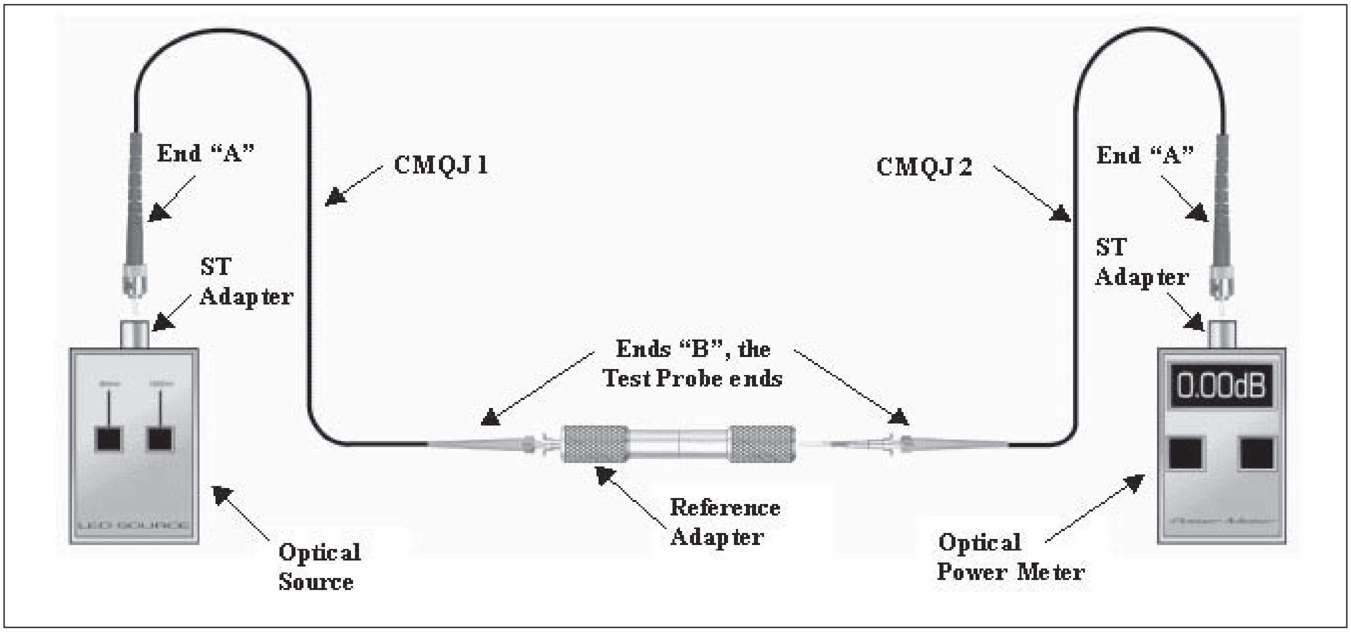


Figure 2. Second Power Measurement (P_2) Setup and CMQJ Field Check (P_2-P_1)

(3) Set light source wavelength (λ) to match applicable Platform maintenance manual requirements and make sure any source modulation is off.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(4) Designate one of the ST-to-Test Probe CMQJ's as CMQJ1 (see Figure 1 for setup).

(5) Designate the ST end of the CMQJ1 as "A" and the Test Probe end as "B".

(6) Place a ST adapter on the optical source.

(7) Place a Test Probe adapter on the power meter.

(8) Connect end "A" of CMQJ1 immediately to the optical source.

(9) Connect end "B" of CMQJ1 immediately to the power meter.

(10) Observe power meter reading. When reading is stable (not changing by more than +/- 0.05 dBm), note the value as P_1. If the value is below the specification of the light source (see operator manual) by more than 0.5dBm , check the batteries in the light source and check CMQJ1.

(11) "Zero out" the power meter (see operator manual). When properly "Zeroed-out" the power meter will read a value of zero dB (within +/- 0.05 dB).

c. Second Power Measurement (P_2) & CMQJ Field Check (P_2-P_1).

NOTE

From this point forward, the power meter should be displaying values in units of dB and not dBm.

The time delay between the measurement of P_1 and P_2 shall be kept to a minimum to prevent inaccurate measurements.

The value obtained for the second power measurement, P_2 should be consistent from test to test. When making multiple cable harness loss measurements, the P_2 measurement can be repeated to verify the test setup is still valid. Generally, this P_2 value should not change by more than +/- 0.1 dB. Changes in the second power measurement greater than +/- 0.1 dB indicate either a dirty/defective CMQJ, a defective light source or an unstable power meter. If changes in the second power measurement greater than +/- 0.1 dB occur, clean or replace the CMQJ and repeat the second power measurement.

NOTE

The value obtained for the second power measurement (P_2), should be less than the value obtained for the first power measurement (P_1). A value of the second power measurement (P_2) greater than the value of the first power measurement (P_1) indicates that either a defective or dirty CMQJ was used for the first power measurement (P_1). If a value for the second power measurement (P_2) greater than the value of the first power measurement (P_1) is obtained, clean or replace CMQJ1 and repeat the first power measurement (P_1) and the second power measurement (P_2).

Select the appropriate type of reference adapter based on the two connectors/test probe CMQJs being connected. A test probe to test probe adapter is used when probe CMQJs are used. A hybrid adapter is used when each CMQJ has a different connector type on the end. For instance, a test probe-to-1.25 mm adapter is used to connect the CMQJ ends together of a test probe to a single ferrule connector CMQJ and one ST-to-test probe CMQJ.

Test probe CMQJ insertion and removal is covered in WP 009 07.

(1) Designate another one of the ST-to-Test Probe CMQJ's as CMQJ2 (see Figure 2 for setup).

(2) Designate the ST end of the ST-to-Test Probe CMQJ, CMQJ2, as "A" and the Test Probe end as "B".

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(3) Detach end "B" of CMQJ1 from the power meter (see Figure 1).

(4) Connect end "B" of CMQJ1 immediately into one end of the reference adapter (see Figure 2).

(5) Remove the Test Probe adapter from the power meter.

(6) Place a ST adapter on the power meter.

(7) Connect end "A" of CMQJ2 immediately to the power meter.

(8) Connect end "B" of CMQJ2 immediately to the other end of the reference adapter.

(9) Observe power meter reading. When reading is stable (not changing by more than +/- 0.05 dB), note the value as P_2. If this stability is not observed; check batteries, CMQJs and general test setup. P_2 should be a value within +0.1 to -0.5 dB range (if not check setup for dirty/worn components).

(a) If P_2 is within the +0.1 dB to -0.5 dB range, continue (the P_2 measurement is acceptable).

(b) If P_2 is higher than +0.1 dB (e.g. +0.3 dB), or If P_2 is lower than -0.5 dB (e.g. -0.7 dB); then check setup for dirty/worn components and repeat P_1 and P_2 measurements.

NOTE

The P_2 measurement here, is not "zeroed out" as it is in the two jumper optical loss measurement method. This is the difference between the two jumper and one jumper optical loss measurement methods.

For measurements on aircraft, or wherever tool control and FOD are a concern, the P_1 (see Figure 1) and P_2 (see Figure 2) measurements of this procedure can be done in a work center after access to the cable harness to test has been accomplished. Then the optical loss tools can be left all connected as shown in Figure 2 (with optical source and power meter energized) and taken out to the cable harness to test. Inspection and cleaning (WP 008 02) will still need to be performed at the cable harness to test.

d. Test Measurement (P_3) and Cable Harness Optical Loss (P_3-P_1).

CAUTION

Make sure that the proper connector probe adapter is used before attaching it to a MIL-DTL-38999 connector with fiber optic termini. Incorrect connector probe adapter may result in damage to the connector termini.

NOTE

Use the adapter that matches the connectors on the cable harness to be tested. For cable harnesses under test terminated with MIL-DTL-38999 connectors, a connector probe adapter is used at each end to connect the test probe end of the CMQJ to the MIL-DTL-38999 connector. For cable harnesses under test terminated with ST connector pigtails at one end, a ST-to-ST adapter is required to connect the CMQJ to the ST connector pigtail end of the cable harness under test. For cable harnesses under test terminated with SC or other single ferrule, fiber optic connectors on one end, a hybrid adapter is required to connect the CMQJ to the pigtail end of the cable harness under test.

The value obtained for the test measurement (P_3), should be less than the value obtained for the second power measurement (P_2). A value of the test measurement power (P_3) greater than the value of the second power measurement (P_2) indicates that either a defective or dirty CMQJ was used for the second power measurement (P_2). If a value for the test measurement (P_3) greater than the value of the second power measurement (P_2) is obtained, clean or replace CMQJ1 and repeat the second power measurement (P_2) and the test measurement (P_3).

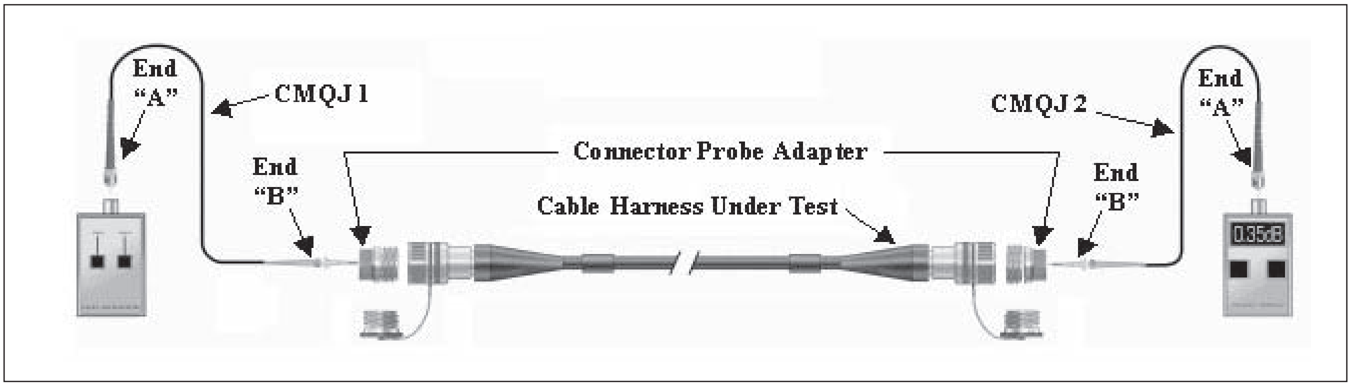


Figure 3. Test Measurement (P_3) and Cable Harness Optical Loss (P_3-P_1)

(1) Identify mating connector probe adapters for each end of the cable assembly/harness under test.

(2) Attach the connector probe adapters to the connectors on each end of the cable harness under test (see Figure 3 for setup).

(3) Remove end "B" of CMQJ1 from the reference adapter, and immediately place end "B" of CMQJ1 into the proper position of the connector probe adapter.

(4) Remove end "B" of CMQJ2 from the reference adapter, and immediately place end "B" of CMQJ2 into the proper position of the second connector probe adapter.

(5) Observe power meter reading. When the reading is stable (not changing by more than +/- 0.05 dB), note the value as P_3. If this stability is not observed; check batteries, CMQJs and general test setup. Record optical power measurement P_3.

NOTE

If optical loss is unacceptable, and the test setup is valid, check connectors for proper mating and inspect /clean(if necessary) all ferrule end faces of the cable under test and CMQJs (see WP 008 02).

(6) Record optical loss. Generally, optical loss is acceptable if P_3 is less than or equal to the specified maximum acceptable optical loss for the cable harness. See specific Platform maintenance manual for the maximum acceptable optical loss value. Optical loss values will be specified in units of dB not dBm.

NOTE

When making multiple measurements for multiple connector positions, inspect/clean (WP 008 02) ends "B" of the two CMQJs and the next selected termini of the cable under test.

Verification of the test setup integrity may be done after any measurement by rechecking the P_2 measurement with the reference adapter. Changes in the second power measurement greater than +/- 0.1 dB indicate either a dirty/defective CMQJ, a defective light source or an unstable power meter. If changes in the second power measurement greater than +/- 0.1 dB occur, clean or replace the CMQJ and repeat the P_1 and P_2 measurements.

Verification of a CMQJ may be done after any measurement by following the CMQJ field check (WP 009 03) , or by following the steps first for the first power measurement (P_1), then for the second power measurement (P_2).

(7) For each connector/terminus position to be tested, remove ends "B" of the two CMQJs then connect them at the next position to be tested and redo Step (6).

NOTE

Specific Platform requirements may not require an additional loss measurement of multimode fiber in the opposite direction.

General practice is to also measure multimode fiber cables in the opposite direction. General practice does not measure single-mode fiber cables in the opposite direction. Swapping the connections of the CMQJs connected to the cable harness under test, accomplishes this directionality change (if the CMQJs are not detached from the optical source and power meters).

(8) Redo step (6) for each connector/terminus position to be tested in the opposite direction. Inspecting/cleaning (WP 008 02) ends "B" of the two CMQJs and the termini is required.

(9) Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

e. Determinations for Acceptance of Optical Loss.

(1) Optical loss is acceptable (in each direction for multimode cable harness), if the measured optical loss does not exceed the maximum acceptable optical loss specified for the cable harness. Specific Platform requirements may not require an additional loss measurement of multimode fiber in the opposite direction. See Platform maintenance manual for the acceptable optical loss value(s). Optical loss values will be specified in units of dB not dBm.

(2) If the measured optical loss (in **either** direction for multimode cable harnesses) is above the maximum acceptable optical loss, then inspect and clean (WP 008 01, and WP 008 02) all the connections and retest. If the optical loss (in either direction for multimode cable harnesses) is still unacceptable, then repair/replacement of cable is needed (See WP 012 01, and WP 013 01).

(3) If the maximum acceptable optical loss for the cable harness is not specified, record the length of the cable from the vendor's data or as measured. If the cable length is less than 10 meters, then a value of 0 may be recorded. If the cable length is unknown a value of "0/unknown" may be recorded.

NOTE

The term B_{CA} = Total cable harness optical loss in dB. Here, $B_{CA} = P_3$ (recorded previously)

The term MAL= Maximum Acceptable Loss. The term A_{CA} = Maximum Attenuation of the Cable. The term L = Length of the cable. The term N_s = Number of splices. The term L_s = Loss of a splice (max.). The term N_{co} = Number of connectors. The term L_{co} = Loss of a connector (max.).

(a) Determine if the measurement is acceptable. Compare the measured optical loss (in each direction for multimode cable harness) to the maximum allowable optical loss. The maximum allowable optical loss is calculated from the maximum specified component optical loss values using the formula; $MAL = A_{ca}L + N_{co}L_{co} + N_sL_s$

1 The cable harness is considered acceptable if the measured optical loss (in each direction for multimode cable assemblies) is equal to or less than the maximum acceptable optical loss.

2 If the measured optical loss (in either direction for multimode cable harnesses) is above the maximum acceptable optical loss, then inspect and clean (see WP 008 01, and WP 008 02) all the connections and retest. If the optical loss (in either direction for multimode cable harnesses) is still unacceptable, then repair/replacement of cable is needed (See WP 012 01 and WP 013 01).

CMQJ Field Check Method (ST-to-ST CMQJ)

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/, 2/

Item	Description	Quantity	Cage Code	Part or Identifying No. 3/
CMQJ FIELD CHECK TEST EQUIPMENT				
	CMQJ (select proper configuration) Note: Other CMQJ types found in Peculiar Sets			
	ST CONNECTOPR CMQJ			
101A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01080-5
101B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01080-7
101	Use to check single mode 9/125 micron fiber size	2	06324	FO01080-9
			08RC6	KFO3000
102A	Use to check multimode 50/125 micron fiber size	1	06324	FO00238-50
			08RC6	KFO3001
102B	Use to check multimode 50/125, restricted launch	1	06324	FO01081-50RL
102C	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00238-62
			08RC6	KFO3002
102D	Use to check multimode 62.5/125, restricted launch	1	06324	FO01082-62RL
102	Use to check multimode 100/140 micron fiber size M38999 ST-to-test probe CMQJ	2	06324	FO00238-100
			08RC6	KFO3003
	M38999 ST-TO-TEST PROBE CMQJ			
106A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01086-5
106B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01086-7
106	Use to check single mode 9/125 micron fiber size	2	06324	FO01086-9
	Use to check multimode 50/125 micron fiber size	1	06324	FO00240-50
	Use to check multimode 50/125, restricted launch	1	06324	FO01087-50RL
	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00240-62
106	Use to check multimode 62.5/125, restricted launch	1	06324	FO01088-62RL
107	Use to check multimode 100/140 micron fiber size	2	06324	FO00240-100
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)			
103	SC-to-ST hybrid adapter	2		
104	SC-to-FC hybrid adapter	2		
105	FC-to-ST hybrid adapter	2		
108	M38999 test probe-to-test probe	1	06324	180-043C
108A	Stepped alignment sleeve, 2.5 mm to 1.25 mm	1	06324	087-037
108B	Stepped alignment sleeve, 2.5 mm to 0.0625 inch	1	06324	087-036
108C	Stepped alignment sleeve, 1.25 mm to 0.0625 inch	1	06324	087-035

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 3/
OPTICAL LOSS TEST EQUIPMENT (cont.)				
	OPTICAL SOURCES & ACCESSORIES			
109	Optical source (LED, 850 nm & 1300 nm, full fill)	1	0XY53	252A-AS100
109A	Optical source (LD, 1310 & 1550 nm)	1		
110	FC adapter (narrow key)	1		
111	ST adapter	1		
	OPTICAL POWER METER & ACCESSORIES			
112	Optical power meter (+3to -60dBm,1mm InGaAs)	1		
113	FC adapter, Snap-On Connector interface (SOC)	1		
114	ST adapter, SOC	1		
115	Test probe adapter, M38999, SOC	1		
ADAPTERS, SINGLE FERRULE, (MATE 2 SINGLE FERRULE CONNECTORS OF THE SAME TYPE)				
STA01	ST-to-ST adapter, single mode, COTS, Ruggedized	1		
STA02	ST-to-ST adapter, multimode, 125 micron, COTS, ruggedized	1		
SCA01	SC-to-SC adapter, single mode, COTS, simplex	1		
SCA02	SC-to-SC adapter, multimode, 125 micron, COTS, simplex	1		
LCA01	LC-to-LC adapter, single mode, COTS, duplex	1		
LCA02	LC-to-LC adapter, multimode, COTS, duplex	1		
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Hand Cleaning (WP 008 02)			

1/ Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. The CMQJ, connector probe adapters and reference adapters in this table are those specified per NAVSEA Drawing 7612821, COTS Measurement Quality Jumpers (CMQJ), For test Equipment, Fiber Optic. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for these drawings.

2/ Inspection equipment for connector cleaning are listed under Cleaning in this volume. Recommend cleaning inspection equipment includes a Fiber Optic Video Inspection System (FOVIS) with applicable inspection probe tips.

3/ Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. **INTRODUCTION**.

2. This work package is for a field check of the CMQJ based on periodicity or usage. Initial acceptance test of the CMQJ is to be done per Method 6F1 of MIL-STD-2042. Field verification test on the CMQJ differs from optical loss test done on cable harnesses. This CMQJ test is done at each connector interface. Any exception is noted below. Optical loss test is done on entire cable harness (two or more interfaces). This CMQJ field check may be performed on different CMQJ configurations (such as the ST-to-test probe CMQJ) if the mating adapters are available for attaching the two CMQJ's (such as the reference adapter for the ST-to-test probe CMQJ) and for interface at the power meter.

3. CMQJ Field Check Method (ST-to-ST CMQJ).

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

Ensure the test equipment calibration is current.

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

During handling, all the cables shall be protected from kinks, twists, crushing, and sharp bends (see Handling Practices WP 006 01).

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. Reference Measurement (P_1).

NOTE

Before making loss measurements, make sure that both the light source and the power meter have been energized for at least 5 minutes to have stable performance.

CMQJ(s) used must be compatible with applicable requirements specified in Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC or NC/NC) should be mated together. Generally, if the fiber size in the cable harness being tested is multimode 50/125 micron or 62.5/125 micron, then ensure that CMQJ1 is the one with the restricted launch condition (CMQJ that states usage is for launch end only).

Test probe CMQJ insertion and removal is covered in WP 009 07.

The light source and optical power meter must be compatible with applicable requirements specified in Platform maintenance manual (such as operating wavelength). If Platform requirements are not applicable, a laser light source is recommended for use with single mode optical fiber cable assembly, link loss measurements.

The source and power meter should be stable (power meter reading not changing by more than +/- 0.05 dBm) over a measurement. If this stability is not observed; check batteries, CMQJs and general test setup.

(1) Turn light source and power meter on. Let them stabilize for at least 5 minutes before making any measurements.

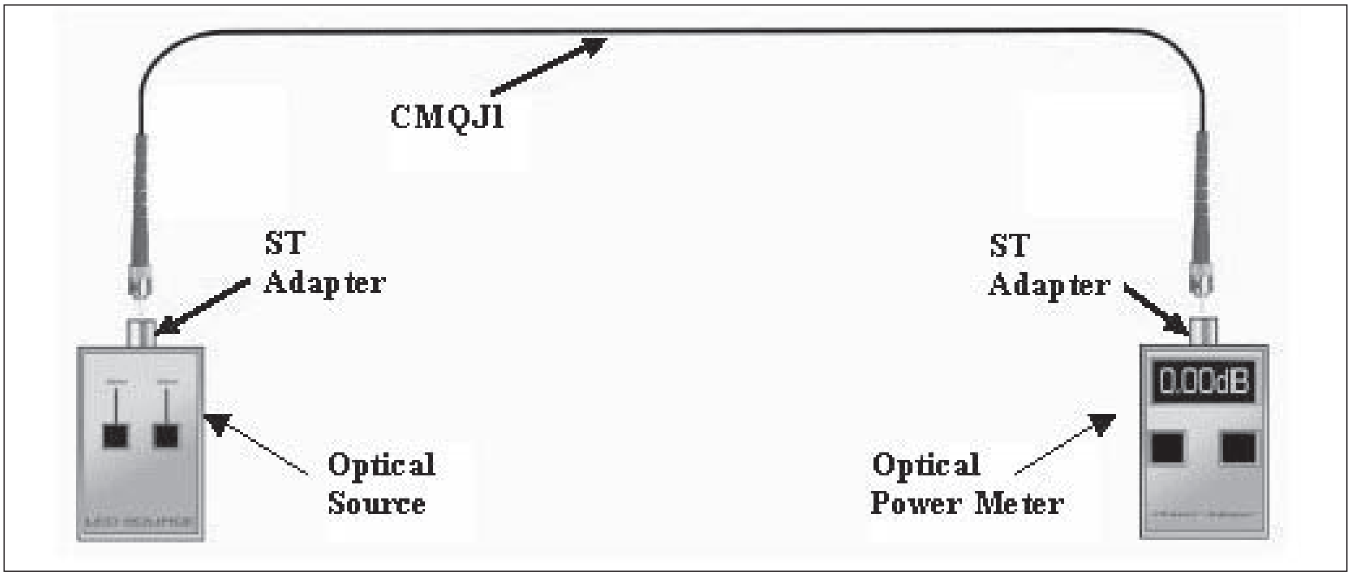


Figure 1. Reference Measurement (P_1) Setup

(2) Set power meter display units to dBm.

(3) Set light source wavelength (λ) to match applicable Platform maintenance manual requirements and make sure any source modulation is off.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02. The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(4) Designate the ends of the ST-to-ST CMQJ under test as "A" and "B".

(5) Place a ST adapter on the optical source.

(6) Place a ST adapter on the power meter.

(7) Connect an already checked CMQJ (designated CMQJ 1) between the light source and power meter (see Figure 1).

(8) Observe power meter reading. When reading is stable (not changing by more than +/- 0.05 dBm), note the value as P_1. If the value is below the specification of the light source (see operator manual) by more than 0.5 dBm , check the batteries in the light source and check CMQJ1.

(9) "Zero out" the power meter (see operator manual). When properly "Zeroed-out" the power meter will read a value of zero dB (within +/- 0.05 dB).

NOTE

From this point forward, the power meter should be displaying values in units of dB and not dBm.

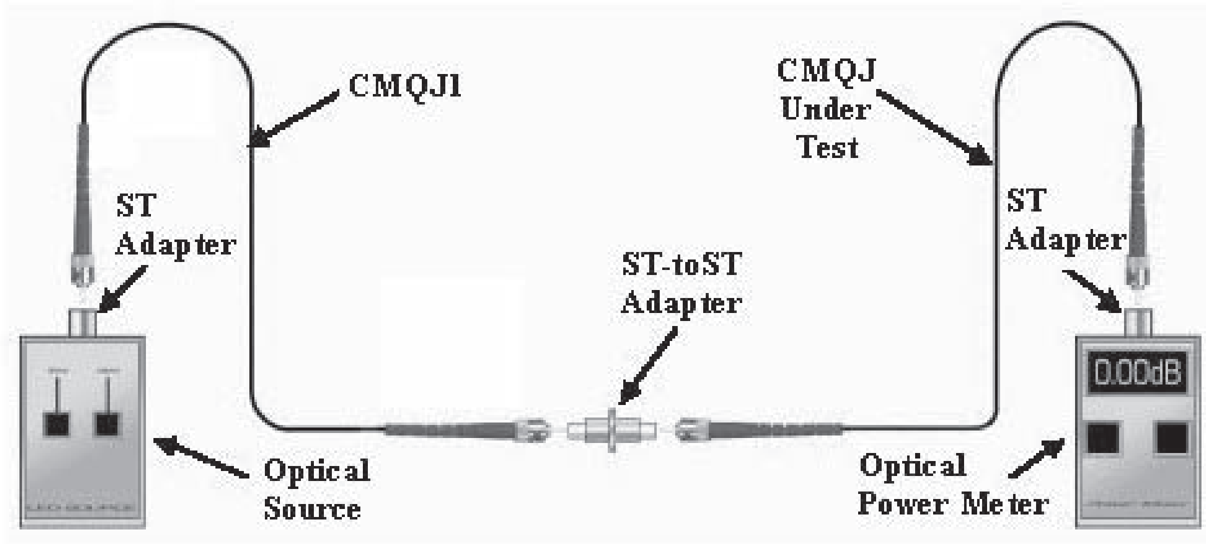


Figure 2. Test Measurement (P_2) Setup for ST-to-ST CMQJ Field Check (P_2-P_1)

The value obtained for the test measurement (P_2), should be less than the value obtained for the reference measurement (P_1). A value of the test measurement (P_2) greater than the value of the reference measurement (P_1) indicates that either a defective or dirty CMQJ was used for the reference measurement (P_1). If a value for the test measurement (P_2) greater than the value of the reference measurement (P_1) is obtained, clean or replace CMQJ1 and repeat the reference measurement (P_1) and the test measurement (P_2).

c. Test Measurement End "A" of CMQJ Under Test (P_2).

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

(1) Disconnect, the end of CMQJ1 connected to the optical power meter, and connect this end of CMQJ1 to an ST-to-ST adapter (see Figure 2).

(2) Connect end "A" of the CMQJ under test to the other end of the ST-to-ST adapter and connect end "B" of the CMQJ under test to the power meter.

(3) Record the optical power as P_2 (in dB), as the test measurement for this end of the CMQJ under test.

d. Determine If End "A" Optical Loss is Acceptable. End "A" of the CMQJ is acceptable if P_2 is is within the +0.1 dB to -0.35 dB range (for an ST connector).

e. Repeat Reference Measurement P_1.

(1) Re-connect the already checked CMQJ (designated CMQJ 1) between the light source and power meter (see Figure 1).

(2) Observe power meter reading. Wait for the reading to be stable (not changing by more than +/- 0.05 dBm).

(3) "Zero out" the power meter (see operator manual). When properly "Zeroed-out" the power meter will read a value of zero dB (within +/- 0.05 dB).

f. Test Measurement End "B" of CMQJ Under Test (P_2).

(1) Disconnect the end of CMQJ1 connected to the optical power meter, and connect this end of CMQJ1 to an ST-to-ST adapter (see Figure 2).

(2) Connect end "B" of the CMQJ under test to the other end of the ST-to-ST adapter and connect end "A" of the CMQJ under test to the power meter.

(3) Record the optical power as P_2 (in dB), as the test measurement for this end of the CMQJ under test.

g. Determine if End "B" Optical Loss is Acceptable. End "B" of the CMQJ is acceptable if P_2 is within the +0.1 dB to -0.35 dB range (for an ST connector).

h. Acceptance of CMQJ. Accept CMQJ under test if P_2 at both ends is within the +0.1 dB to -0.35 dB range (for an ST connector).

i. Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

Optical Return Loss Measurement Method

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/, 2/

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL RETURN LOSS TEST EQUIPMENT				
	CMQJ (select proper configuration) Note: Other CMQJ types found in Peculiar Sets			
	ST CONNECTOR CMQJ			
101A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01080-5
101B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01080-7
101	Use to check single mode 9/125 micron fiber size	2	06324 08RC6	FO01080-9 KFO3000
	M38999 ST-TO-TEST PROBE CMQJ			
106A	Use to check single mode 5.8/125 micron fiber size	2	06324	FO01086-5
106B	Use to check single mode 7.5/125 micron fiber size	2	06324	FO01086-7
106	Use to check multimode 62.5/125, restricted launch	1	06324	FO01088-62RL
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)			
103	SC-to-ST hybrid adapter	2		
104	SC-to-FC hybrid adapter	2		
105	FC-to-ST hybrid adapter	2		
108	M38999 test probe-to-test probe	1	06324	180-043C
108A	Stepped alignment sleeve, 2.5 mm to 1.25 mm	1	06324	087-037
108B	Stepped alignment sleeve, 2.5 mm to 0.0625 inch	1	06324	087-036
108C	Stepped alignment sleeve, 1.25 mm to 0.0625 inch	1	06324	087-035
	OPTICAL SOURCES & ACCESSORIES			
E101	Return loss meter & test set (LD, 1310 & 1550 nm), one unit, ST & FC adapters, mandrel, 10 to 45 dB ORL measurement range NSN 6650-01-508-2437	1		
	Return loss meter & test set (LD, 1310 & 1550 nm), one unit, APC-SC interface, APC jumper, mandrel, 0 to 65 dB ORL measurement range	1	0NL21	ORL3-3 ASC
CONNECTOR PROBE ADAPTERS 3/				
	COMMON M38999 CONNECTOR PROBE ADAPTERS			
118	M3-11P-2P, dwg no. 7612821-M3-11P-2P	1	06324	180-044NF06-11-2P
119	M3-11R-2S-N, dwg no. 7612821-M3-11R-2S-N	1	06324	180-044NF07-11-2S
120	M3-13P-4P, dwg no. 7612821- M3-13P-4P	1	06324	180-044NF06-13-4P
121	M3-13R-4S-N, dwg no. 7612821- M3-13R-4S-N	1	06324	180-044NF07-13-4S
122	M3-15P-5P, dwg no. 7612821- M3-15P-5P	1	06324	180-044NF06-15-5P
123	M3-15R-5S-N, dwg no. 7612821- M3-15R-5S-N	1	06324	180-044NF07-15-5S

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL RETURN LOSS TEST EQUIPMENT (cont.)				
CONNECTOR PROBE ADAPTERS 3/ (cont.)				
	COMMON M38999 CONNECTOR PROBE ADAPTERS (cont.)			
124	M3-17P-8P, dwg no. 7612821- M3-17P-8P	1	06324	180-044NF06-17-8P
125	M3-17R-8S-N, dwg no. 7612821- M3-17R-8S-N	1	06324	180-044NF07-17-8S
126	M3-19P-11P, dwg no. 7612821- M3-19P-11P	1	06324	180-073NF06-19-11P
127	M3-19R-11S-N, dwg no. 7612821-M3-19R-11S-N	1	06324	180-073NF07-19-11S
128	M3-25P-37P, dwg no. 7612821- M3-25P-37P Note: Two adapters are included with this item no.	1	06324	180-073NF06-25-37AP 180-073NF06-25-37BP
129	M3-25R-37S-N, dwg no. 7612821- M3-25R-37S-N Note: Two adapters are included with this item no.	1	06324	180-073NF07-25-37AS 180-073NF07-25-37AS
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS			
207	M3-17P-8S-A, dwg no. 7612821- M3-17P-8S-A	1	06324	180-044NF06-17-8S
208	M3-17R-8P-A, dwg no. 7612821- M3-17R-8P-A	1	06324	180-044NF07-17-8PA
209	M3-21P-16P, dwg no. 7612821- M3-21P-16P	1	06324	180-072NF06-21-16P
210	M3-23P-54P, dwg no. 7612821- M3-23P-54P	1	06324	180-073NF06-23-54P
211	M3-23R-54S-N, dwg no. 7612821- M3-23R-54S-N	1	06324	180-073NF07-23-54S
212	M3-23R-54P-N, dwg no. 7612821- M3-23R-54P-N	1	06324	180-073NF00-23-54P
213	M3-25R-29S-C, dwg no. 7612821- M3-25R-29S-C	1	06324	180-044NF07-25-29SC
214	M3-25P-43P, dwg no. 7612821- M3-25P-43P	1	06324	180-044NF06-25-43P
215	M3-25R-43S-N, dwg no. 7612821- M3-25R-43S-N	1	06324	180-044NF07-25-43S
ADAPTERS, SINGLE FERRULE, (MATE 2 SINGLE FERRULE CONNECTORS OF THE SAME TYPE)				
STA01	ST-to-ST adapter, single mode, COTS, Ruggedized	1		
STA02	ST-to-ST adapter, multimode, 125 micron, COTS, ruggedized	1		
SCA01	SC-to-SC adapter, single mode, COTS, simplex	1		
SCA02	SC-to-SC adapter, multimode, 125 micron, COTS, simplex	1		
LCA01	LC-to-LC adapter, single mode, COTS, duplex	1		
LCA02	LC-to-LC adapter, multimode, COTS, duplex	1		

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
SUPPLEMENTAL TOOLS				
	TOOLS TO INSERT & REMOVE TERMINI IN M38999 CONNECTORS			
141	Insertion & extraction tool for M29504/4 & /5 (plastic)	3	81349	M81969/14-03
142	Insertion tool M29504/4 & /5 (metal)	1	81349	M81969/8-207
143	Extraction tool M29504/4 & /5 (metal)	1	81349	M81969/8-208
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Hand Cleaning (WP 008 02)			
1/	Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. The CMQJ, connector probe adapters and reference adapters in this table are those specified per NAVSEA Drawing 7612821, COTS Measurement Quality Jumpers (CMQJ), For test Equipment, Fiber Optic. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for these drawings.			
2/	Inspection equipment for connector cleaning are listed under Cleaning in this volume. Recommend cleaning inspection equipment includes a Fiber Optic Video Inspection System (FOVIS) with applicable inspection probe tips.			
3/	Connector probe adapter designations (for use with the MIL-DTL-38999 connector): Designations in description (such as M3-11R-2S-N) are as follows: M3 = Type of multiple termini connector compatible with the connector probe tip 11R = Connector probe adapter shell size and body type (P =plug, R = receptacle) 2S = Number of insert cavities and termini type for insert cavity (P = pin, S = socket) N = keying position (N = normal, also A through F are applicable, for receptacle type probe adapters only. Plug type connector probe adapters can fit any keyed M38999 receptacles).			
4/	Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.			

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. **INTRODUCTION**.

2. This work package is the method to perform an optical return loss test on cable harnesses with single mode, optical fiber using an Optical Return Loss Meter (ORLM). This WP addresses the operation of an ORLM both with and without an interface cable.

3. Optical Return Loss Measurement Method.

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection “tip” will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection “tip” will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

Ensure the test equipment calibration is current.

This procedure involves the use of COTS Measurement Quality Jumper cables (CMQJs). Dirty or defective CMQJs will lead to low or unacceptable cable assembly return loss values. CMQJs used in these procedures should be clean and should be of known good quality. Test organizations are encouraged to institute an CMQJ verification program in which the quality of CMQJs is regularly validated. See WP 009 01 and WP 009 03 for CMQJ verification methods.

During handling, all the cables shall be protected from kinks, twists, crushing, and sharp bends (see Handling Practices WP 006 01).

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

Always cover connectors (with ESD or dust caps) immediately after unmating. Never use tape to cover connectors with fiber optic termini in them.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. Optical Return Loss Measurement.

NOTE

CMQJ(s) used must be compatible with applicable requirements specified in the Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC, APC/APC or NC/NC) should be mated together. Generally, if the fiber size in the cable harness being tested is multimode 50/125 micron or 62.5/125 micron, then ensure that CMQJ1 is the one with the restricted launch condition (CMQJ that states usage is for launch end only).

Test probe CMQJ insertion and removal is covered in WP 009 07.

The ORLM must be compatible with applicable requirements (such as operating wavelength) specified in Platform maintenance manual for the cables being tested. These requirements include compatibility with wavelength, fiber type (multimode or single mode) and fiber core size.

NOTE

Refer to the manufacturer's instructions for additional information.

(1) Turn ORLM on. Let it stabilize for at least 5 minutes before making any measurements.

(2) Set the ORLM in optical return loss mode.

(3) Set ORLM wavelength (λ) to match applicable Platform maintenance manual requirements. Generally, select the 1550 nm wavelength, if the ORLM can perform return loss measurements at multiple wavelengths.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Mating of a non-APC to an APC (angle polished connector) on the ORLM can cause damage to both or either the connector and interface port.

NOTE

The SC/APC connector is an angle polished SC connector. The angle on the end of the connector ferrule can be observed in a visual inspection.

Two configurations for the ORLM are addressed in this WP. In one configuration, the ORLM has a SC/APC connection port. The ORLM comes with a interface cable. One end of this interface cable has a SC/APC connector that mates with ORLM SC/APC connection port. The other end of the interface cable is connected to a CMQJ. In the second configuration, the ORLM has a ST connection port. No interface cable is supplied with or used with this ORLM. A CMQJ is connected directly to the ORLM connection port.

(4) Connection at the ORLM port.

(a) ORLM configuration with a SC/APC connection port. Attach the SC/APC connector of the ORLM interface cable to the optical receptacle of the ORLM.

(b) ORLM configuration with a ST connection port. Select the applicable CMQJ1 and connect one end of CMQJ1 with a ST connector on the end directly to the ORLM. IF there are two ports on the ORLM, connect to the port labeled transmit or Tx.

NOTE

Do not connect CMQJ1 to the optical fiber cable assembly under test. This connection is not completed until step (10).

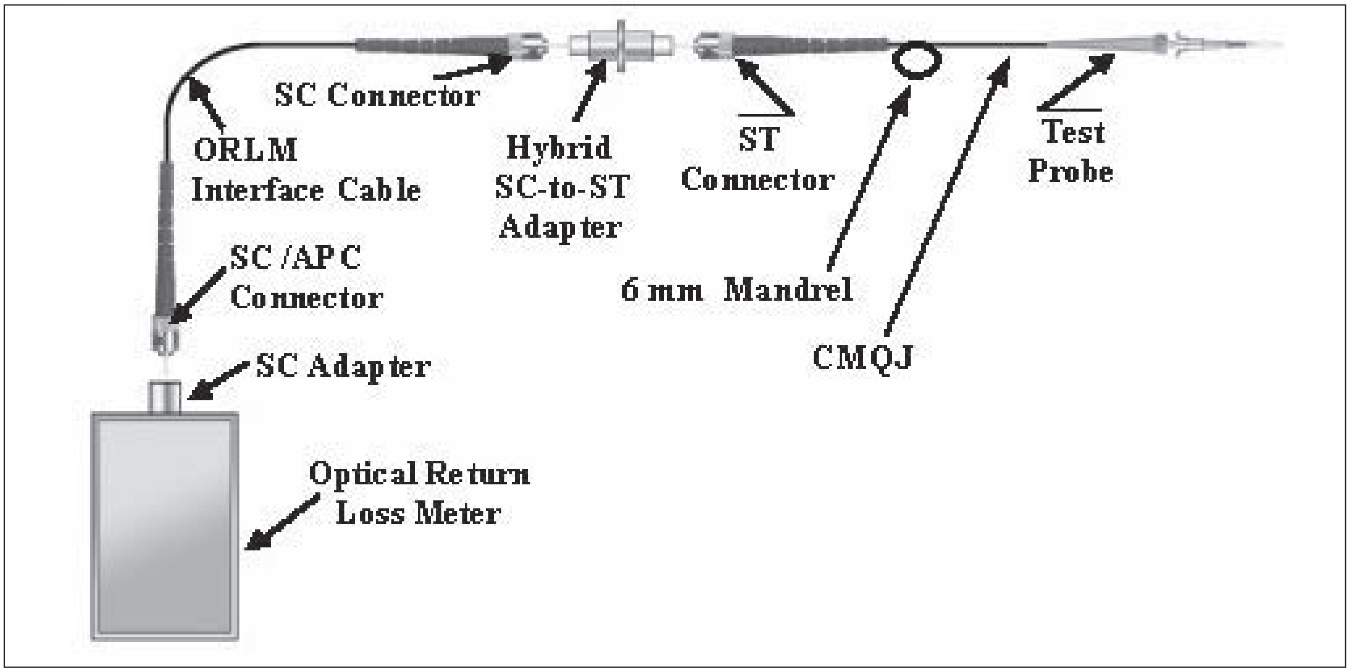


Figure 1. ORLM Reference Setup (Typical)

Use the adapter that matches the connector on the end opposite to the ORLM interface port. For ORLM interface cables terminated with ST connectors at the end opposite to the connector for the ORLM interface port, a ST-to-ST adapter is required to connect CMQJ1 to the ST connector on the ORLM interface cable. For ORLM interface cables terminated with SC or other single ferrule, fiber optic connectors at the end opposite to the connector for the ORLM interface port, a hybrid adapter is required to connect CMQJ1 to the SC or other single ferrule connector on the ORLM interface cable.

For cable harnesses under test terminated with MIL-DTL-38999 connectors, a ST-to-Test probe CMQJ is used as CMQJ1.

For cable harnesses under test terminated with ST connector pigtails, the ST-to-ST CMQJ is used for CMQJ1.

For cable harnesses under test terminated with SC or other single ferrule, fiber optic connectors on one end, a SC-to-Test probe CMQJ or applicable single ferrule connector-to-Test probe CMQJ is used for CMQJ1.

(5) Connection to the ORLM interface cable.

(a) ORLM configuration with a SC/APC connection port. Select the applicable CMQJ1, and connect the ST connector end of the CMQJ1 to the ORLM interface cable using the applicable adapter as shown in Figure 1 (see second **NOTE** above).

(b) ORLM configuration with a ST connection port. No action required.

NOTE

Ten mandrel wraps are usually sufficient to obtain a stable value.

Each wrap (winding around the mandrel) should be in contact with the previous one. Each turn must be in contact in contact with the mandrel (for a snug wrap). Do not twist the cable as it is being wrapped.

When measuring enhanced polish products a stable value greater than 40 dB should be indicated on the ORLM display.

(6) Wrap for reference measurement.

(a) ORLM configuration with a SC/APC connection port. Snugly wrap (wind) the CMQJ1 around a 6 mm (0.25 inch) mandrel. CMQJ1 should be wrapped around the mandrel until a stable value greater than 30 dB is indicated on the ORLM display. This should be observed within seven to ten mandrel wraps.

(b) ORLM configuration with a ST connection port. For NSN ORLM (such as a Model 525N-60), press the reference softkey prior to wrapping. There will be no value displayed. Snugly wrap (wind) the CMQJ1 around a 6 mm (0.25 inch) mandrel for about seven to ten mandrel wraps.

(7) Reference the ORLM.

(a) ORLM configuration with a SC/APC connection port. Press the applicable key to reference the ORLM.

(b) ORLM configuration with a ST connection port. For NSN ORLM (such as a Model 525N-60), press the next softkey after wrapping. Otherwise, press the applicable key to reference the ORLM.

NOTE

Do not unwrap CMQJ1 from the mandrel until the referencing process is complete (see operator manual).

(8) Unwrap the CMQJ1 from the mandrel and smooth out the cable.

(a) ORLM configuration with a SC/APC connection port. No further action required.

(b) ORLM configuration with a ST connection port. For NSN ORLM (such as a Model 525N-60), press the next softkey after unwrapping the cable.

NOTE

If a different value is displayed, then reconnect the ORLM interface cable to CMQJ1 and repeat steps (6), (7), (8) and (9). If this does not remedy the problem, then clean the ORLM interface cable and CMQJ1 connections, and repeat steps (4) through (9). This **NOTE** is not applicable for an ORLM configuration with a ST connection port.

(9) Verify that the ORLM is displaying a value between 14.3 dB and 15.9 dB.

CAUTION

Make sure that the proper connector probe adapter is used before attaching it to a MIL-DTL-38999 connector with fiber optic termini. Incorrect connector probe adapter may result in damage to the connector termini.

NOTE

Use the adapter that matches the connectors on the cable harness to be tested. For cable harnesses under test terminated with MIL-DTL-38999 connectors, a connector probe adapter is used at each end to connect the test probe end of the CMQJ to the MIL-DTL-38999 connector. For cable harnesses under test terminated with ST connector pigtails at one end, a ST-to-ST adapter is required to connect the CMQJ to the ST connector pigtail end of the cable harness under test. For cable harnesses under test terminated with SC or other single ferrule, fiber optic connectors on one end, a hybrid adapter is required to connect the CMQJ to the pigtail end of the cable harness under test.

(10) Connect the appropriate end of the optical fiber cable harness under test to CMQJ1.

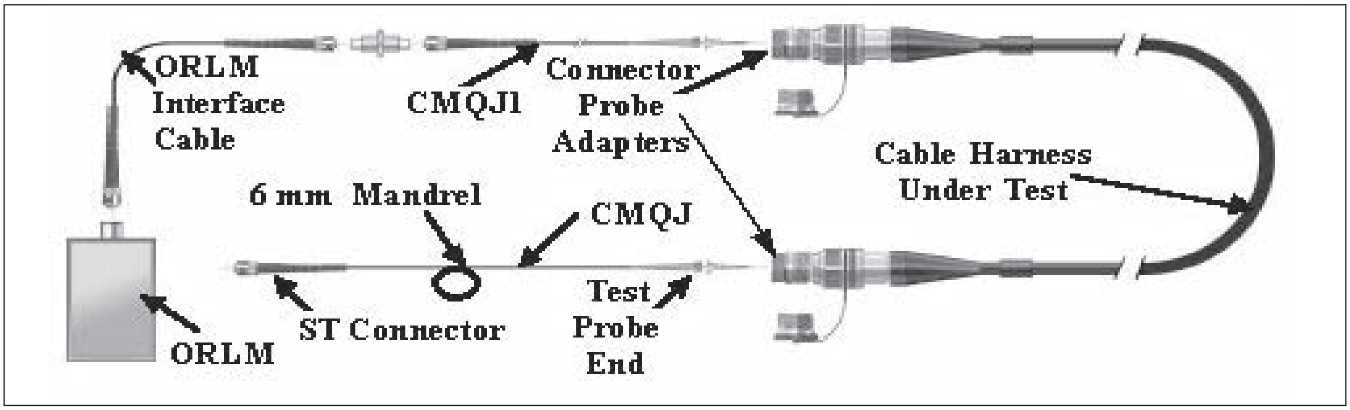


Figure 2. ORLM Cable Harness Measurement Setup (Typical)

(11) Select the applicable CMQJ2, and connect CMQJ2 to the other end of the optical fiber cable harness under test as shown in Figure 2.

NOTE

The CMQJ2 (or the appropriate single fiber cable of CMQJ2) should be wrapped around the mandrel until a stable value is indicated on the ORLM display. Ten mandrel wraps are usually sufficient to obtain a stable value (i.e., a value that varies within 1.0 dB).

(12) Wrap the CMQJ2 (or the appropriate single fiber cable of CMQJ2) around a 6 mm (0.25 inch) mandrel.

NOTE

The CMQJ2 (or the appropriate single fiber cable of CMQJ2) should be wrapped around the mandrel until a stable value is indicated on the ORLM display. Ten mandrel wraps are usually sufficient to obtain a stable value.

(13) Record the value displayed by the ORLM.

NOTE

Do not unwrap CMQJ2 from the mandrel until the return loss value has been recorded.

(14) Unwrap CMQJ2 from the mandrel and smooth out the cable.

NOTE

If the optical fiber cable harness under test is terminated with single fiber connectors on the input side, disconnect CMQJ2 from the cable harness under test. Repeat steps (9) through (15) for the other fibers in the optical fiber cable harness under test.

If the optical fiber cable harness under test is terminated with multi-fiber connectors on the input side, disconnect the optical fiber cable harness under test and the ORLM interface cable from CMQJ1. Repeat steps (5) through (15) for the other fibers in the optical fiber cable harness under test.

(15) Repeat the test for each fiber in the optical fiber cable harness.

(16) Repeat this measurement for each fiber at the other end of the cable harness, if specified in the Platform manual.

(17) Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

c. Acceptance of Optical Return Loss.

NOTE

The optical fiber cable assembly is considered acceptable if the measured return loss is greater than or equal to the minimum specified cable harness return loss. If the measured return loss is acceptable, proceed to step (3) below. If the measured return loss is less than the minimum cable harness return loss, proceed to step (2) below.

(1) Verify the measured return loss is larger than the specified value in the Platform manual.

(2) If the return loss value is not acceptable (i.e., larger than the specified value), disconnect and clean all the connections and retest. If the measured cable harness return loss is still unacceptable, re-polish the optical fiber cable harness terminations or replace the defective components and retest.

(3) If the optical fiber cable harness is not going to be immediately connected to its mating connectors, install protective caps over the optical fiber cable assembly connectors.

THIS PAGE LEFT INTENTIONALLY BLANK

Fault Location Isolation Method Using OTDR

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/, 2/

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL TIME DOMAIN REFLECTOMETER TEST EQUIPMENT				
	CMQJ (select proper configuration) Note: Other CMQJ types found in Peculiar Sets			
	FC CONNECTOR CMQJ			
	Use to check single mode 5.8/125 micron fiber size	1	06324	FO01083-5
			08RC6	KFO30008
	Use to check single mode 7.5/125 micron fiber size	1	06324	FO01083-7
	Use to check single mode 9/125 micron fiber size	1	06324	FO01083-9
			08RC6	KFO3009
	Use to check multimode 50/125 micron fiber size	1	06324	FO00239-50
			08RC6	KFO30010
	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00239-62
			08RC6	KFO30011
	Use to check multimode 100/140 micron fiber size	1	06324	FO00239-100
			08RC6	KFO30012
	M38999 FC-TO-TEST PROBE CMQJ			
	Use to check single mode 5.8/125 micron fiber size	1	06324	FO01090-5
	Use to check single mode 7.5/125 micron fiber size	1	06324	FO01090-7
	Use to check single mode 9/125 micron fiber size	1	06324	FO01090-9
	Use to check multimode 50/125 micron fiber size	1	06324	FO00242-50
	Use to check multimode 62.5/125 micron fiber size	1	06324	FO00242-62
	Use to check multimode 100/140 micron fiber size	1	06324	FO00242-100
E102	OTDR, standard resolution, slots for at least two removeable OTDR modules, 15 lb maximum weight, 12 x 12 x 6 inches maximum footprint, battery and AC powered	1		
E102A	OTDR module, single mode, 1550 nm wavelength, ST connection port, 5 ns to 100 ns minimum pulsewidth range, 15 meter maximum attenuation deadzone, 25 dB minimum dynamic range	1		
E102B	OTDR module, multimode, 850 nm wavelength, ST connection port, for up to 100/140 micron core sizes, 5 ns to 100 ns minimum pulsewidth range, 5 meter maximum attenuation deadzone, 20 dB minimum dynamic range	1		
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)			
103	SC-to-ST hybrid adapter	2		
104	SC-to-FC hybrid adapter	2		
105	FC-to-ST hybrid adapter	2		

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
OPTICAL TIME DOMAIN REFLECTOMETER TEST EQUIPMENT (CONT'D)				
	REFERENCE ADAPTERS (SELECT PROPER CONFIGURATION)(CONT'D)			
108	M38999 test probe-to-test probe	1	06324	180-043C
108A	Stepped alignment sleeve, 2.5 mm to 1.25 mm	1	06324	087-037
108B	Stepped alignment sleeve, 2.5 mm to 0.0625 inch	1	06324	087-036
108C	Stepped alignment sleeve, 1.25 mm to 0.0625 inch	1	06324	087-035
CONNECTOR PROBE ADAPTERS 3/				
	COMMON M38999 CONNECTOR PROBE ADAPTERS			
118	M3-11P-2P, dwg no. 7612821-M3-11P-2P	1	06324	180-044NF06-11-2P
119	M3-11R-2S-N, dwg no. 7612821-M3-11R-2S-N	1	06324	180-044NF07-11-2S
120	M3-13P-4P, dwg no. 7612821- M3-13P-4P	1	06324	180-044NF06-13-4P
121	M3-13R-4S-N, dwg no. 7612821- M3-13R-4S-N	1	06324	180-044NF07-13-4S
122	M3-15P-5P, dwg no. 7612821- M3-15P-5P	1	06324	180-044NF06-15-5P
123	M3-15R-5S-N, dwg no. 7612821- M3-15R-5S-N	1	06324	180-044NF07-15-5S
124	M3-17P-8P, dwg no. 7612821- M3-17P-8P	1	06324	180-044NF06-17-8P
125	M3-17R-8S-N, dwg no. 7612821- M3-17R-8S-N	1	06324	180-044NF07-17-8S
126	M3-19P-11P, dwg no. 7612821- M3-19P-11P	1	06324	180-073NF06-19-11P
127	M3-19R-11S-N, dwg no. 7612821-M3-19R-11S-N	1	06324	180-073NF07-19-11S
128	M3-25P-37P, dwg no. 7612821- M3-25P-37P Note: Two adapters are included with this item no.	1	06324	180-073NF06-25-37AP 180-073NF06-25-37BP
129	M3-25R-37S-N, dwg no. 7612821- M3-25R-37S-N Note: Two adapters are included with this item no.	1	06324	180-073NF07-25-37AS 180-073NF07-25-37AS
	CURRENT PROGRAM/AIRCRAFT SPECIFIC M38999 CONNECTOR PROBE ADAPTERS			
207	M3-17P-8S-A, dwg no. 7612821- M3-17P-8S-A	1	06324	180-044NF06-17-8S
208	M3-17R-8P-A, dwg no. 7612821- M3-17R-8P-A	1	06324	180-044NF07-17-8PA
209	M3-21P-16P, dwg no. 7612821- M3-21P-16P	1	06324	180-072NF06-21-16P
210	M3-23P-54P, dwg no. 7612821- M3-23P-54P	1	06324	180-073NF06-23-54P
211	M3-23R-54S-N, dwg no. 7612821- M3-23R-54S-N	1	06324	180-073NF07-23-54S
212	M3-23R-54P-N, dwg no. 7612821- M3-23R-54P-N	1	06324	180-073NF00-23-54P
213	M3-25R-29S-C, dwg no. 7612821- M3-25R-29S-C	1	06324	180-044NF07-25-29SC
214	M3-25P-43P, dwg no. 7612821- M3-25P-43P	1	06324	180-044NF06-25-43P
215	M3-25R-43S-N, dwg no. 7612821- M3-25R-43S-N	1	06324	180-044NF07-25-43S

Support Equipment Required 1/, 2/ (cont.)

Item	Description	Quantity	Cage Code	Part or Identifying No. 4/
ADAPTERS, SINGLE FERRULE, (MATE 2 SINGLE FERRULE CONNECTORS OF THE SAME TYPE)				
STA01	ST-to-ST adapter, single mode, COTS, Ruggedized	1		
STA02	ST-to-ST adapter, multimode, 125 micron, COTS, ruggedized	1		
SCA01	SC-to-SC adapter, single mode, COTS, simplex	1		
SCA02	SC-to-SC adapter, multimode, 125 micron, COTS, simplex	1		
LCA01	LC-to-LC adapter, single mode, COTS, duplex	1		
LCA02	LC-to-LC adapter, multimode, COTS, duplex	1		
SUPPLEMENTAL TOOLS				
	TOOLS TO INSERT & REMOVE TERMINI IN M38999 CONNECTORS			
141	Insertion & extraction tool for M29504/4 & /5 (plastic)	3	81349	M81969/14-03
142	Insertion tool M29504/4 & /5 (metal)	1	81349	M81969/8-207
143	Extraction tool M29504/4 & /5 (metal)	1	81349	M81969/8-208
144	Bare fiber adapter, ST	1		
145	Pen cleaver (scribe), fiber optic, carbide NSN 5110 01 419 4360	1		
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Hand Cleaning (WP 008 02)			

1/ Items in this table are those specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. The CMQJ, connector probe adapters and reference adapters in this table are those specified per NAVSEA Drawing 7612821, COTS Measurement Quality Jumpers (CMQJ), For test Equipment, Fiber Optic. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for these drawings.

2/ Inspection equipment for connector cleaning are listed under Cleaning in this volume. Recommend cleaning inspection equipment includes a Fiber Optic Video Inspection System (FOVIS) with applicable inspection probe tips.

3/ Connector probe adapter designations (for use with the MIL-DTL-38999 connector):
Designations in description (such as M3-11R-2S-N) are as follows:
M3 = Type of multiple termini connector compatible with the connector probe tip
11R = Connector probe adapter shell size and body type (P =plug, R = receptacle)
2S = Number of insert cavities and termini type for insert cavity (P = pin, S = socket)
N = keying position (N = normal, also A through F are applicable, for receptacle type probe adapters only. Plug type connector probe adapters can fit any keyed M38999 receptacles).

4/ Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. INTRODUCTION.

2. This work package provides a general method for verifying the acceptability of a cable spool prior to sectioning/cutting the spool into individual lengths to construct a cable harness. One procedure is to find the fiber length and verify it is the same length as marked on the cable spool. A shorter length found is an indication of finding a break in an optical fiber. A second procedure is to observe the attenuation trace along the length of the spooled cable. A step decrease in attenuation is an indication of spliced cable or a pinch/imperfection (unacceptable features to start cable construction). A steep slope in the attenuation (high attenuation along the fiber length) is also unacceptable. This method requires the use of an Optical Time Domain Reflectometer (OTDR). The trace of reflection and attenuation over the length of the optical fiber is used to identify the existence and location of breaks or points of high attenuation. For accurate attenuation measurements, an optical source and power meter should be used. The OTDR used for this measurement has a standard resolution. A future WP will be developed for finding the location of a break in a short length of cable (such as a cable harness). This task requires the use of a different type OTDR having much finer resolution (high resolution OTDR).

3. Fault Location Isolation Method Using OTDR.

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection “tip” will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/ mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

Ensure the test equipment calibration is current.

During handling, all cables shall be protected from kinks, twists, crushing, and sharp bends (see Handling Practices WP 006 01).

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

CMQJ(s) used must be compatible with applicable requirements specified in the Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC, APC/APC or NC/NC) should be mated together.

Test probe CMQJ insertion and removal is covered in WP 009 07.

The OTDR must be compatible with applicable requirements (such as operating wavelength) specified in Platform maintenance manual for the cables being tested. These requirements include compatibility with wavelength, fiber type (multimode or single-mode) and fiber core size.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. Finding the Group Index.

(1) Following the OTDR manufacturer's instructions, energize the OTDR.

(2) Enter the group index of the cable to test.

(a) If the group index of the cable is known, then enter the group index.

1 Refer to the Platform manual for the proper group index.

2 Next proceed to the test setup.

(b) If the group index of the cable is not known, do the following:

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

1 Connect a spool of cable in which the cable length has been verified (calibrated cable length) to the OTDR, in accordance with the OTDR manufacturer's instructions.

2 Enter the required parameters, except the cable group index, in accordance with the OTDR manufacturer's instructions

3 Adjust and place the cursor at the beginning of the trace to obtain the distance coordinate z_1 (see Figure 1).

4 Place the second cursor at the end of the trace to obtain the distance coordinate z_2 (see Figure 1).

5 Adjust the group index setting until the difference (z_2-z_1) equals the length of the calibrated cable length.

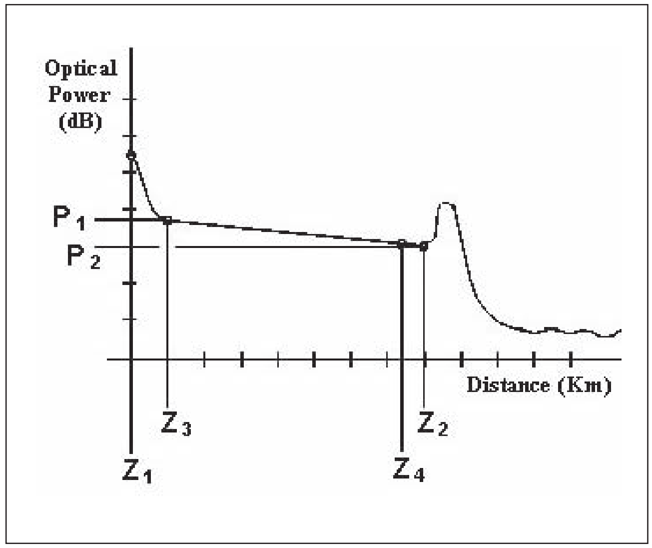


Figure 1. OTDR Display (Typical)

(3) Disconnect the calibrated cable length from the OTDR.

c. Test Setup.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

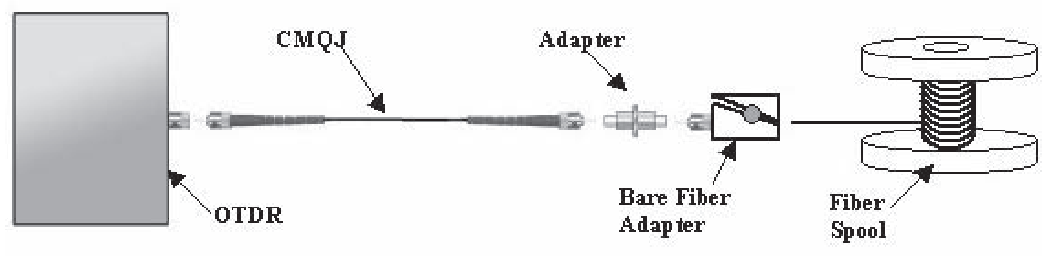


Figure 2. Test Setup

NOTE

This setup is to observe distance and attenuation for verifying and that there are no breaks/kinks in a spool of fiber optic cable.

If the correct configuration CMQJ is available with a FC connector on one end, then the FC-to-ST jumper is not required. Proceed to step (3) and substitute the words "FC connector" for "ST connector" on one end of CMQJ1. Figure 2 shows the test setup for the configuration without the additional FC-to-ST jumper.

The CMQJ or the alternative FC-to-ST jumper may also be referred to as a low loss, dead zone cable. The CMQJ or alternative jumper should have a minimum length of 10 meters (up to 50 meters on older OTDR models) to distinguish the reflection at the OTDR optical interface port from the connection of the dead zone cable (CMQJ) to cable spool under test. For purposes of verifying that there are no breaks or kinks and attenuation is not excessive, the 2 meter length CMQJ is sufficient. The reflections at the OTDR and at the CMQJ-to-test cable interfaces will appear as one large reflective pulse (as opposed to two pulses shown in Figure 3).

(1) Connect a ST-to-ST adapter to the ST connector end of the FC-to-ST jumper.

(2) Select the applicable CMQJ for CMQJ1.

NOTE

Use the adapter that matches the connectors on the CMQJ. For a CMQJ terminated with SC or other single ferrule, fiber optic connectors on one end, a hybrid adapter is required to connect the CMQJ to the bare fiber adapter on the cable spool under test.

For unterminated cable ends, use the ST-to-ST CMQJ connected to a bare fiber adapter to connect to unterminated cable ends. For ferrule hole diameter sizes that may not be commercially available (such as for a nominal 140, 155 or 172 micron diameter), use a terminus or connector with the correct ferrule hole diameter as a bare fiber adapter.

(3) Connect the end of the fiber cable spool under test to CMQJ1 using the appropriate adapter.

NOTE

This procedure was developed from EIA/TIA-455-61 (FOCP-61) "Measurement of Fiber or Cable Attenuation Using an OTDR".

d. Test for Fiber Break and Cable Spool Attenuation.

(1) Verify Distance. Adjust and place the cursor at the beginning (z_1) and the end (z_2) of the trace for the cable spool under test (see Figure 3). Record the cable spool length (z_2 - z_1) and confirm that the measured length matches the length that is recorded on the cable spool.

NOTE

Any sudden drop off of the attenuation trace, before the end of the cable harness, indicates a break in the fiber.

The first part of the trace shown in Figure 3 corresponds to the CMQJ and the second part corresponds to the cable spool under test. Since a 2 meter CMQJ is used, the reflections at the OTDR and at the CMQJ-to-cable spool interfaces will appear as one large reflective pulse (as opposed to the first two pulses shown in Figure 3).

A length that is less than that of the spool of cable indicates a break in the fiber.

(2) Verify no kinks and large optical losses. Adjust and place the cursor at the beginning (z_3) and end (z_4) of the linear portion of the trace for the channel under test (see Figure 3). Record the cable attenuation in dB, (P_3) and (P_4) at these two positions. The OTDR may automatically calculate the cable attenuation. If it does not, calculate the attenuation (B) in dB/km using the equation $B=(P_3-P_4)/(z_4-z_3)$.

NOTE

A step change in attenuation trace along the fiber is an indication of kinks or splices in the spool of cable. Both kinks and splices are not acceptable. Reject the cable.

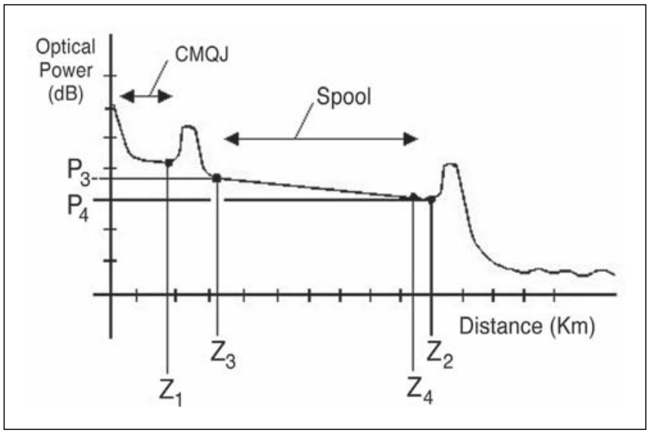


Figure 3. OTDR Display (Typical)

Generally, the loss of a cable is determined with optical loss tools (see WP 009 01). With the OTDR, if the maximum measured attenuation for a fiber exceeds the fiber's attenuation per length specification by more than 1 dB/km, the cable may have been damaged. Verification of suspected damage should be performed with optical loss tools (see WP 009 01). If the attenuation along the cable in dB/km exceeds the maximum allowed cable attenuation by more than 3 dB/km, redo the CMQJ-to-cable spool interface. When bare fibers or splices are used at this interface, poor cleaves will cause high optical losses.

(3) The cable spool under test is considered satisfactory if there are no breaks in the fiber.

(4) Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

THIS PAGE LEFT INTENTIONALLY BLANK

Fault Location Isolation Method Using Fault Finder

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required 1/

Item	Description	Quantity	Cage Code	Part or Identifying No. 2/
116	Visual Fault Finder (w/ 2.5mm interface)	1		
SUPPORT EQUIPMENT INCLUDED BY REFERENCE				
	See Support Equipment for Inspection (WP 008 01) and Manual Cleaning (WP 008 02)			
1/	Item in this table is that specified per NAVSEA Drawing 7612822, Test Set, Fiber Optic, Aircraft, Optical Link Test Equipment & Accessories. Any revisions to these items will be found in and are approved through the NAVAIR 4.8.1.3 acceptance process for this drawing.			
2/	Part numbers listed are for manufacturers' products that have been identified to meet the full requirements for the item. Other manufacturers are welcome to produce equivalent products for outfitting the set. Applicability to be determined through the applicable supply process.			

Materials Required

Cleaning consumable supplies only. Cleaning supplies are listed under Manual Cleaning Procedures in this volume (see WP 008 02).

1. INTRODUCTION.

2. This work package (WP) is a visual inspection troubleshooting method to determine if there is a break in the fiber. A light source in the range of visible light is used. If a fiber break is present, the visible light is seen through the outer jacket at the break, but not at the far end. One limitation with this method is that it is only effective when one of the two cases occurs. The first case is when there is a break and visible light can be seen at the break through the outer jacket. The second case is when there is a break and no light is visible at the far end. The operator must be aware that visible light may be seen through the outer jackets of some cables, but not others. Also, sufficient light may be transmitted through a hairline crack to be observed at the outer end. One can conclude there is a break, only if visible light may be seen through the outer jacket. One cannot conclude there is no break, when some light is seen at the output end. The fault finder cannot be used to conclude there is no break. Optical loss tools (see WP 009 01) are used to determine when a fiber optic cable is not at fault. Optical loss tools should be used to determine if testing with a fault finder is appropriate.

3. Fault Location Isolation Method Using Fault Finder.

WARNING

DO NOT stare into the end of an optical fiber connected to an LED or laser diode. Light may not be visible but can still damage the eye.

The fault finder is a Class III-A visable laser source. The user is responsible for following manufacturer operating instructions regarding safe operation. Specifically, the user is required to “contain" the beam at all times, even at the exit of a cable under test.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

NOTE

Inspection of an instrument interface/optical source transmit port. To inspect an optical transmit port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection “tip" will easily mate to this. The image of a ferrule end face, from a fiber pigtail connected to a LD or LED, will be observed on the FOVIS. Surrounding the fiber core and cladding, an image of the optical port backing/mounting panel will be observed. This mounting panel may be metal, not ceramic. As a result, more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the fiber surface.

Inspection of an instrument interface/optical receiver port. To inspect an optical receiver port, an adapter (such as an ST adapter) must be installed on the instrument interface port. The FOVIS ST inspection "tip" will easily mate to this. There is a photodetector behind the optical connection port on an optical power meter or the Rx port on an OLTS (optical loss test set). The image of this large photodetector will be displayed by the FOVIS. No image will be viewed of a ferrule end with a fiber in the center. Adjust the FOVIS focus until some distinguishable features on the photodetector surface or the surrounding surface are observed. Dirt or film deposits on the photodetector surface may now be seen. Surrounding the photodetector, some of the optical port backing/mounting panel may be observed. This mounting panel may be metal, not ceramic. As a result, a more roughened surface features may be mistaken as dirt/particles. Inspection and cleaning, using the methods specified in WP 008 02, may be used as the discriminator to differentiate dirt and film deposits from roughened surface imperfections. The latter can be identified by being unchanged after cleaning and appearing only outside the photodetector surface.

During handling, all cables shall be protected from kinks, twists, crushing, and sharp bends (see Handling Practices WP 006 01).

CMQJs wear out. CMQJs must be maintained by inspection and cleaning per WP 008 01 and WP 008 02. CMQJs must be replaced when they perform poorly after proper inspection and cleaning per WP 008 01 and WP 008 02.

Connector adapters accumulate dirt. Connector adapters must be maintained by inspection and cleaning per WP 008 01 and WP 008 02.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Do not touch the ends of the fiber as they may be razor sharp. Wash your hands before and after handling bare fiber.

(2) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. Procedure.

CAUTION

Inspect, clean (if needed) and re-inspect after cleaning a connector/terminus ferrule and mating instrument adapters/interfaces immediately before each mating to ensure accurate and reproducible results. Perform the inspection and cleaning per WP 008 02.

NOTE

The number one cause for an increased optical loss, after an insufficiently tight connection, is dirt and film deposits. No single cleaning method has been found to date that will guarantee a clean end face on the ferrule. Magnified visual inspection together with cleaning is important, when practical. Visual inspection is done using a FOVIS. Recommended cleaning supplies are listed in WP 008 02.

NOTE

If the cable harness is terminated on one end, select the terminated end.

(1) Select one end of the cable harness under test.

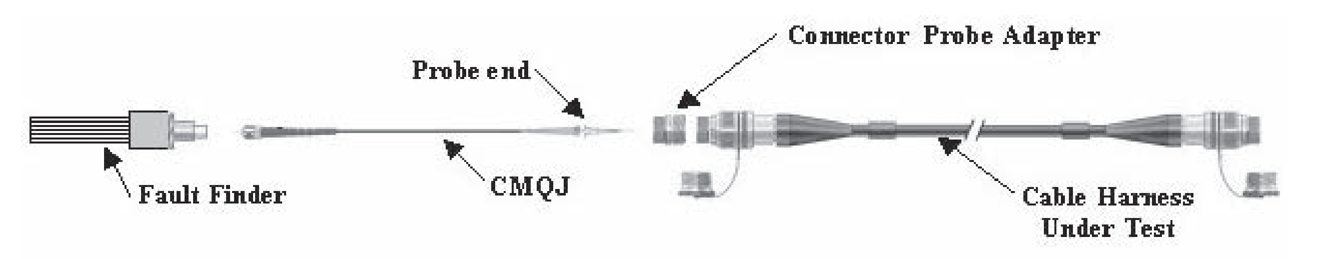


Figure 1. Fault Finder, Light Leakage Through Cable Jacket

NOTE

Different types of CMQJs may be used in this procedure. CMQJ selection is provided based on the type of connector on the cable harness. For testing a cable harness with a MIL-DTL-38999 connector, the ST-to-Test probe CMQJ is used. For testing a cable harness with a ST connector, a ST-to-ST CMQJ is used for the end of the cable harness. For testing a cable harness with other types of single ferrule connectors, a ST-to-applicable single ferrule connector CMQJ is used for the end the cable harness with the applicable single ferrule connector pigtail.

CMQJ(s) used must be compatible with applicable requirements specified in the Platform maintenance manual for fiber size and ferrule end face polish. Only like polish types (PC/PC or NC/NC) should be mated together.

Test probe CMQJ insertion and removal is covered in WP 009 07.

(2) Select the applicable CMQJ.

CAUTION

Make sure that the proper connector probe adapter is used before attaching it to a MIL-DTL-38999 connector with fiber optic termini. Incorrect connector probe adapter may result in damage to the connector termini.

NOTE

Use the adapter that matches the connectors on the cable harness to be tested. For cable harnesses under test terminated with MIL-DTL-38999 connectors, a connector probe adapter is used at each end to connect the test probe end of the CMQJ to the MIL-DTL-38999 connector. For cable harnesses under test terminated with ST connector pigtails at one end, a ST-to-ST adapter is required to connect the CMQJ to the ST connector pigtail end of the cable harness under test. For cable harnesses under test terminated with SC or other single ferrule, fiber optic connectors on one end, a hybrid adapter is required to connect the CMQJ to the pigtail end of the cable harness under test.

If the ends of the cable are not terminated with a connector, then use the ST-to-ST CMQJ connected to a bare fiber adapter to connect to unterminated cable ends.

(3) Connect the appropriate end of the cable harness under test to the CMQJ1 using the appropriate adapter (see Figure 1).

(4) Connect the ST connector end of CMQJ1 to the fault finder adapter port.

NOTE

The visable output of the fault finder from the cable under test must be contained. Do not stare directly into the opposite end of the fiber. Use a white card or some other means to verify light is present. One alternative approach is to inspect for light by viewing the fiber from the side instead of from the edge. If this approach is used and no light is seen, then use a white card to verify the absence of light.

Light may be visible at the opposite end and the fiber could still be cracked or otherwise partially broken.

If no light is seen, verify that the fault finder is turned to the "ON" position and is generating visible light output, before inspecting the cable jacket for leaks.

If no light is seen, verify that any intermediate connectors are properly tightened, before inspecting the cable jacket for leaks.

Fault finders usually have a "blinking" mode that may enhance detection of visable light leakage through the fiber cable's outer jacket (and possible over-braiding).

Cable over-braiding, inaccessible cable sections and bright ambient background conditions severely limit the use of the fault finder in detecting and locating fiber breaks.

(5) Turn the fault finder to the "ON" position.

(6) Test Conclusions.

(a) Fiber Breakage Conclusion. A fiber break can be concluded if visable fault finder light is seen leaking through the cable outer jacket. See Figure 2.

1 When a fiber break has been conclusively found, the accurate location (within +/- 1 inch of a cable end) of the break must be documented so that a repair can be initiated. See WP 012 and WP 013.

(b) Fiber Break Suspected. A fiber break can only be strongly **suspected** if no light is seen at the output end of the cable under test and there are no intermediate connectors. In this case all connections should be inspected and cleaned (WP 008 02), then the cable must be closely examined for leakage through the cable outer jacket. If leakage through the cable outer jacket cannot be determined, then OTDR tools (WP 009 05) must be used.

(c) No Breakage Conclusion. The fault finder cannot be used to conclude there is no break. Optical loss tools (WP 009 01) are used to determine when a fiber optic cable is not at fault.

(d) Inconclusive. All other conditions observed with the fault finder are inconclusive evidence.

(e) Multiple Fiber Breaks. Only the first or first and second of multiple fiber breaks may be observed.

(9) Once testing is completed, secure test equipment. Install protective caps (dust covers) over all CMQJs, cable harness connectors and test equipment ports.

Figure 2. Fault Finder, Light Leakage Through Cable Jacket

THIS PAGE LEFT INTENTIONALLY BLANK

Test Probe CMQJ Insertion and Removal

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Material Required

None

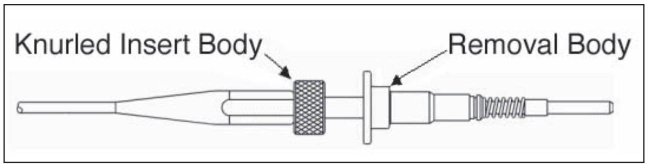


Figure 1. Parts of the Test Probe

1. INTRODUCTION.

2. This work package is the method to be used by personnel for inserting and removing the test probe end of a CMQJ to and from a connector probe adapter. The test probe CMQJ is used with a connector probe adapter for testing a multiple termini connector.

3. TEST PROBE INSERTION AND REMOVAL.

a. Test Probe Insertion.

(1) Insert a test probe end of a CMQJ into a connector probe adapter by gripping the knurled area (knurled insert body) firmly between your thumb and index finger (see Figure 1 and Figure 2).

(2) While holding the test probe by the knurled insert body, press the test probe into the selected cavity on the connector probe adapter until a click is heard or full engagement is felt (see Figure 2). This click indicates that the spring is fully loaded and the retention clip is engaged.

b. Test Probe Removal.

(1) Remove or extract a test probe from a connector probe adapter by pushing the removal body (extended flange) on the test probe into the connector probe adapter until the retention clip is disengaged (see Figure 3). Position tip of thumb and finger on external flange while pad of the thumb and index finger is on the knurled insert body.

(2) Maintain the hold on the removal body (extended flange) depressed towards the connector probe adapter while holding the pad of the thumb and index finger is on the knurled insert body. Pull the test probe out of the connector probe adapter (see Figure 4).

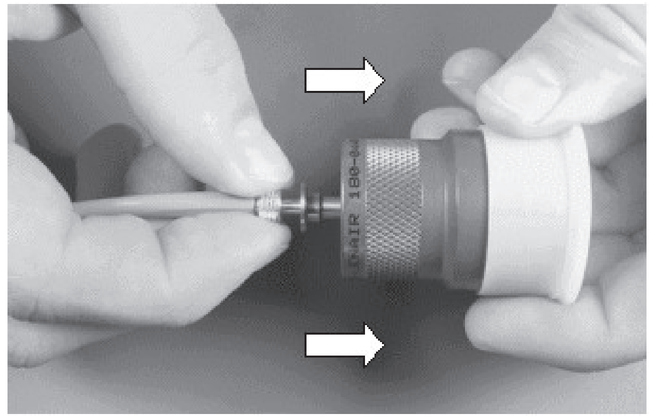


Figure 2. Grip Knurled Insert Body and Press Into Cavity

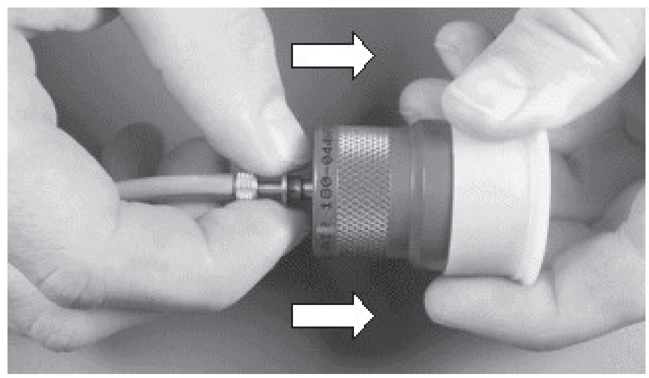


Figure 3. To Extract, Push Extended Flange Towards Connector

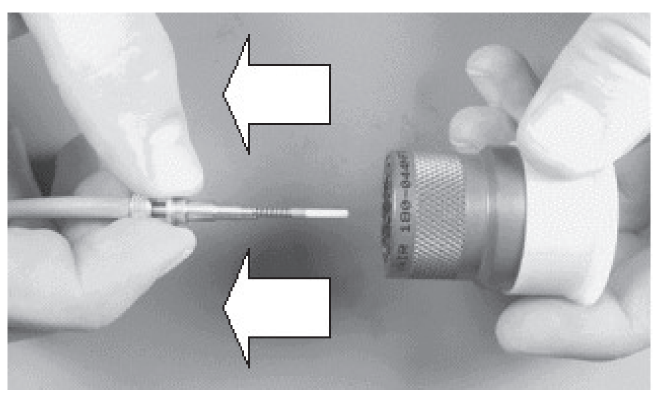


Figure 4. Extract While Maintaining Hold on Extended Flange

Connector Terminations

Reference Material

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Termination Process Overview with Associated Risks	010 01	13 August 2004

Record of Applicable Technical Directives

None

1. POLICY, CURRENT, FIBER OPTIC TERMINATION. There are no approved and verified, common fiber optic connector termination procedures for aircraft (fixed wing and rotary) applications. See specific Platform maintenance plan for cable replacement guidance.

2. RISK OF TERMINATING WITHOUT APPROVED PROCEDURES. It is critical that fiber optic connector ferrule end faces meet all specified surface topology criteria required by the specific Platform. Without approved and verified fiber optic termination procedures, required fiber optic end face surface topology criteria cannot be accurately, repeatedly and reliably produced. Use of other than approved terminating procedures can result in the mating of incompatible fiber optic end faces. The mating of incompatible end faces can result in degraded performance of fiber optic connectors.

THIS PAGE LEFT INTENTIONALLY BLANK

Termination Process Overview with Associated Risks

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

CAUTION

This guidance is not to be used in lieu of a specific procedure.

2. This work package provides general guidance on major steps in performing terminations along with the associated risks.

3. TERMINATION PROCESS OVERVIEW WITH ASSOCIATED RISKS.

a. Cut and Strip. A typical fiber optic cable (simplex cable) consists of an outer jacket, strength member (such as aramid yarn or woven fiberglass), and the fiber buffer / coating. These must be carefully cut back and stripped in the termination process. This operation requires the use of cable cutting and buffer stripping tools. Risks associated with the cut and strip operations are as follows:

(1) Strip Cable Jacket. Correct tools and correct technique when using the proper tools must be employed. Otherwise, penetration of the outer cable jacket (nicks, cuts, etc.) or fiber breakage may occur . For instance, pushing off the simplex cable jacket with a tightly held simplex cable stripper can lead to fiber breakage.

(2) Cable Length. Tolerance on cable length is tight when building a harness with multiple fiber cables. For instance, the tolerance on the overall length of a cable harness may be +13/-0 mm (+0.5/-0.0 in) with a tolerance on each cable in the harness of +7/-0 mm (+0.25/-0.0 in). Violating the tolerance places excessive tensile loading on some of the terminations, leading to breakage.

(3) Strip Length. Strip dimensions must be accurate. Incorrect lengths may allow the internal fiber to be unsupported and exposed within the ferrule. This may lead to greater optical attenuation or fiber cracking.

(4) Strip Buffer. Proper technique must be used when stripping off the buffer using a mechanical stripper. Removal of the buffer from the optical fiber may lead to scoring of the glass when improper tools or when correct tools with improper technique is used. Most buffer materials must be removed in 6 mm (0.25 inch) segments. Other buffer materials (such as silicone) may be removed in one section. Polyimide coating on polyimide coated optical fiber is not removed. Once exposed, bare, uncoated optical fiber (i.e., the optical fiber with the buffer removed) is in its most vulnerable state from the point of buffer removal until the termination process is completed.

(5) Clean Optical Fiber. The exposed optical fiber is cleaned to remove residual buffer scrapings and any dirt acquired during the stripping operation. The optical fiber is wiped from the cable jacket out to the fiber end. Repeated wiping is not done. This can weaken the fiber.

(6) Cut Strength Member Yarn. Cutting of the strength member (such as Kevlar or woven fiber glass) must be done so that an even cut is obtained. Special scissors are required to ensure a complete and clean cut. Otherwise, protruding strands may interfere with connector/terminus retention mechanisms.

b. Mix Epoxy and Inject into Connector. This sequence involves precise mixing of a two-part epoxy and injecting it into the barrel of the connector / terminus with a syringe. Epoxy must be carefully mixed and injected to avoid a structurally weak and/or optically lossy termination. The operations of this sequence involve subtle technicalities that can significantly affect performance, quality and reliability. Some of these operations are:

(1) Preliminary Operation.

(a) Ferrule Hole Inspection. The ferrule hole must be free of dirt/debris or the fiber will not fit through the ferrule hole. The fiber will easily break if it is forced. A quick visual inspection is sufficient with corrective action taken when light is not visible from the back of the connector/terminus.

(b) Dry Fit Fiber. This is done when ferrules with tight hole tolerances are specified. Connectors/ termini with several different ferrule hole diameters must be kept on hand. An operation to dry fit the connector/terminus onto each fiber length must be done (starting with the size for with smallest ferrule hole diameter and working up) to ensure proper ferrule hole clearance before the injection of epoxy. Potential for fiber breakage is increased with the performance of this operation.

(c) Prevent Epoxy Wicking. Epoxy wicking must be avoided. Less viscous epoxies may wick down the strength member yarn (such as Kevlar or woven fiber glass) and into the unexposed length of the cable underneath the simplex cable jacket. Potential for fiber breakage is increased as the hardened epoxy prevents fiber movement within the cable jacket. An extreme transition is created where the fiber is more prone to be placed in an unacceptably sharp bend. Measures can be taken to prevent wicking.

(2) Mix Epoxy. Specified quantities of each part of a two part epoxy must be mixed together for the epoxy to exhibit the required performance properties. Epoxy in premixed packets are used to ensure the correct mixture percentages are obtained. Epoxy has a limited shelf life so care must be taken to ensure that it has not expired. Techniques for mixing the epoxy must include measures to minimize the introduction of air bubbles while obtaining a uniform mixture. Air bubbles in cured epoxy can lead to higher fiber optical loss, intermittent performance and the potential for fiber breakage.

(3) Inject Epoxy.

(a) Quantity. A syringe is used to inject a sufficient, but not excessive, amount of epoxy into the connector/terminus. Some connectors/termini require a special syringe tip configuration to ensure a complete fill is obtained. An insufficient quantity can leave exposed bare or buffered fiber, whereas an excessive amount may interfere with mechanical functions. Excess epoxy may cause adherence to cure adapters, making connector/terminus removal form cure adapters difficult after completion of curing step.

(b) Epoxy Bead Size. Epoxy application must ensure a small epoxy bead exists to secure the fiber at the ferrule tip. Improper bead size may impede the termination process. Too large an epoxy bead on the ferrule end face will result in excess polishing time, expenditure of additional consumable materials and placing deeper scratches in the fiber. Too small (or complete lack of) a bead may potentially result in fiber breakage.

c. Crimp Cable Strength Member. Some connector/terminus configurations require crimping of the strain relief (such as strength member yarn) of fiber optic cable onto the connector / terminus. The use of the proper crimp tools and dies is essential to obtain the proper cable reinforcement without damaging the fiber.

(1) Die Size. Proper crimp tool die size must be used. Otherwise, potential exists for loss of barrel integrity (resulting in fiber breakage) or reduced strength of cable strain relief capture mechanism (resulting in connector/terminus separation from the cable).

(2) Crimp Technique. Proper crimp technique must be employed for mechanical fit (no "fins" produced in crimp), sufficient strain relief retention, and for minimizing of any cable strain relief protrusion from the crimp sleeve (no mechanical seating/interface problems).

(3) Heat Shrink/Heat Gun. Heat shrink may be used to cover the strength member yarn, to transition down to the desired finish diameter and to provide strain relief (prevent sharp bends) at the boundary between connector and cable. (Epoxy is used to secure the fiber in the connector/terminus and to secure the strength member yarn onto the outside or inside of the connector/terminus barrel when a crimp sleeve is not used.) A heat gun is used to reduce the diameter of the heat shrink. The potential to overheat the cable exists with use of the heat gun. Other general usage restrictions with heat guns apply, such as the avoidance of usage around fuels and other combustible materials.

d. Cure Epoxy. Cure epoxy to secure the optical fiber to the ferrule at a specified cure cycle (schedule). This operation requires the use of specified curing oven and connector/terminus holding fixtures. The cure schedule is optimized to give the most desired set of epoxy properties for the intended aircraft environment.

(1) Epoxy Cure Schedule. The time and temperature (or times and temperatures if a multiple step cure is required) in which a specified epoxy is cured must be followed to obtain the required performance properties. Otherwise, an insufficient cure may result in degraded optical performance (due to fiber movement) or reduced cable strain relief.

(2) Handling Technique. Improper placement in curing oven or in curing adapters may result in an incomplete cure. Improper placement of cabling exiting from connectors/termini may result in epoxy penetrating and then hardening on the cable jacket.

(3) Overheating. Improper cure schedule used can result in overheating and degrading of cable assembly materials (primarily the optical fiber buffer and the cabling components).

e. Polishing. This process polishes the ferrule end face of a connector/terminus to obtain the required optical loss and return loss. This step is the one which determines the geometry (surface topology) of the ferrule end face. The method/procedure employed must be one that will provide consistent results with acceptable optical performance and end face geometry. This operation requires the use of specialized polishing pads, pucks and plates to rough polish through to fine polish the ferrule end face. Different polishing techniques result in different finishes for the ferrule end face.

(1) Cleave Excess Fiber Stub. Proper technique must be used to cleave the protruding length of fiber from the ferrule. Otherwise, potential for shattering of the fiber at the ferrule end face can result.

(2) Polishing Paper Selection. Too small of a grit size paper may result in excessive polishing time. Too large of a grit size paper may place permanent, large scratches in the fiber.

(3) Polishing Puck. Use of specified polishing puck (tool) is required for obtaining end face geometry (surface topology) requirements consistently and efficiently.

(4) Polishing Procedure. Using a verified polishing procedure provides consistent results. This is mandatory to obtain specified Platform optical performance requirements (optical loss, return loss) and end face geometry. Otherwise, use of different tools, consumable materials and techniques will usually produce terminations that look good, but have degraded optical performance and unacceptable end face geometries. When polishing pucks, polishing paper, etc. are used properly in accordance with the specified connector termination procedure, connector end face geometries with optical loss and return loss (single mode only) values, as specified in the component specifications, will be obtained.

f. Inspection. Inspection of the ferrule end face occurs during and after the polishing step. During the polishing step, a ferrule end face inspection is performed after each operation in which a different polishing paper is used.

(1) Inspection Type. Visual, magnified (200x minimum) inspections are performed using a Fiber Optic Video Inspection System (FOVIS), during and after the polishing operation. The inspection is done to verify the optical surface is smooth and free of scratches, pits, chips and fractures. As an option, an eye safe light source, may be used to illuminate the opposite end of the fiber for better core visibility.

(2) Inspection Limitations. Inspections are limited to two dimensional visual examinations of the ferrule end face. These inspections are done under 400X magnification for terminations (200X for inspection and cleaning during mating operations). These inspections provide only a partial, two-dimensional representation to assess acceptability. A properly done termination negates the need to perform optical loss and end face geometry measurements to completely assess acceptance of the termination.

Cable Harness Assembly

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
M38999 Cable Harness Assembly	011 01	13 August 2004

Record of Applicable Technical Directives

None

NOTE

There is no one method for assembly of a fiber optic cable harness for aircraft (fixed wing and rotary) applications. This work package contains general guidance. See the platform maintenance manual for the assembly of a specific cable harness.

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for different types of assembly methods to build cable harnesses. The first subordinate work package, WP 0011 01, addresses an assembly method to build up simplex fiber optic cables into a cable harness configured with MIL-DTL-38999 Series III connectors and convoluted tubing. Future subordinate work packages are planned to address other configurations.

THIS PAGE LEFT INTENTIONALLY BLANK

M38999 Cable Harness Assembly

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. **INTRODUCTION**.

2. This work package is for an assembly method to build up simplex fiber optic cables into a cable harness configured with MIL-DTL-38999 Series III multiple terminus connectors and convoluted tubing.

3. **ASSEMBLY (BUILD UP) OF M38999 CABLE HARNESS**.

CAUTION

Throughout the assembly process, cable twisting must be kept to a minimum. Kinking and excessive bending must be prevented to avoid damaging or breaking the fiber optic cables. General Handling Practices are in covered (WP 006 01).

NOTE

Fiber optic cables can be pulled through as a group provided that the fiber optic termini endfaces are covered and staggered. Termini are not provided with dust caps.

If the fiber optic cables will be maintained with a remove and replace maintenance plan, then the individual fiber cables should be smooth along their full length. They should have no labels within eighteen inches of the cable ends, that could cause friction when pulling an individual cable out.

a. Preparing Terminated Fiber Optic Cable Assemblies for Inclusion Into Convoluted Tubing.

(1) Cover the endfaces of the termini with dust caps.

(2) Tape the dust covers to the termini using electrical tape.

(3) Stagger the termini with a 3/4" spacing between each termini. See Figure 1.

(4) Start at the first termini and wrap the fiber optic cables with electrical tape in a spiraling clockwise motion with approximately a 1/4" overlap. See Figure 2.

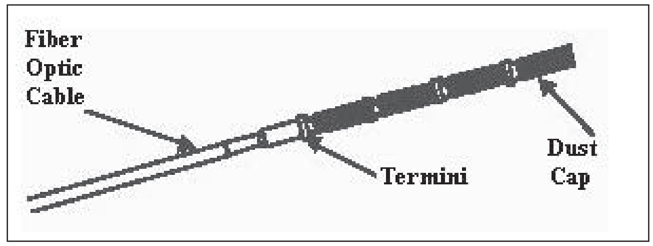


Figure 1. Staggering Termini

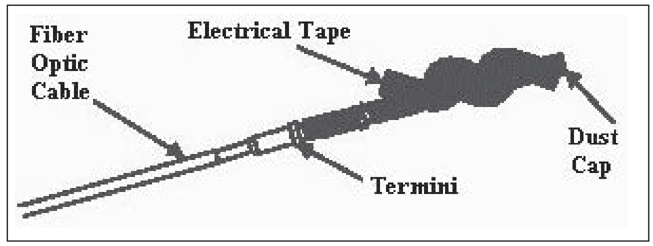


Figure 2. Wrapping Over Termini With Electrical Tape

NOTE

The pull cord should be longer than the convoluted tubing.

(5) Lay the pull cord onto the taped staggered termini, starting at the dust cover of the first termini, and run back approximately 3 inches. Then run the pull cord back in the opposite direction back towards where the pull cord originated. See Figure 3.

NOTE

An additional pull cord may be run along side the fiber bundle and stowed for use on additional cable pulls. See platform guidance on providing this additional pull cord.

(6) Start at the first termini and spiral wrap using electrical tape with a 50% overlap in a clockwise direction. See Figure 4.

NOTE

Convoluted tubing can be split or non-split.

CAUTION

Do not push fiber optic cables through convoluted tubing as the fiber optic cables can snag and be severely damaged.

b. Inserting Fiber Optic Cable Assemblies Into the Convoluted Tubing.

(1) Feed Pull Cord into Convoluted Tubing.

(a) Short Lengths. Feed the free end of the pull cord into the unmarked end of the convoluted tubing.

(b) Long Lengths. Longer runs of convoluted tubing with complex bends will require a leader. Make a leader out of a flannel or other soft cloth patch attached to a string long enough to pass completely through the convoluted tubing. The patch should fit loosely in convoluted tubing (See Figure 5). Use compressed air at no more than 35 psi to blow patch and attached string through the convoluted tubing. (A vacuum source from the exit side also works well, but be careful not to allow the patch to be pulled in the vacuum device.)

(2) Install the compression nut from the adapter onto the marked end of the convoluted tubing. Ensure that the threads are orientated towards the marked end of the convoluted tubing.

(3) Feed the free end of the pull cord, into the unmarked end of the convoluted tubing.

(4) Route the free end of the pull cord until it exits out the opposite marked end of the convoluted tubing.

(5) While pulling on the free end of the pull cord, carefully start guiding the taped bundled fiber optic cable assemblies into the unmarked end of the convoluted tubing. Continue to gently pull the bundled fiber optic cable assemblies until they exit out the marked end of the convoluted tubing.

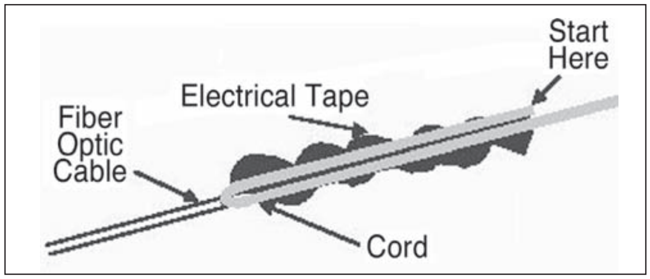


Figure 3. Placement of Pull Cord

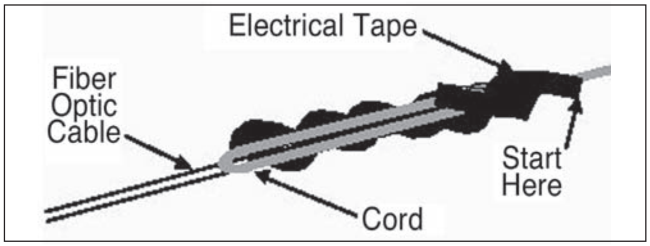


Figure 4. Attaching Pull Cord Using Electrical Tape

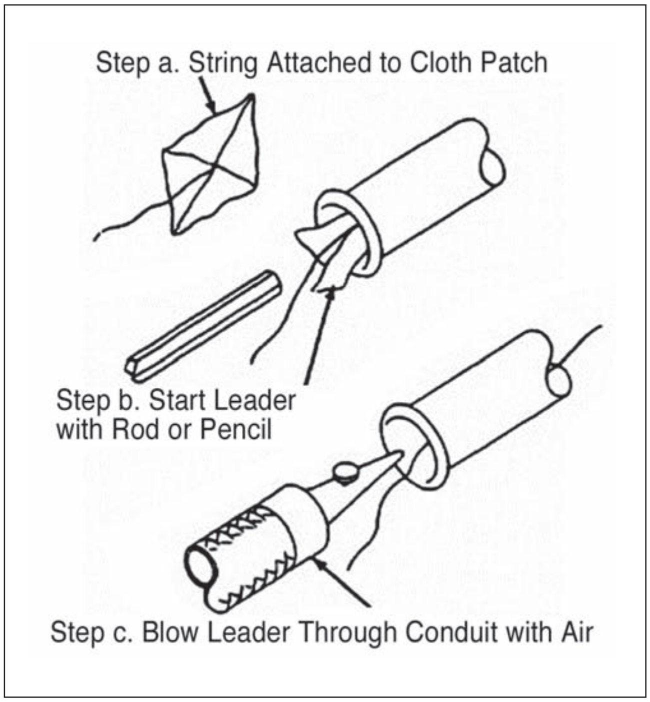


Figure 5. Leader for Convoluted Tubing

CAUTION

Take your time when untaping the fiber optic cable assemblies. Severe damage can result to the termini.

(6) Carefully untape the bundled fiber optic cable assemblies and remove the dust caps from the termini.

(7) Inspect the fiber optic cable assemblies for any damage. The inspection should include assessment with optical loss (link loss) and visual fault finder tools. If damage is found, then repairs will be needed.

CAUTION

Severe damage (fiber breakage) is likely, if insertion tool(s) are not used to insert the termini into the connector cavities.

(8) Slide the adapter housing over all of the termini before inserting the termini into the M38999 connector. Use the appropriate Platform maintenance manual for guidance to insert the termini into the designated cavities. Insertion tool(s) shall be used to insert termini in all cases.

(9) Fit the split bushing, from the adapter, over the convoluted tubing. Carefully slide the adapter housing up and over the split bushing with the captured convoluted tubing.

(10) Thread the adapter housing onto the rear of the M38999 connector. Ensure that the split bushing still has the convoluted tubing captured while threading the adapter housing onto the M38999 connector.

(11) Thread the compression nut onto the rear of the adapter housing and torque to 40 +/- 5 inch pounds.

Cable Harness Installation

Reference Material

None

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
General Practices for Cable Harness Installation	012 01	13 August 2004

Record of Applicable Technical Directives

None

1. INTRODUCTION.

2. This work package (WP) is divided into subordinate work packages for different types of installation guidance with cable harnesses. The first subordinate work package, WP 012 01, addresses general guidance for installing a cable harness. Future work packages are planned to address unique techniques to be used for specific configurations.

3. READY FOR INSTALLATION (RFI) POLICY. The following action must be performed and criterion met for any new installation, replacement or repair of a fiber optic cable component or cable assembly (including cable, cable bundle, cable harness and connector):

a. Performance of an optical loss test procedure per WP 009 01.

b. Verification that the cable assembly installed or containing the item repaired meets the Platform maximum acceptable optical loss for that cable assembly.

THIS PAGE LEFT INTENTIONALLY BLANK

General Practices for Cable Harness Installation

Reference Material

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

Clamp, Cushioned Metal	MS21919
Tape, Finish C, Glass Tying, Size 2	A-A-52083
Tape, Finish C, Glass Tying, Size 3	A-A-52083
Tape, Finish C, Polyester Tying, Size 2	A-A-52081
Tape, Finish C, Polyester Tying, Size 3	A-A-52081

1. **INTRODUCTION**.

2. This work package provides general guidance for installing a cable harness. The guidance includes cable bend diameter considerations, types of protection over cable, special protective measures while routing, routing practices, cable pull do's and don'ts, primary support, secondary support, connector coupling guidelines, and transporting cable harnesses. When available, maintenance personnel should always look first to the aircraft maintenance manual for guidance. The information provided herein should not be used for design or modification on the optical cabling. Design and modifications should be performed in accordance with SAE–AS50881.

a. The materials and components used in the design of aircraft are intended to meet strict performance, reliability, and safety requirements. Replacement of any component or material with a substitute must be approved in advance by the applicable Platform Office.

3. INSTALLATION OF FIBER OPTIC CABLE AND CABLE ASSEMBLIES.

a. Safety Summary. The safety precautions in WP 004 01 shall be observed. The following safety precautions are restated for emphasis:

(1) Safety glasses shall be worn at all times when handling bare fibers or dispensing epoxy.

(2) Do not touch the ends of the fiber, as they may be razor sharp. Wash your hands before and after handling bare fiber.

(3) Avoid skin contact with epoxies.

(4) Do not stare into the end of a fiber until verifying that the fiber is not connected to a laser light source or LED.

b. Cable Primary Support.

(1) Primary Support. Primary support of fiber optic cable and cable assemblies shall be provided by metal cushion clamps in accordance with MS21919.

(a) Plastic cable clamps SHALL NOT be used for the primary support of fiber optic cable or cable assemblies.

(b) Lacing Tape SHALL NOT be used for the primary support of fiber optic cable or fiber optic cable assemblies.

(c) Plastic Cable Straps SHALL NOT be used for the primary support of fiber optic cable or fiber optic cable assemblies.

(2) MS21919 Part Number. An example of a MS21919 part number is as follows:

(a) Example: MS21919 WDG-8.

(b) MS21919: Basic specification describing the clamps.

(c) W: Indicates the base of the open end of the loop has a wedge to assist locking the clamp together (See Figure 1). Applicable for sizes 2 through 48 only.

(d) D: Defines the band material (See Table 1).

(e) G: Defines the cushion material (See Table 1).

(f) -8: Defines the cable thickness, which the band can hold (See Table 2).

(3) Clamp Replacements. When engineering drawings, mainframe manuals, etc. specify the canceled part numbers as shown in Table 3 and 4, replace the clamp as indicated.

(4) Clamp Size And Restrictions. If a clamp needs to be replaced and is not specified by the aircraft maintenance manual, use a MS21919 WCJ-* for sizes -2 through -48 and MS21919 CJ-* for sizes -50 through -66.

(a) Clamp shall be installed such that they do not exert more pressure on the cable than the minimum required to prevent slipping.

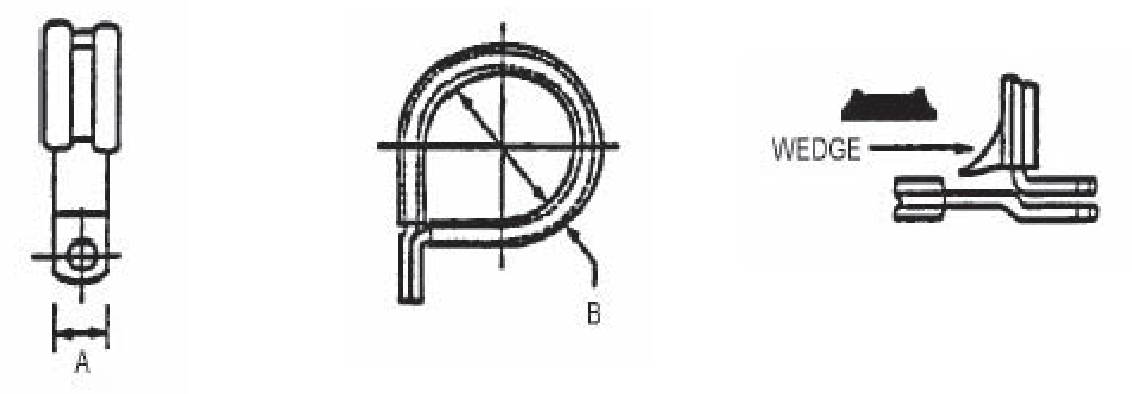


Figure 1. MS 21919 Clamp

Table 1. Material Clamp Codes

Material Codes Authorized	Max Temperature
DE = Aluminum Band with Ethylene Propylene Cushion	(212° F)
DF = Aluminum Band with Nitrile Cushion	(212° F)
DC = Aluminum Band with Chloroprene Cushion	(212° F)
CE = Cres Band with Ethylene Proplene Cushion	(275° F)
CF = Cres Band with Nitrile Cushion	(212° F)
CH = Cres Band with Silicone Cushion	(400° F)
CG = Cres Band with Chloroprene Cushion	(212° F)
CJ = Cres Band with Fluorosilicone Cushion	(450° F)
F = Low Carbon Steel Bands with Nitrile Cushion	(212° F)
G = Low Carbon Steel Bands with Chloroprene Cushion	(212° F)
H = Low Carbon Steel Bands with Silicone Cushion	(400° F)

Table 2. Clamp Sizes

Clamp Dash No.	Cable Thickness	Dash No.	Cable Thickness
1	1/16	27	1 5/8
2	1/8	28	1/ 3/4
3	3/16	29	1 3/4
4	1/4	30	1 7/8
5	5/16	31	1 7/8
6	3/8	32	2.0
7	7/16	33	2.0
8	1/2	34	2 1/8
9	9/16	35	2 1/8
10	5/8	36	2 1/4
11	11/16	37	2 1/4
12	3/4	38	2 3/8
13	13/16	40	2 1/2
14	7/8	42	2 1/2
15	15/16	43	2 1/2
16	1	44	2 3/4
17	1 1/16	45	2 3/4
18	1 1/8	46	2 3/4
19	1 3/16	48	3.0
20	1 1/4	50	3.0
21	1 5/16	52	3 1/4
22	1 3/8	54	3 1/4
23	1 7/16	56	3 1/2
24	1 l/2	58	3 1/2
25	1 9/16	66	4.0
26	1 5/18	64	4.0
Note 1 MS25281 - F* is not available in sizes - 21 through 66. 2 MS25281 - R* is not available in sizes - 33 through 66			

Table 3. Clamp Replacement for -2 through -48

Cancelled Part Number	Replacement Part Number
MS21919WB (F, G, H) ( )	MS21919W (F, G, H) ( )
MS21919B (F, G, H) ( )	MS21919W (F, G, H) ( )
MS21919D (F, G) ( )	MS21919WD (F, G) ( )
MS21919C (F, G, H) ( )	MS21919WC (F, G, H) ( )
MS21919 (F, G, H) ( )	MS21919W (F, G, H) ( )
MS21919DH ( )	MS21919WCH ( )
MS21919WDH ( )	MS21919WCH ( )

Table 4. Clamp Replacement for -50 through-66

Cancelled Part Number	Replacement Part Number
MS21919WC (F, G, H) ( )	MS21919C (F, G, H) ( )
MS21919WD (F, G) ( )	MS21919D (F, G) ( )
MS21919WB (F, G, H) ( )	MS21919 (F, G, H) ( )
MS21919B (F, G, H) ( )	MS21919 (F, G, H) ( )
MS21919DH ( )	MS21919CH ( )
MS21919WDH ( )	MS21919CH ( )
MS21919 (F, G, H) ( )	MS21919 (F, G, H) ( )

(b) The clamp shall not deform the cable so that the optical performance characteristics are degraded.

(5) Placement in Cable Clamps.

(a) Cable Installation. Pull through cable clamp. Do not push through a cable clamp. Preference is to open the cable clamp and lay the portion of the cable, cable bundle or cable harness into the cable clamp.

NOTE

If a cushioned clamp (clamp with rubber channel or insert) is used, then no sliding should be evident when a moderate force is applied. Tighten cable, conduit and convoluted tube to constrain without constricting. This is to ensure that no deformation, kink or pinch will occur. Tighten cable wrap until constriction is observed, but no deformation, kink or pinch is evident.

(b) Tightening of cable clamp. Tighten cable clamps to the degree that the cable is snug, but to the extent that cable does not deform, kink or pinch. Ensure that the cable, cable bundle or cable harness will slide in the clamp when a moderate force is applied.

(6) Use of Rubber Channels. Use channel rubber with banding straps where the latter is allowed

c. Cable Secondary Support.

(1) Lacing Types. The following tying types may be used to provide secondary support to fiber optic cable or cable assemblies:

(a) For low vibration applications, use finish C polyester tying tapes, size 2 or 3 in accordance with A-A-52081.

(b) For medium or high vibration applications, use finish C, glass tying tapes, sizes 2 or 3 in accordance with A-A-52083.

(2) General Precautions. When lacing or tying fiber optic cables and cable assemblies, observe the following precautions:

(a) Lace or tie bundles securely enough to support the cable or cable assemblies between primary supports. Extreme care should be used in tying the lacing tape to assure that the tie does not deform the cable or cable assemblies.

CAUTION

Applying lacing ties too tightly can lead to degraded optical performance or fiber breakage. Use extreme caution when applying lacing tape to assure that the ties do not deform the cable or cable assembly.

(b) Do not use ties on the part of a cable group or bundle located inside a conduit.

(3) Continuous Lacing. Continuous lacing may not be used for secondary support of fiber optic cable or cable assemblies.

(4) Plastic Cable Straps. Plastic Cable Straps SHALL NOT be used for secondary support of fiber optic cable or cable assemblies.

d. Cable Bend Diameter Considerations.

(1) Minimum Bend Diameter. The minimum bend diameter is the diameter at which a cable or cable harness can be bent without degrading optical performance or the diameter at which a loose tube cable, convoluted tube or conduit can be bent without kinking (tube collapse causing fiber breakage). Two types of minimum bend diameters, short-term and long-term bend diameters, must be considered.

(2) Short-Term Bend Diameter. The short-term bend diameter applies during handling and installing. When the short-term bend diameter is not specified:

(a) Use a value of eight times the cable diameter for simplex, tight buffer cable (i.e., four times the cable diameter if working in terms of cable bend radius).

(b) Use a value of 20 times the cable diameter for simplex, loose tube cable (e.g., 2 mm diameter loose tube cable results in a 40 mm cable bend diameter).

(c) Use a value of 20 times the tube diameter for convoluted tube or conduit (e.g., 0.5 inch convoluted tubing results in a 10 inch cable bend diameter).

(3) Long-Term Bend Diameter. The long-term bend diameter applies to the completed installation. When the short-term bend diameter is not specified:

(a) Use a value of 16 times the cable diameter for simplex, tight buffer cable (i.e., eight times the cable diameter if working in terms of cable bend radius).

(b) Use a value of 20 times the cable diameter for simplex, loose tube cable.

(c) Use a value of 20 times the tube diameter for convoluted tube or conduit.

e. Protecting Cables and Cable Assemblies From Chafing.

(1) Chafing. Chafing shall be prevented by routing and clamping bundles to prevent contact with edges of equipment and structure. Where physical separation of at least 3/8-inch cannot be maintained, the edges shall be covered with suitable protection strips or grommets. Grommets and protection strips shall be securely fastened in place. Grommets for maintenance usage and replacements are provided in Table 5. The grommets consist of two types: donut and caterpillar.

(2) Donut Grommet Installation. Rubber (donut) grommets should be in accordance with MS35489. Donut grommets consist of rubber and are resistant to hot oils and coolants. The grommet has a maximum temperature application of 250°F. An example of the grommet is shown in Figure 2. The grommet should be replaced with an unsplit grommet whenever possible. When grommet must be split, it shall be split as shown in Figure 3.

(a) MS35489 Part Number. An example of the part number using MS35489-14X is as follows:

1 MS35489: Basic and detail specification number representing NASM3036 basic specification and MS35489 detail specification for a donut grommet.

Table 5. Caterpillar Grommet Replacement

ObsoleteNASM21266-	Sheet Thickness(in.)	Replacements		Sheet Thickness(in.)
		M22529/2-	M22529/3-	
-1	.015 - .052	-1C-85	-1C-85	.025 - .036
-2	.052 - .085	-2C-85	-2C-85	.036 - .063
-3	.085 - .128	-3C-85	-3C-85	.059 - .074
-4	.128 - .192	-4C-85		.070 - .09
-5	.192 -.255	-5C-85		.090 - .111
-6	.255 - .318	-6C-85		.105 - .134
-7	.318 - .380	-7C-85 8		.178 - .19
-8	.380 - .510	-8C-85		.240 - .260
N/A	N/A	-1C-*		.025 - .036
N/A	N/A	-2C-*		.036 - .063
N/A	N/A	-3C-*		.059 - .074
N/A	N/A	-4C-*		.070 - .093
N/A	N/A	-5C-*		.090 - .111
N/A	N/A	-6C-*		.105 - .134
N/A	N/A	-7C-*		.178 - .198
N/A	N/A	-8C-*		.240 - .260
NOTES * Indicates the number of castles listed in Table 6 for the mounting edge thickness (-1, -2, etc.) and the length required, (this WP, paragraph 012 01-3e4)				

2 -14: Represent a specific size grommet for a particular hole size and edge thickness.

3 x: When present represents a silicone rubber. No letter represents a synthetic rubber.

(b) MS35489 Grommet Replacement. When an engineering drawing, maintenance manual, etc. or no information on the grommet is provided, use the silicone rubber grommet (i.e. MS35489-14X).

(c) MS35489 Grommet Installation. The grommet should be installed as follows:

1 Measure the diameter of the hole and edge wall thickness.

2 Using the information provided in MS35489 specification, choose the correct silicone rubber grommet.

3 Pressure inserts the grommet in the hole.

CAUTION

Do not damage the grommet.

4 If the grommet will not fit without apparent damage, cut the grommet as shown in Figure 3.

(3) Caterpillar Grommet Installation. Caterpillar grommets should be in accordance with NASM22529/2 and /3 detail specifications. The

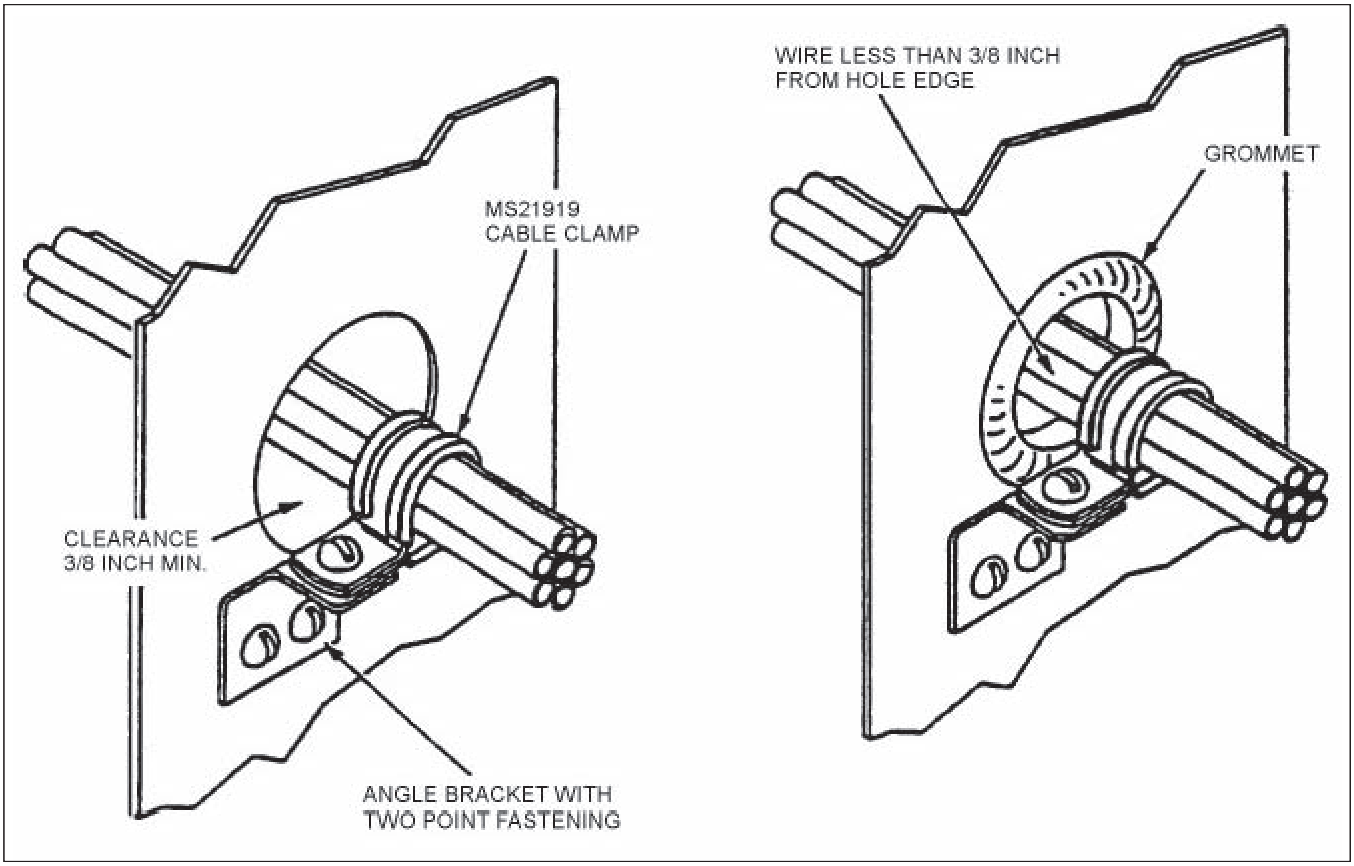


Figure 2. Methods of Chafing Prevention

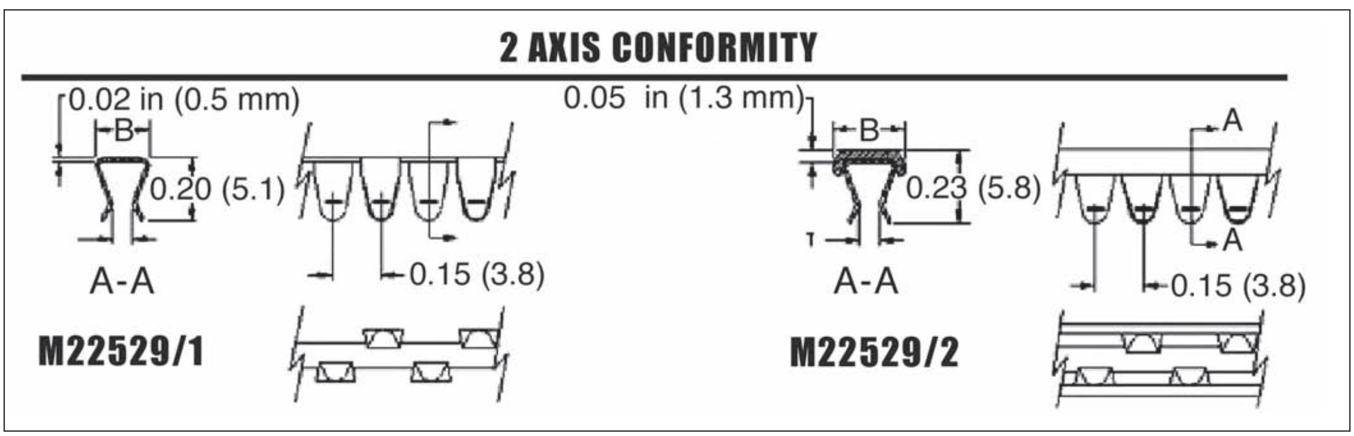


Figure 3. Lightening Hole Grommet Mounting

composite coated steel grommet has a maximum temperature application of 290°F. When the NASM21266 nylon caterpillar grommet is specified in an aircraft manual or engineering drawing, use the NASM22529/2 or /3 composite grommet. For a specified sheet thickness, substitute the NASM21266 grommet with the NASM2259/2 or /3 grommet as shown in Table 5.

(a) NASM22529 Part Number. The caterpillar part number, using M22529/2-1C-85 and M22529/2-4R-25 as two examples, is as follows:

1 M22529: Basic specification number representing NASM22529, which defines the general requirement for caterpillar grommet.

2 /2: Detail specification number representing NASM22529/2 which defines the specific details of a particular caterpillar grommet.

3 -1: Thickness of the material on which the grommet can be mounted.

4 C: Denotes a precut length requirement. R: Indicates grommets are mounted on a reel.

5 Circular Hole Grommet Edging Cut Lengths.

a -85: Represents the number of castles in a precut length at intervals of 0.015 inches (see Figure 3).

b -25: Indicates the length of the reel grommet (i.e. 25 feet). (See Table 6).

(b) NASM22529 Description. An illustration of the grommet is provided in Figure 4. The grommet is a green, epoxy coated stainless steel strip with teeth (castles) staggered on each side of the strip. From center to center the castles are 0.15 inches apart. The surface, opposite castles is a gray elastomer cushion used to reduce the abrasion characteristics of the hole or edge on which the strip is mounted. The strip is secured on the edge of the hole by separating the castles (spring loaded) when pressing on the strip.

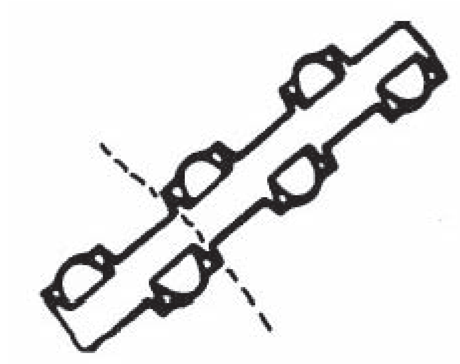


Figure 4. Cut Grommet

Table 6. Circular Hole Grommet Edging Cut Lengths

Cut Length		
Nominal Hole Diameter	L Length	In Castles
2.000	6.00	40
2.250	6.90	46
2.250	7.65	51
2.750	8.40	56
3.000	9.15	61
3.250	10.05	67
3.500	10.80	72
3.750	11.55	77
4.000	12.30	82
4.250	13.20	88
4.500	13.95	93
4.750	14.70	98
5.000	15.45	103
5.250	16.35	109
5.500	17.10	114
5.750	17.85	119
6.000	18.60	124

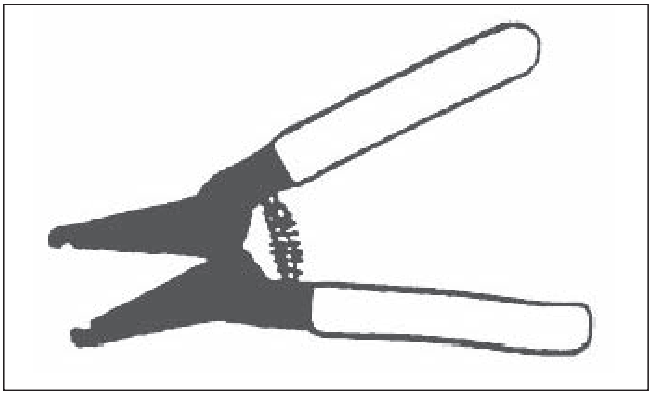


Figure 5. Bypass Shears

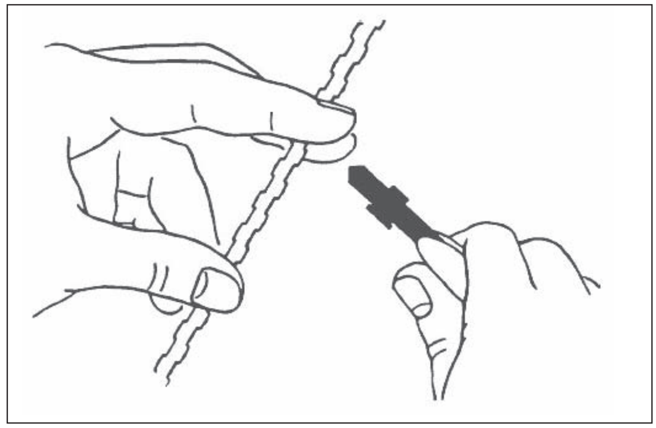


Figure 6. Gripping Grommet

(c) NASM22529/2 Flat Edge Hole Installation. To install grommets on non-lightening, flat edge feed through holes as shown in Figure 2 perform the following:

CAUTION

Do not use NASM22529/2 grommet in horn shaped lightening strike hole (this WP, paragraph 012 01-3e4).

1 Examine the NASM21266 nylon grommet, which is glued to the feed through hole, for breaking of teeth or separation from the edge.

2 Remove the old grommet when needed. Be sure all old excess material is removed and discarded to avoid FOD.

3 Measure the diameter of the hole and edge wall thickness. Determine the length needed to cover the hole from Table 2 for the measured wall thickness.

4 Measure the required grommet length.

5 Using a full bypass shears (part number MFE-100) shown in Figure 5, hold the grommet as shown in Figure 6.

CAUTION

Safety glasses should be used.

6 Cut the grommet between the castles at a 90° angle as shown in Figure 4. To assure the absence of deformation of adjacent castles close to the cut-off, be sure to grip both sides of the cut.

7 Cut the grommet at a 45° angle as shown in Figure 4.

8 Install the grommet by compressing the grommet firmly on the hole edge with the slit between the two ends of the grommet located at the top of the hole. If it appears that the bundle wire were to become loose and rub against the split, it should be located in such a manner that the wire pressure will be on the opposite side from the split. Be sure grommet is completely compressed firmly on the edge of the hole as shown in Figure 7.

9 If the width of the split is greater than 0.3 inches, replace the grommet.

(4) NASM22529/3 Lightening Hole Installation. To install grommets in horn shaped lightening holes as shown in Figure 7, follow the same procedure as for the NASM22529/2 flat edge hole except use a M22529/3 grommet. The NASM22529/3 part number format is the same as for the NASM22529/2 part number. However, the NASM22529/3 grommet must be cut at a 90° angle instead of a 45° as shown in Figure 8.

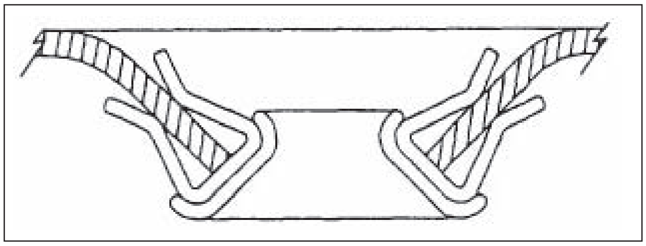


Figure 7. Lightening Hole Grommet Mounting

f. Connector Coupling.

CAUTION

Do not use excessive force to mate plug to receptacle.

(1) Connector Coupling: Assemble connector to receptacle as follows:

(a) Inspect fiber optic termini for cleanliness using platform approved procedures and equipment prior to beginning mating. Appropriate inspection and cleaning practices are covered in WP 008 01 and WP 008 02.

NOTE

Unmated connectors should be covered with appropriate caps (example, ESD caps, dust caps or bags) to prevent introduction of contaminates onto the fiber optic termini end faces. Unmated connectors should not be covered with tape.

(b) Locate the proper position of the plug in relation to the receptacle by aligning the key of one part with the groove or keyway of the other part. (Figure 2).

CAUTION

Do not twist bundle excessively to achieve proper mating of plug to receptacle.

Do not misconnect plug and receptacle by forcing pins into the resilient insert, either by misalignment of properly mating connector or by joining connectors with identical shells but differently keyed insert arrangements.

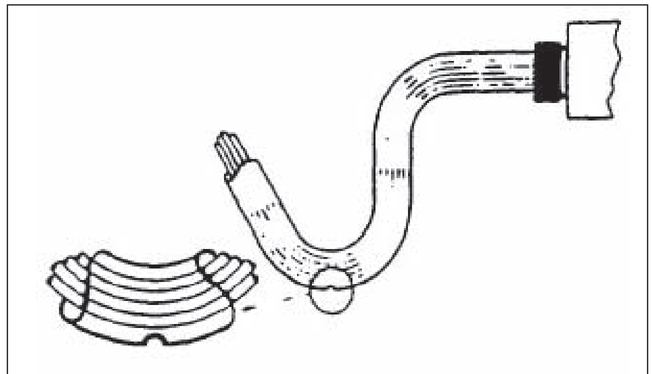


Figure 8. Drainage Hole in Low Point of Tubing or Tape

(c) Start the plug into the receptacle with a light forward pressure and engage the threads of coupling ring and receptacle.

(d) Alternately push in the plug and tighten the coupling ring until the plug is completely seated.

(e) When mating a connector with bayonet lock coupling, make sure that all locking rivets of the coupling are engaged.

CAUTION

Be careful not to lock the plug while cocked, i.e., two locking rivets engaged and one not engaged.

Do not hammer a plug into its receptacle. Never use a torque wrench or pliers to lock coupling rings.

(f) For threaded connectors, make sure the fully mated indicator stripe on the receptacle is covered by the coupling ring of the connector when view normally to the axis of the connector. (See Figure 9).

(g) A bayonet connector is fully mated when the connector-locking pin can be visually seen in the inspection hole. (See Figure 9).

(1) BEFORE COUPLING, MATING HALVFS MUST BE EXAMINED FOR:

A. PROPERLY SEATED CONTACTS
B. ALL CAVITIES FILLED WITH CONTACTS (EXCEPT UNUSED COAX)
C. NO VISIBLE BENT CONTACTS
D. ALL UNWIRED CAVITIES WITH ENVIRONMENTAL SEALS WITH PROPER SEALING PLUGS
E. APPLICABLE BACKSHELL TIGHTENED ON CONNECTOR, AND, WHERE CABLE CLAMP CLAMP IS USED, SADDLE BARS TIGHTEN

(2) AFTER EXAMINATION AND MATING, VERIFY CONNECTOR HAS LOCKED AND/OR IS TIGHT, DEPENDING ON TYPE.

NOTE
WHEN A THREAD CONNECTOR HAS NO INDICATOR LINE, MAKE CERTAIN THAT IT HAS BEEN SUFFICIENTLY TIGHTENED.

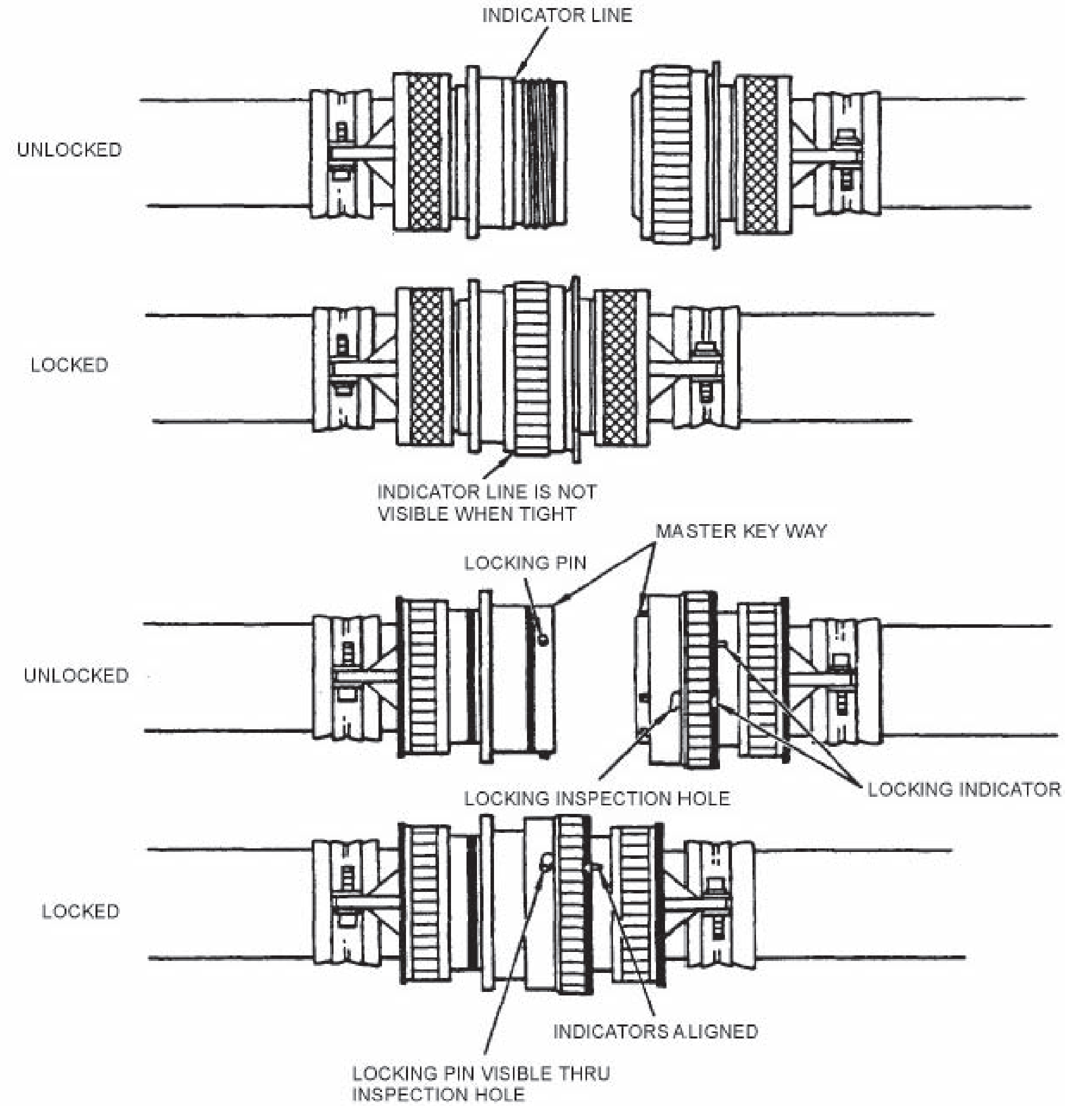


Figure 9. Mating or Coupling Connectors

g. Types of Protection Over Cable.

(1) Types of Protection. The following four types of protection, over the cable or in which the cable is placed, defined for this work package is as follows:

(a) Conduit. Metallic tube in which individual cable or cable bundles are placed.

(b) Non-Metallic Conduit. Convoluted tube or non-metallic straight tube in which individual cable or cable bundles are placed.

(c) Cable Wrap. Non-metallic, convoluted tube with one slit running along the length of the tube. Cable wrap is also referred to as split loom.

(d) Over-Braid. Metallic wire or non-metallic string woven into a web shape, tubular configuration.

(2) Guidance on Primary Use.

(a) Conduit. Pre-install in aircraft, then pull cable, cable bundle or cable harness through the conduit

1 Measure the bundle wires before installing in conduit. The bundle diameter must not exceed 80% of the internal diameter of the conduit.

(b) Non-Metallic Conduit. Convoluted tube is used during fabrication of a cable harness with a multiple termini connector (such as the M38999) on one or both ends. Non-metallic, straight tube is pre-install in aircraft; then the cable, cable bundle or cable harness is pulled through the conduit.

1 Measure the bundle wires before installing in conduit. The bundle diameter must not exceed 80% of the internal diameter of the conduit.

(c) Cable Wrap. Pre-install in aircraft; then open the slit and place cabling into the cable wrap.

(d) Over-Braid. Metallic wire or non-metallic overbraid is not placed directly on top of a fiber optic cable or cable bundle.

(3) Guidance for tightening inside cable clamps.

(a) Conduit and Non-Metallic Conduit. Tighten to constrain without constricting. Constricting the conduit or non-metallic conduit will kink the tube structure resulting in potential fiber breakage.

(b) Cable Wrap. Cable wrap may be tightened to point of constriction since the constriction does not create a hard point is which a kink will occur.

h. Special Protective Measures While Routing.

(1) Protection from Excessive Heat. Route fiber optic cable, cable bundles or cable harness away from high temperature equipment (engines, heat exchangers, exhaust stacks, heating ducts, de-icers, etc.) where possible. Install heat installation barriers or use other protective measures where routing cannot be avoided.

(2) Protection from Excessive Moisture. Route fiber optic cable, cable bundles or cable harness away from areas that may build-up or have high moisture (such as wheel well area) where possible. Install drip proof shields or use other protective measures where routing cannot be avoided in areas with a high moisture build-up. Also, place drainage holes at trap points and at the lowest point between each set of support clamps.

(a) Drip Loop. Where cabling is dressed downward to a connector, terminal block, panel, or junction box, a trap, or drip loop, shall be provided in the cabling to prevent fluids or condensation from running into the device. Extreme care shall be exercised to assure that the drip loop does radius does not exceed the minimum bend radius requirements 3.d herein.

(3) Protection from Exposure to Fluids. Route fiber optic cable, cable bundles or cable harness away from areas of potential immersion into fluids (such as in a bilge) where possible. Install as high as practicable within the space to avoid immersion into a fluid except where attachment to equipment is required. Enclose fiber optic cable, cable bundles or cable harness in conduit where fluid immersion cannot be avoided.

(4) Protection at an Access Port. Route fiber optic cable, cable bundles or cable harness so as to minimize abrasion at access ports. Install so that there is twist instead of bend across hinges

(5) Protection from Abrasion. Route fiber optic cable, cable bundles or cable harness attached to assemblies where relative movement occurs (such as at flight control surfaces, control wheels and column, control stick, wheel well etc.) or attached to frequently removed or replaced equipment (such as an LRM or WRA) so as to minimize effects of abrasion. Causes for abrasion include rubbing of the cable and excessive twisting or bending. Install in flexible, nonmetallic tubing where practicable. Use abrasion protective tape (such as in accordance with MIL-T-4053) where tubing is not practicable

i. Routing Practices.

(1) General Practice Tips.

(a) Never push cable, cable bundles or cable harness through clamps, convoluted tubing or conduit. Always push through (or lay in clamps) using guidance provided in this work package.

(b) Install cable in convoluted tubing prior to placement of metallic or non-metallic overbraid on top of cable.

(c) Do not place any tension, compressive or bending force during routing of the cable, cable bundles or cable harness.

(d) Install cable and cable assemblies so as to avoid the application of axial and lateral loads to the cable and terminations.

(e) Cable and cable assemblies used as part of systems required to maintain flight control are required to have redundant channels routed in separate routing paths. This is intended to prevent damage to one routing from disabling both channels of a redundant system. DO NOT deviate from the design intent of separate routing paths without prior approval from the applicable Platform Office.

(f) Never support any wire or wire bundle from a plumbing line carrying flammable fluids or oxygen. Clamps may be used only to insure separation.

(2) Cable Slack.

(a) Secure cables, cable bundles or cable harnesses as close as possible to the equipment without violating the long-term bend diameter.

(b) Ensure sufficient slack between equipment and the last point of cable support for cable, cable bundles or cable harness entering hard-mounted equipment.

(c) Ensure an additional slack between equipment and the last point of cable support for cable, cable bundles or cable harness entering resilient or shock-mounted equipment that exceeds the travel distance of the resilient or shock-mount.

(d) Ensure sufficient slack between multiple termini connectors (such as the MIL-DTL-38999) attached to equipment and the last point of cable support for cable, cable bundles or cable harness.

(3) Cable Removal. Remove wherever possible any cable, cable bundles or cable harness no longer used or rendered useless.

(4) Abrasion Tape in Fluid Prone Areas. Apply abrasion protective tape in an overlapping manner so that the tape will shed, not trap, liquid. Place drain holes only at the trap points.

(5) Abrasion Tape in Non-Fluid Prone Areas. Prior to wrapping, place small diameter holes (about 1/8 to 3/16 inch) every 2 inches in the tape.

(6) Routing in Pre-Installed Conduit. Perform cable pull per WP 0011 01 (Assembly of M38999 cable harness).

(7) Routing with Electrical Cable.

(a) Supporting Cable. Ensure that optical cables do not support electrical cables.

(b) Cable Position. Place fiber optic cables, cable bundles or cable harnesses on top of electrical cables where the two types are to be mixed in the same cable clamps.

(c) Installation Sequence. Install fiber optic cables, cable bundles or cable harnesses last when mixed with electrical cables in the same cable clamp.

(d) Protective Coverings. Use protective coverings over the fiber optic cable, cable bundles or cable harness where the installation of electrical cables over fiber optic cable, cable bundles or cable harness cannot be avoided. Monitor the fiber optic cable during the electrical cable pull as an alternative to the use of protective coverings. Ensure that the fiber optic cable, bundles or cable harness does not support the electrical cable.

(e) Routing Through Aircraft Pre-Installed Conduit. Install fiber optic cables in convoluted tubing first, then pull both fiber optic and electrical cables through the conduit in the aircraft at the same time .

(8) Use of Protective Sleeve. Use protective sleeves in locations where rubbing or sharp surfaces cannot be avoided and rerouting is not practical. Do not use protective sleeves in lieu of good routing practices.

(9) Connector/Termini Terminations.

(a) Handling and Installation. Handle and install cable, cable bundles or cable harness as to prevent placing stresses on the connector/termini terminations.

(b) Ferrule Protection. Keep dust covers or protective caps on termini and connectors whenever possible during routing.

(c) Connector Removal from Harness. Do not remove connectors during installation whenever possible (this prevents cables within bundles from relaxing to a different length).

(d) Pulling on Connector. Do not pull a fiber optic cable harness by the connectors. Take hold of the cables behind the backshell with one hand and pull gently. Support the connector with the other hand.

(e) Pulling on Cable in Direction Opposite of Connector. Do not pull on the cable immediate after the backshell in the direction opposite to the connector. Such pulls cause terminus misalignment and cable shifts resulting in increased optical loss.

(f) Pulling on Termini. Do not pull a fiber optic cable bundle by the termini. Take hold of the cables behind the termini with one hand and pull gently. Support the termini with the other hand.

(10) Routing Near Fluid Lines.

(a) Route fiber optic cable, cable bundles or cable harness above fluid lines and equipment, and not below, whenever possible.

(b) Route fiber optic cable, cable bundles or cable harness below fluid lines at an angle, rather than parallel, to the fluid lines in locations that the fiber optics must pass below the fluid lines.

j. Cable Pulls Do’s and Don’ts.

(1) General Guidance. Perform cable pulls of fiber optic cable, cable bundle or cable harness by feeding in a segment-by-segment fashion then securing it into the clamps. Do not use block and tackle, chain falls or other mechanical devices for the cable pull. Avoid kinks, twisting, sharp bends or stretching caused by an excessive pulling force. Pull slowly so that if the cable is caught, it will be noticed readily and the cable pull can be stopped before any damage occurs.

(2) Do’s.

(a) Do wear proper clothing and safety equipment (gloves, eye protection, etc.) while pulling cable.

(b) Do use a step ladder properly (reposition versus leaning over).

(c) Do pull slowly enough that it is noticed readily if cable gets caught.

(d) Do inspect and remove debris, burrs, sharp edges, etc. from bulkhead penetrations and other items along the cable route.

(e) Do pull the cable as straight as possible. Pull out straight, a little at a time, at a tight bend or turn.

(f) Do pull all the cable through prior to making a turn or coming to a bend. (Alternative: Leave a loop at the turn and feed the cable a little at a time. Feed cable through at a loop with one hand, then pull more cable to bring the loop back to its original size with the other hand. Perform this “free flowing loop” operation in a steady, synchronous motion.)

(g) Do stay parallel to the direction of other cables in a clamp during the pull.

(h) Do keep the fiber optic cable being pulled on top of other cables in the clamp.

(i) Do make a gradual transition while crossing other cables.

(j) Do review these essential cable pull techniques periodically and when new personnel are present.

(3) Don’ts.

(a) Don’t push through a conduit (always pull, never push).

(b) Don’t jerk on or pull in a jerking motion.

(c) Don’t pull down on the cable. (This would usually occur at a bend or at a cable clamp).

(d) Don’t pull at a tight bend.

(e) Don’t force a cable inside a tight bend.

(f) Don’t pull too fast.

(g) Don’t pull too hard.

(h) Don’t run through objects with rough (sharp) edges.

(i) Don’t pull underneath other cables.

(j) Don’t get intertwined with other cables.

(k) Don’t wrap end of cable in a fist during the pull.

(l) Don’t hang end of cable so that one point in the run is placed in a tight bend.

(m) Don’t use any mechanical device to do the pull (block & tackle, chain fall, etc.).

k. <u>Transporting.</u>

(1) Place the cable, cable bundle or cable harness in a coil that does not exceed the minimum bend diameter. Avoid bends, kinks and twisting.

(2) Support termini/connector ends and breakout segments. Place on a backing material and tie down. Tie the connectors and breakout segments to the coil when no backing material is available.

(3) Wrap the cable, cable bundle or cable harness in bubble wrap.

(4) Place the cable, cable bundle or cable harness in container large enough so that the cable, cable bundle or cable harness will lay flat without altering the shape of the coils.

(5) Pick up the cable, cable bundle or cable harness by the coil, never by the connector or breakout segment.

(6) Isolate wrapped cable, cable bundle or cable harness during transportation to extent that no parts or equipment are stacked on top.

Cable and Harness Replacement/Repair

Reference Material

Alphabetical Index

None

LIST OF SUBORDINATE WORK PACKAGES

SUBJECT	SUBORDINATE WORK PACKAGE	DATE
Cable and Harness Replacement/Repair Overview	013 01	13 August 2004

Record of Applicable Technical Directives

None

1. POLICY, FIBER OPTIC CABLE AND HARNESS REPLACEMENT/REPAIR. Cable and harness replacement/repair approach is Platform specific. Repair set/kit requirements, if any, are to be defined by each Platform. See specific Platform maintenance plan for cable replacement/repair guidance.

THIS PAGE LEFT INTENTIONALLY BLANK

Cable and Harness Replacement/Repair Overview

Reference Material

None

Alphabetical Index

Record of Applicable Technical Directives

None

Support Equipment Required

None

Materials Required

None

1. INTRODUCTION.

NOTE

This overview is for informational purposes only.

2. This work package provides an overview and general guidance on the applicable approaches for fiber optic cable and harness replacement or repair. It is recognized that no one approach is appropriate for each aircraft configuration (such as fixed wing and rotary) or specific variants of each configuration. Two approaches are addressed for cable/harness replacement (redundancy and threading) and two others provided for cable/harness repair (fusion splicing and mechanical splicing). The application with the listing of advantages and disadvantages are given for each approach.

3. APPROACHES TO CABLE/HARNESS REPLACEMENT.

a. Redundancy. Inclusion of cable spares within fiber optic cable bundles/harnesses.

(1) Applications. Fiber optic cable/harness design may include provisions for redundancy when the application permits. These provisions include cable spares (simplex cables) and patch panels. Damaged cables/harnesses are replaced by substituting to one of the cables identified as a spare by moving connectors at the patch panel, termini within a connector or other routing schemes. The redundant cable, when not part of a cable harness, may be separated from the normal cable to maximize survivability.

(2) Advantages.

(a) Cable rerouting can take place with a minimum of down time.

(b) Requires minimum level of skill to perform substituting operation.

(3) Disadvantages

(a) Initial cost is greater to install cables that may not be used.

(b) Redundant cables add weight that some Platforms may not be able to tolerate.

b. Threading. Positioning of replacement cable along side of existing cable or cable harness.

(1) Application. When the application permits and redundancy cannot be accommodated, threading of replacement cabling may be done along with existing cable harness.

(2) Advantages.

(a) Threading approach does not require that cabling within an existing cable harness be disturbed.

(3) Disadvantages.

(a) Replacement cable may need to be threaded through areas with no or limited access.

(b) Damaged cable remains in cable harness resulting in additional weight once the new cable is installed.

(c) Requires level of skill to thread cable and replace termini of the damaged cable in the connector with that of the threaded cable.

(d) Replacement cable is more susceptible to damage since it is located on the outside of a cable harness.

4. APPROACHES TO CABLE/HARNESS REPAIR.

a. Fusion Splice. Two optical fibers are melted or fused together by means of a fusion splice apparatus using such methods as electric arc, laser or gas flame. During fusion, the surface tension of molten glass tends to realign the fibers on their outside diameter, changing fusion splicer initial alignments performed. As a result, a small core distortion may be present. Fusion splice operators must be highly trained and remain proficient to make low-loss, reliable fusion splices. Fusion splicing yields depend on the strength and loss requirements. Factors affecting splicing yields include condition of the splicing machine, personnel experience and environmental conditions.

(1) Applications. Joining of two cables during initial installation or two broken cables for cable repair. There must be sufficient length of cable allotted in the cable harness for strip back of cable jacket and the splicing operation. Also, the optical cable to be spliced and the fusion splicer must be compatible and there must be sufficient room near the cable ends for the fusion splicer to be used.

(2) Advantages.

(a) Obtain a fused joint that is stronger than the surrounding fiber.

(b) Low loss value at the joint. Fused joints may have on average, a lower loss value than for a mechanical connection (either splice or connector).

1 Single mode loss of 0.05 to 0.2 dB for fusion splice versus 0.2 to 0.5 dB for a mechanical connection.

2 Multimode loss of 0.1 to 0.2 dB for fusion splice versus 0.1 to 0.2 dB for a mechanical splice or 0.2 to 0.5 for a mechanical connection.

(c) Low optical return loss value at the fused joint.

(3) Disadvantages

(a) User Skill Level.

1 Must perform on continual basis to become/remain proficient.

2 Must use skill in setup, selection of correct profile parameters, etc.

(b) Automation.

1 Does not eliminate skill requirement for strip and cleave operations.

2 Increases access requirement.

(c) Environmental Factors.

1 Cleanliness and accessibility are a necessity.

2 Optical loss can vary with environmental change if splice is not fused properly. The splice may deceivingly appear to be adequate when visually inspected.

(d) Quality Assurance.

1 Difficult to assess splice quality in the field. Visual inspection is not adequate.

(e) Process.

1 Fiber recoating required for high reliability.

(f) Added Optical Loss.

1 Spliced cable contains an additional interface that results in additional optical loss and an interface that may degrade over time.

(g) Electric Power.

1 Electric power required for fusing the fibers.

2 Electric arc constitutes an explosion hazard.

(h) Cost.

1 Higher initial equipment cost for fusion splicer..

2 Requires investment and maintenance of a good quality cleaver.

(i) Parameter Settings.

1 Different parameter settings need to be established for each fiber configuration.

2 Parameter settings must be adjusted to compensate for factors such as electrode wear.

b. Mechanical Splice. Two optical fibers are held in alignment for an indefinite period without movement by means of a mechanical fixture (such as a tube/capillary, rods or v-groove substrate) within the mechanical splice. Precision cleaves on the fiber ends and index matching fluid is used as two measures to ensure low optical loss.

(1) Application. Same as that for a fusion splice.

(2) Advantages.

(a) Requires less skill to accomplish repairs.

(b) Can be performed with no need for electric power for some splice designs (using hand tools only).

(3) Disadvantages.

(a) Requires investment and maintenance of a good quality cleaver.

(b) Splice construction/materials limits scope of applications more than other types of cable repair approaches.

(c) Spliced cable contains an additional interface that results in an additional interface that may degrade over time.

(d) User skill required for strip and cleave operations.

(e) Splice performance may be unstable if splice protectors are not used correctly.

(f) Difficult to assess splice quality in the field.

By Order of the Secretary of the Army:

PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army
0433706

Distribution:
To be distributed in accordance with initial distribution number (IDN) 311333, requirements for TM 1-1500-323-24-4.

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

PIN: 082112-000