

Characterization and Requirements for New Aerospace Fiber Optic Cable Assemblies -
Jumpers, End Face Geometry, Link Loss Measurement, and Inspection

RATIONALE

Aerospace end users have identified a need for beginning of life, fiber optic jumper, end face inspection and link loss measurement criteria for aerospace fiber optic cable harness assemblies.

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1. GENERAL

1.1 Purpose

This document is intended to address inspection and testing of fiber optic cable assemblies at beginning of life (BOL). It is understood that the equipment described in this document is intended for use in a fabrication environment.

The purpose is to develop aerospace fiber optic standards for quality and testing of;

- Jumpers, measurement quality, for aerospace testing (AMQJs)
- End face geometry, examination of termination quality
- Link Loss measurement definition
- Inspection, end face finish, acceptability, cleanliness

1.2 Scope

To create a standard that instructs both supplier and user in the testing and characterization of initial build fiber optic cable assemblies for avionics/aerospace applications. This can be in the plant or in the avionics "box." It includes specification of jumpers (aerospace measurement quality jumpers), end faces, link loss requirements and inspection.

1.3 Cleaning

All optical end faces shall be cleaned prior to any processing, inspection and testing. Contamination is the primary cause of link loss and can cause damage to an end face. For guidelines on cleaning, refer to IPC-8491-1.

1.4 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

1.4.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

ARP5061 Guidelines for Testing and Support of Aerospace, Fiber Optic, Interconnect Systems

1.4.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI Z136.4-2005 Recommended Practice for Laser Safety Measurements for Hazard Evaluation

1.4.3 ARINC Publications

Available from ARINC, 2551 Riva Road, Annapolis, MD 21401. www.arinc.com.

ARINC 805 Fiber Optic Test Procedures

1.4.4 IEC Publications

Available from International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland, Tel: +44-22-919-02-11, www.iec.ch.

IEC 61280-4-1 Fibre-optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement

1.4.5 IPC-ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

Available from IPC, 3000 Lakeside Drive, Bannockburn, IL 60015, Tel: 847-597-2862, www.ipc.org.

IPC-8497-1 Cleaning Methods and Contamination Assessment for Optical Assembly

1.4.6 TIA Publications

Available from Telecommunications Industry Association, 2500 Wilson Boulevard, Suite 300, Arlington, VA 22201, Tel: 703-907-7700, www.tiaonline.org/standards/.

TIA/EIA-455	Fiber Optic Test Procedures
TIA/EIA-455-8 (FOTP-8)	Measurement of Splice or Connector Loss and Reflectance Using an OTDR (ANSI/TIA/EIA-455-8-2000)
TIA/EIA-455-34 (FOTP-34)	Interconnection Device Insertion Loss Test (ANSI/TIA/EIA-455-34A 95)
TIA/EIA-455-43 (FOTP-43)	Output Near-Field Radiation Pattern Measurement of Optical Waveguide Fibers (ANSI/TIA/EIA-455-43-A-99)
TIA/EIA-455-47 (FOTP-47)	Output Far-Field Radiation Pattern Measurement. (superseded by ANSI/TIA-455-177-B)
TIA/EIA-455-107 (FOTP-107)	Determination of Component Reflectance or Link/System ReturnLoss Using a Loss Test Set
TIA/EIA-455-171 (FOTP-171)	Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies (ANSI/TIA/EIA-455-171-A)
TIA/EIA-455-203 (FOTP-203)	Launch Power Distribution Measurement
TIA-526-7 (OFSTP-7)	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-526-14 (OFSTP-14)	Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
TIA/EIA Standard 604-5 (FOCIS 5)	FIBER OPTIC CONNECTOR INTERMATEABILITY STANDARD - Type MPO
TIA/EIA-TSB-142	Optical Return Loss Meters Measurement and Application Issues
TIA/EIA TSB-178	Launch conditions

1.4.7 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-9495, <https://assist.daps.dla.mil/quicksearch/>.

MIL-DTL-38999	General Specification for Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment, Removable Crimp and Hermetic Solder Contacts
MIL-PRF-64266	Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable, Genderless Termini, Environment Resisting, General Specification for

MIL-PRF-29504 Termini, Fiber Optic Connector, Removable, General Specification For

1.4.8 Other Publications

Telcordia GR-326-CORE Generic Requirements for Single-mode Optical Connectors and Jumper Assemblies

2. INSPECTION

2.1 Intent

This section defines the requirements and methods for inspecting terminated fiber optic cable end faces in aerospace termini/connectors. Procedures are given for the inspection process itself. Thresholds are provided for grading an end face and determining acceptance. Generally, this section applies to fibers that are terminated in a ferrule. However this section may apply to un-terminated polished fibers.

2.2 Apparatus

2.2.1 Hardware Classification

There are two types of inspection relevant to fiber optic manufacture and deployment.

2.2.1.1 Low Resolution: A low resolution video or optical microscope shall be used to examine the fiber and ferrule end face prior to mating and test to ensure that the surface is polished and clean. Typical magnification is 100X. Intended for initial viewing of terminus to look for defects over the entirety of the ferrule and endface.

2.2.1.2 High Resolution: At the beginning of life, following initial polishing, a high resolution video or optical microscope shall be used to examine the optical fiber surface or end face for fine scratches and other defects. Recommended magnifications are 200X for multimode and 400X for single mode.

2.2.2 Validation/Verification Artifact

Microscopes shall be validated using a NIST traceable artifact. The artifact shall be capable of validating that the microscope's magnification, resolution, and contrast rendering abilities are sufficient for the application. As optical performance can degrade over time, this calibration test must be performed periodically, at 6 month to 12 month intervals.

2.2.2.1 Low Resolution Artifact(s) shall be able to validate a 2.0 micron (μm) feature in a 500 micron diameter field of view. For examples, see Informative References section I-3 Artifacts.

2.2.2.2 High Resolution Artifact(s) shall be able to validate the following:

- System is able to validate a feature of 1 micron. This artifact scratch must be manufactured in accordance with NIST traceable guidelines.
- System can view or scan a region of interest of at least 125 microns.

Factors such as contamination within the optics, video adjustments on the monitor, and degradation of electrical components can affect the inspection system's performance. Maintenance and calibration shall be per inspection equipment manufacturer's recommendations.

2.3 Definition For Inspecting End Faces

WARNING: Photonic systems may emit optical power that is damaging to the human eye.

- Ensure that the system is powered-down prior to inspection.
- Follow the equipment manufacturer's operating procedures and warnings.
- Follow safety guidelines of ANSI Z136.4-2005.

2.3.1 Zones

Defects on fiber optic end faces become likely to degrade signal performance when they are located near the mode field (core). For that reason, acceptance criteria are defined in “zones”. Those zones are concentric rings centered on the core of the fiber. The acceptance criteria become less stringent the further the zone is from the core. The dimensions of the zones are calculated as follows and are specifically given in Figures 1 and 2.

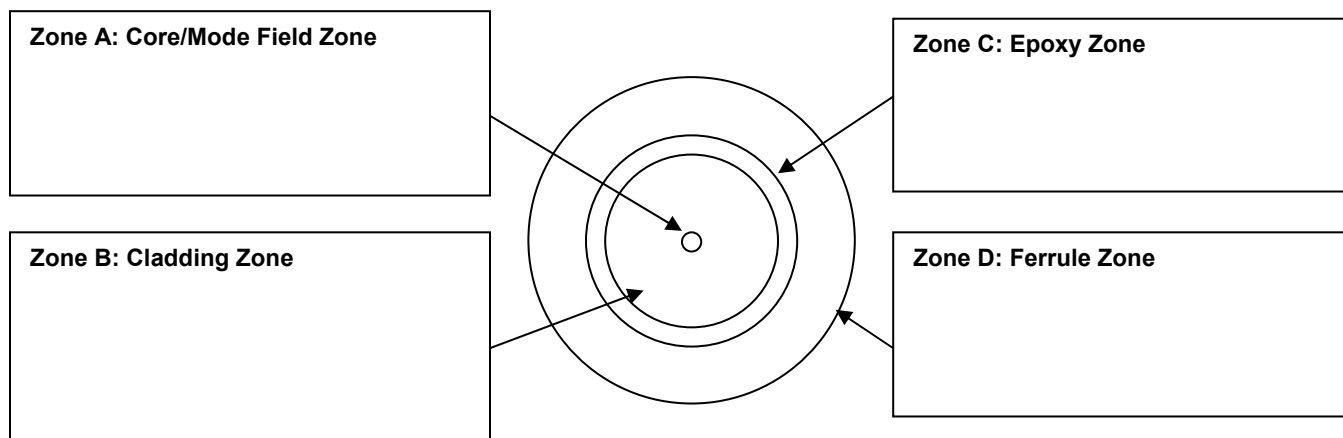


FIGURE 1 - VISUAL ACCEPTANCE CRITERIA FOR SINGLE MODE FIBER OPTIC END FACE

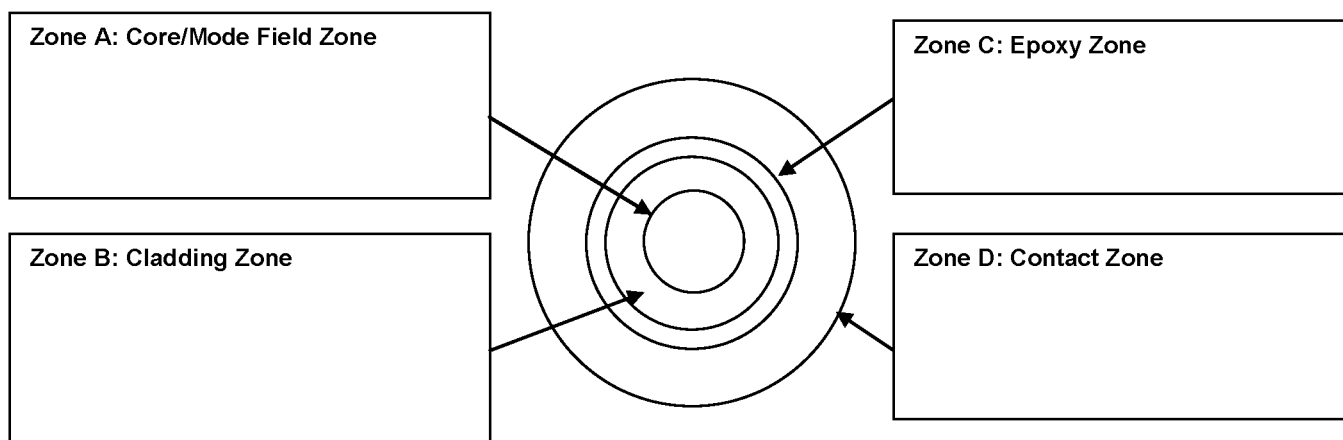


FIGURE 2 - VISUAL ACCEPTANCE CRITERIA FOR MULTI-MODE FIBER OPTIC END FACE

TABLE 1 - INSPECTION ZONES FOR OPTICAL FIBER END FACES

Zone Name	Multimode Zone Dimensions	Singlemode Zone Dimensions
A, Core/Mode Field	Core diameter multiplied by 1.1 (defined as Core diameter + 10%)	25 microns
B, Cladding	From the Core OD of Zone A to the OD of the cladding minus 5 microns	From the mode field OD of Zone A to the OD of the cladding minus 5 microns
C, Epoxy (Adhesive/Coating)	From the OD of Zone B or coating to the ID of the ferrule plus 10 microns	From the OD of Zone B to the ID of the ferrule plus 10 microns
D, Contact (Ferrule)	From the OD of Zone C to 2 times the cladding diameter not to exceed 450 microns	From the OD of Zone C to 2 times the cladding diameter not to exceed 450 microns

2.4 Definition of End Face Anomalies

Any features that are visible after cleaning are considered defects. End face defects occur during the processing of the termini/ connectors. End face processing defects include: particles, pits, chips, scratches, embedded debris, loose debris, cracks, etc., For the purposes of this document, all defects will be grouped into categories. Acceptance criteria are based on these categories.

- a. Scratches: linear surface defects that cannot be removed through cleaning.
- b. Defects: All other visible features not removed by cleaning process.
- c. Cracks/Structural Defects: cracks and structural defects are not just surface defects, but extend into the optical fiber. Backlighting the fiber can render cracks visible. These defects are cause for rejection.

2.5 Inspection Procedure

2.5.1 Clean end face and insert fiber into the correct validated inspection device, and focus. Identify all anomalies within the defined zones and refer to Table 2 to determine if the fiber is acceptable.

2.5.2 Where the end face fails requirements shown in Table 2, suitable disposition shall be done per Figure 3, disposition flow chart.

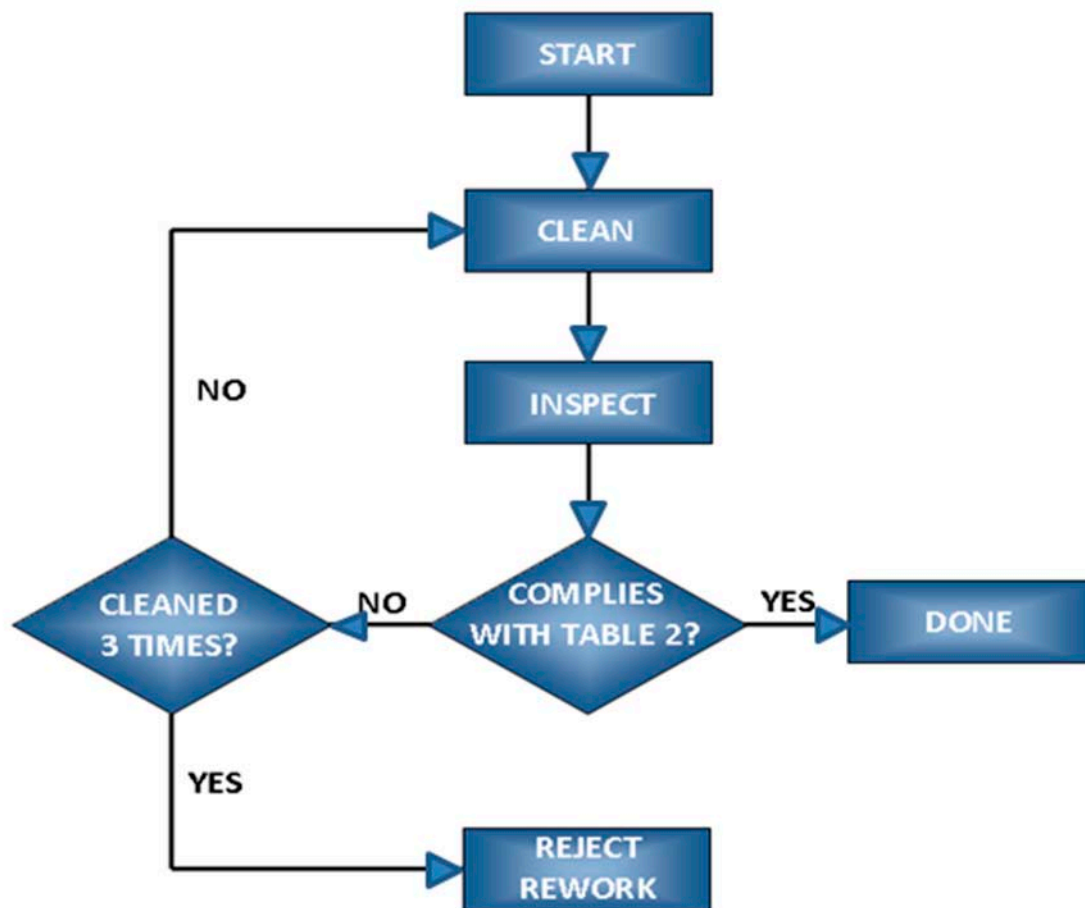


FIGURE 3 - DISPOSITION FLOW CHART

TABLE 2 - ALLOWABLE DEFECTS FOR FIBER END FACES

Zone	Description	Grade A (default) ¹		Grade B (tailored) ¹	
		Defects	Scratches	Defects	Scratches
A	Core/Mode Field Zone	None	None	None $\geq 1 \mu\text{m}$	None $\geq 1 \mu\text{m}$
B	Cladding Zone	None	None	$5 \leq 5 \mu\text{m}$ None $> 5 \mu\text{m}$	None $> 3 \mu\text{m}$
C	Epoxy (Adhesive/Coating) Zone	any	any	any	any
D	Contact (Ferrule) Zone	None $> 10 \mu\text{m}$ No Cracks	any	None $> 10 \mu\text{m}$ No Cracks	any

NOTES:

1. No cracks, voids, or loose debris are allowed anywhere on termini endfaces.
2. Unless otherwise specified, Grade A shall be the default requirements. All U.S. government aerospace applications shall utilize grade A endface inspection criteria.

3. INSERTION LOSS / LINK LOSS TEST PROCEDURES

3.1 Intent

This section defines the requirements and methods outlining the detailed test equipment, tooling and other accessories to perform optical testing of terminated fiber optic cable, after end face requirements are met and before release to any secondary operation. It specifically describes the methods and setup requirements for making insertion loss and link loss measurements.

3.2 Required Equipment – Conventional Insertion Loss testing

3.2.1 Optical Power Meter (OPM)

The optical power meter (OPM) is an instrument to measure the optical power emanating from a connectorized optical fiber. Power meters are designed and calibrated for use in a particular optical power range and wavelength.

For making insertion / link loss measurements (change in optical power), a built-in relative power mode should be used. This eliminates the need for comparing the two power readings manually by noting and subtracting the reference measurement result from the final measurement result.

The optical detector incorporated in the power meter shall have an active area diameter suitable for the fiber type measured. The active area must be large enough to capture all light emitted from the fiber.

For general information use refer to SAE ARP5061 for specifications on optical power measurement stability of Optical Power Meters.

3.2.2 Stabilized Light Source (SLS)

The stabilized light source (SLS) is an instrument used together with the OPM to measure attenuation or optical loss of a harness or link. For multimode applications, the SLS shall be capable of providing 850 nm and/or 1300 nm wavelength(s) at power level of no less than -17 dBm (850 nm)/-13 dBm (1300 nm). For single-mode applications the SLS shall be capable of providing 1310 nm and/or 1550 nm wavelength(s) at a power level of no less than -10 dBm.

For general information, refer to SAE ARP5061 for specifications on spectral characteristics, center wavelength accuracy, and power stability required for an SLS.

3.2.3 Aerospace Measurement Quality Jumper (AMQJ)

AMQJs are jumper cables that are required to interconnect the cables under test to the OPM and SLS described in 3.2.1 and 3.2.2. See Section 3.4 for detailed description of AMQJs and their use.

3.3 Launch Condition Requirements

The detailed requirements for light launch conditions are defined at the measurement location, typically the end of the Aerospace Measurement Quality Jumper (AMQJ), see section 3.4. The rationale for defining launch condition requirements at the end of the AMQJ rather than at the output of the light source is that there may be other launch condition-altering fiber optic components used between the light source and the end of the AMQJ. These components may include, but are not limited to fiber optic branching components and fiber optic switches. Fiber optic components may alter the light energy distribution in the fiber (launch condition). The launch condition requirements for optical measurements shall be defined in the detailed specification. Definition may be provided by either prescribing test equipment and fiber sizes for AMQJs or format of a light launch condition such as Near Field / Far Field, CPR (Coupled Power Ratio) or encircled flux specification. Accepted launch conditions for 62.5 micron and 100 micron core size aerospace fiber optic cables are detailed in ARP5061 as AS62 and AS100 launch conditions. Specific commercial standards for multimode light launch conditions and 50 micron aerospace launch conditions are in process to be published. The following documents provide guidance: IEC 61280-4-1, TIA/EIA-TSB-178, TIA/EIA-455-203, and TIA/EIA-526-14.

3.3.1 Launch Condition Methods

The launch condition requirements for optical measurements shall be defined in the detailed specification. Definition may be provided by prescribing test equipment and fiber sizes for AMQJs or by prescribing format of a light launch condition as Near Field / Far Field or encircled flux specification. The Near Field / Far Field method is the preferred method for aerospace applications.

3.3.1.1 Conventional Insertion Loss Method

Once launch conditions are defined TIA 455-34 and ARINC 805 test methods shall be followed to determine cable assembly and connector insertion loss.

3.4 AMQJ

AMQJs are aerospace measurement quality jumpers, generally of higher quality than the production cable assemblies they are being used to test. AMQJs jumper cables that are required to interconnect the measurement instruments and the cables under test. AMQJs shall be used when making optical measurements. Acceptance and recertification criteria for AMQJs shall be specified in program / detailed specification. AMQJs that have degraded or do not meet acceptance criteria may cause non-compliant product to appear as compliant and/or cause compliant product to appear as non-compliant. Refer to TIA/EIA 455-171 appendix A for the definition of the requirements of the AMQJ.

3.4.1 AMQJ Maintenance and Verification

AMQJs shall be inspected periodically.

- a. Inspection and recertification criteria shall be defined in the detailed specification or by the manufacturer.
- b. Inspection and recertification cycle shall be defined by program specifications or by the manufacturer.
- c. Unless otherwise specified in the program / detailed specification the recertification shall be performed every 3 months after initial use of the AMQJ or after 50 mating cycles (whichever comes first). Visual inspection shall be performed before every mating cycle.
- d. Each AMQJ shall be provided with a means of traceability (Serial number/date code and certification).

Unless otherwise specified in the program / detailed specification or by the manufacturer the following shall serve as a re-certification procedure for AMQJs. Requirements for measuring insertion loss (IL) and return loss (RL) of AMQJs are as follows when tested in accordance with the applicable test Setup.

1. When mated to another AMQJ, the IL of the AMQJ under test shall not exceed 0.75 dB for ten successive mating cycles along with a standard deviation not exceeding ± 0.10 dB.
2. When mated to another AMQJ, the RL of the AMQJ under test shall be the minimum acceptable RL specification with a tolerance of $-0/+5$ dB. Ten successive matings between the reference-AMQJ and the AMQJ-under-test shall not exhibit a standard deviation exceeding 1.00 dB.
3. Perform visual inspection per Table 2, Grade A.

3.4.2 AMQJ Guided Probes

In the testing and troubleshooting of fiber optic cable assemblies and harnesses, a Fiber Optic Probe (FOP) can be used as an AMQJ. Requirements for AMQJs shall apply to AMQJ probes. The AMQJ probe uses a modified terminus together with a precision mating adapter. This design emulates an actual interconnection. Typically, a quick release mechanism (which can be manipulated by hand, without special tools) on the terminus end emulates the terminus/shell insert/release mechanism. The use of the adapter (a modified plug or receptacle) ensures that the terminus mates in a manner like the “real” connector. As with any un-keyed termination, rotation of the ferrule is not allowed.

An AMQJ probe is shown in Figure 4. The probe uses a standard, low-loss commercial telecom connector (FC, LC, SC or ST) on the “instrumentation end” where connected to the test equipment.

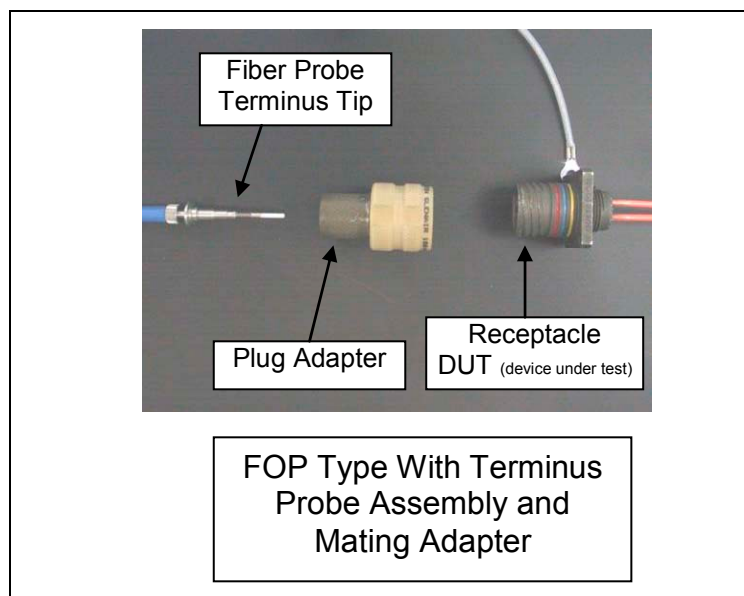


FIGURE 4 - EXAMPLE OF FIBER OPTIC AMQJ PROBE

3.4.3 Non-AMQJ Standalone Probes

In the testing and troubleshooting of fiber optic cable assemblies and harnesses, a Fiber Optic Probe (FOP) can be used as a non-AMQJ test cable. The non-AMQJ probe uses a modified terminus to mate to the terminus under test.

The non-AMQJ fiber optic probe can be used in lieu of an AMQJ or AMQJ probe when the correct configuration is not available subject to program procedures. However, since non-AMQJ fiber optic probes are generally designed for “one channel at a time” measurements, keep in mind that there is significantly more manipulation due to manually moving from one channel to another of a multi-pin connector when using this method rather than using a multi-channel AMQJ or an AMQJ probe. The non-AMQJ probe lacks the actual connector retention and alignment found in an AMQJ.

Figure 5 shows a non-AMQJ probe. The “instrumentation end” of the non-AMQJ probe uses a standard, low-loss commercial telecom connector (FC, LC, SC or ST) where connected to the test equipment.

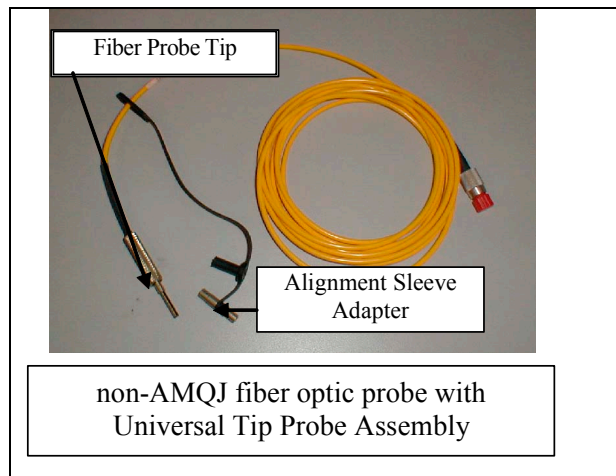


FIGURE 5 - EXAMPLE OF FIBER OPTIC NON-AMQJ PROBE

A non-AMQJ probe uses a “universal” terminus or tip design. The “working end” of this probe is a compatible ferrule (for use with physical contact connectors) or interface (for use with expanded beam connectors) which is intermatable with the socket interface of the interconnect in use.

To use a non-AMQJ probe with a socket interface, simply insert the “tip” into the socket cavity of the device under test and take measurement while maintaining mating pressure. Then move to the next position and take the next reading. For mating to a pin interface, insert the alignment sleeve onto the mating pin and insert the “tip” into the sleeve while maintaining mating pressure.

A non-AMQJ probe is used when “quick and rough” measurements are required to verify performance or isolate a problem and FOP Type B or AMQJ is not available. However, since FOPs are generally designed for “one channel at a time” measurements, keep in mind that there is significantly more manipulation due to manually moving from one channel to another of a multi-pin connector when using this method rather than using a multi-channel AMQJ.

WARNING A fiber optic non-AMQJ probe may be used as a substitute for a real “connection”, i.e. using proper AMQJ's. In general, fiber optic non-AMQJ probe may not fully emulate a mating connection and may provide erroneous and/or non-repeatable measurement results. Since the user also has direct control of the “tip” or terminus contact, care must be taken not to damage the mating interface by improper alignment or excess force. Incorrect insertion of the terminus tip can damage and even break socket-contact alignment sleeves.

3.5 Measurements

This section provides an overview of common acceptance procedures applicable to both supplier and customer of fiber optic cable assemblies. Connectors have to be clean prior to mating. Refer to the applicable sections for specifications on visual endface inspection and acceptable endface quality as appropriate. Verify that light sources and optical power meters used for measurements meet the requirements per sections 3.2.1 and 3.2.2.

Insertion Loss (IL) testing verifies that cable assemblies meet optical loss performance requirements.

The first group describes tests for measuring connector loss (cable assembly insertion loss). Measurements of individual connector losses are often necessary when cable assemblies fail the link loss test. Connector loss measurements are used to determine which of the two connector ends causes the failure. Table 3 categorizes Cable Under Test configurations for Connector Insertion Loss.

The following steps shall be followed to determine the proper test procedure:

Step 1: Determine whether the objective of the loss test is to measure the connector loss (one connector end only) or the link loss (the entire cable assembly – both connector ends). Refer to 3.5.1.1 for measurements of connector loss. Refer to 3.5.2 for measurements of link loss.

Step 2: Determine the applicable configuration number for the Cable Under Test.

Step 3: Determine whether the connector is “probe-able” or not. Probe-able connectors are multi-fiber connectors that allow individual measurements to be conducted on individual termini by use of fiber optic probes (FOP). Fiber optic probes are described in sections 3.4.2 and 3.4.3.

TABLE 3 - CABLE INSERTION LOSS ASSEMBLY CONFIGURATIONS

Configur ation	Description	Connector Insertion Loss	Cable Under Test Direction of Test →
1	Simplex assemblies with like connectors that can be mated to each other via a coupling. Connectors can be mated directly to an OPM or OLS.	Figure 6	A  A
2	Simplex assemblies with unlike connectors that can not be mated to each. Connectors can be mated directly to an OPM or OLS.	Figure 7	A  B
3	Multi-channel assemblies with unlike connectors that can't be mated to each other. Only one side of the assembly can be mated directly to an OPM or OLS.	Figures 8, 9	A  R
4	Multi-channel assemblies with unlike connectors that can't be mated to each other. Only one side of the assembly can be mated directly to an OPM or OLS.	Figures 10	A  P
5	Multi-channel assemblies with unlike connectors on each side that can be mated together i.e. plug on one end and rcpt on other end. Connectors can't be mated directly to an OPM or OLS.	Figures 11,12	R  P
6	Multi-channel assemblies with like connectors on each side that can't be mated together i.e. plug on one end and plug on other end. Connectors can't be mated directly to an OPM or OLS.	Figures 13	P  P

The second group of tests is designed for measuring link loss (segment loss) also called cable assembly attenuation with the particular section of the cable under test shaded in gray. Each group of tests addresses various Cable Under Test configurations. Table 4 categorizes Cable Under Test for Cable Assembly Link Loss as they appear in practical applications.

TABLE 4 - CABLE LINK LOSS ASSEMBLY CONFIGURATIONS

Configuration	Description	Connector Link Loss	Cable Under Test Direction of Test →
1	Simplex assemblies with like connectors that can be mated to each other via a coupling. Connectors can be mated directly to an OPM or OLS.	Figure 14	A  A
2	Simplex assemblies with unlike connectors that can not be mated to each other. Connectors can be mated directly to an OPM or OLS.	Figure 15	A  B
3	Multi-channel assemblies with unlike connectors that can't be mated to each other. Only one side of the assembly can be mated directly to an OPM or OLS.	Figures 16	A  R
4	Multi-channel assemblies with unlike connectors that can't be mated to each other. Only one side of the assembly can be mated directly to an OPM or OLS.	Figures 17	A  P
5	Multi-channel assemblies with unlike connectors on each side that can be mated together i.e. plug on one end and rcpt on other end. Connectors can't be mated directly to an OPM or OLS.	Figures 18	R  P
6	Multi-channel assemblies with like connectors on each side that can't be mated together i.e. plug on one end and plug on other end. Connectors can't be mated directly to an OPM or OLS.	Figures 19	P  P

Examples:

- Configuration 2 can be a SC, FC or any other simplex connector placed on side B of the cable assembly.
- Configurations 3 & 4 can be a MIL-DTL-38999 connector on one side of the cable assembly, and a Multi-fiber Termination Push-on (MTP) connector on the other side.
- Configuration 3 & 4 can be a fanout assembly with FC connectors on side A and a multi-channel MIL-DTL-38999 connector on side P or side R.

The recommended measurement methodologies for configurations 1 through 6 are published in TIA-455 Fiber Optic Test Procedures (FOTP's) and in TIA-526 Optical Fiber System Test Procedures (OFSTP's). See Table 5.

NOTE: For the reference setup for Figures 8-13 a modified reference is required in order to maintain the reference.

NOTE: For Figures 8-13 the Test Probe Cable and Test Probe Adapter may also be used for insertion loss testing. Refer to Figures 9 and 12.

TABLE 5 - INDUSTRY METHOD CROSS REFERENCE

Configuration	TIA/EIA test procedure document and method			
	Connector Insertion Loss (IL)		Cable Attenuation/Link Loss	
	SM	MM	SM	MM
1 through 6	FOTP-171 Method D3	FOTP-171 Method D1, D2	OFSTP-7 Method A1	OFSTP-14 Method B

Cable harnesses for aerospace applications can represent a wide variety of connector and breakout configurations. The AMQJ must interface with the test equipment as well as the Cable Under Test. These AMQJ's can be very simple for single-way to single-way configurations or more complex in configuration for multi-channel breakouts.

Three test set-up examples are provided to clearly illustrate the various test configurations:

- a. For single-way assemblies
- b. For breakout assemblies (multi-channel connectors breaking out to multiple single-way connectors)
- c. For multi-channel connector to multi-channel connector configurations.

3.5.1 Test Method

The sections 3.5.1.1 and 3.5.2 describe two fundamentally different test objectives. Section 3.5.1.1 addresses connector loss measurements that intend to determine loss contribution of only one side of a cable assembly (the side connected to the AMQJ). Section 3.5.2 describes measurement method to determine the attenuation of the entire cable assembly (link loss) including contributions from both ends of the assembly.

3.5.1.1 Connector Insertion Loss Measurements (Connector Loss)

This section provides for a common acceptance procedure applicable to both supplier and customer of fiber optic cable assemblies. Note: Connectors have to be clean when mated. Refer to the applicable sections for specifications on visual endface inspection, acceptable endface quality as appropriate.

Unlike the cable assembly attenuation measurement, this measurement method is intended to isolate the loss of one end of the cable assembly under test. The preferred terminology is Connector Insertion Loss (IL), otherwise cable assembly attenuation is the total link loss (both ends and the fiber in-between) of a cable harness. The measurement methodology described in this section is based on TIA-455-171 Method D. The Pass Acceptance figure is simply the maximum IL (in dB) for the near-end connector under test (that is, the connector end closest to the SLS).

The test set-up requires both a stabilized light source (SLS) as well as an optical power meter (OPM). The source can be a standalone SLS unit or built into a combinational Optical Loss Test Set. The optical power meter can also be a standalone OPM unit (as described above) or built into a combinational Optical Loss Test Set. Be aware some power meters have a physical contact interface. When invoking the use of these instruments the technician should confirm fiber type and size are compatible with the cable under test.

The following three subsections provide illustrated examples for measuring IL of a single-way connector end, multi-channel breakout, and a multi-channel connector.

The key difference between these tests and the cable assembly attenuation measurements is that the far-end AMQJ (connection to the OPM) needs to be fabricated from a larger core, higher NA multimode cable than the fiber used in the cable under test. This special cable will be called a Large Core AMQJ, or LC- AMQJ. Another common name for this cable is a Bucket Cable (the larger core fiber being a big bucket that collects all the emitted light without loss). Care should be taken to see that the LC-AMQJ is compatible with the power meter being used, that the entire output of the LC-AMQJ will enter the active detection area of the power meter.

When using Fiber Optic Probes in troubleshooting or measuring loss in the aircraft's optical links, the Fiber Optic Probes should be manufactured and maintained using the same specifications and strict requirements as outlined for AMQJs.

It shall be noted here that the following procedures for measuring connector loss include the loss of the cable (fiber) itself. For short cable assemblies this loss is negligible. Singlemode fiber for example has a typical loss of 0.3 dB per kilometer at 1310 nm. Therefore, for a typical aircraft link length of 10 meter to 50 meter length this results in 0.003 dB to 0.015 dB respectively. The loss of multimode fiber at 850 nm can be up to 3.00 dB per kilometer. Here link lengths of 10 meter to 50 meter length can exhibit 0.03 dB to 0.15 dB of loss respectively. These fiber losses should be estimated before selecting a measurement procedure and their contribution to the measurement result should be included.

3.5.1.2 IL for Single Channel Cable Assemblies (Configuration 1)

- Step 1 – Connect the optical test equipment and one AMQJ as shown in Figure 6. With source set to first wavelength, verify absolute output power of SLS. Then establish 0.00 dB reference level. The default is to connect the Launch-AMQJ directly to the OPM during the reference power measurement.
- Step 2 – Disconnect the AMQJ from the power meter. Insert the cable under test between the power meter and the launch-AMQJ with the appropriate coupling. The OPM will display the insertion loss of the cable assembly under test as a negative dB value.
- Step 3 – Unless using a dual wavelength, automated OLTS, repeat the measurement for additional wavelengths as required. When changing to a different wavelength, the light source and power meter will need to be re-referenced before performing test measurements.

NOTE: The test set up is for testing insertion loss (component loss) for one end of the cable assembly under test. This test does not test the insertion loss for the connector attached to the end of the OPM

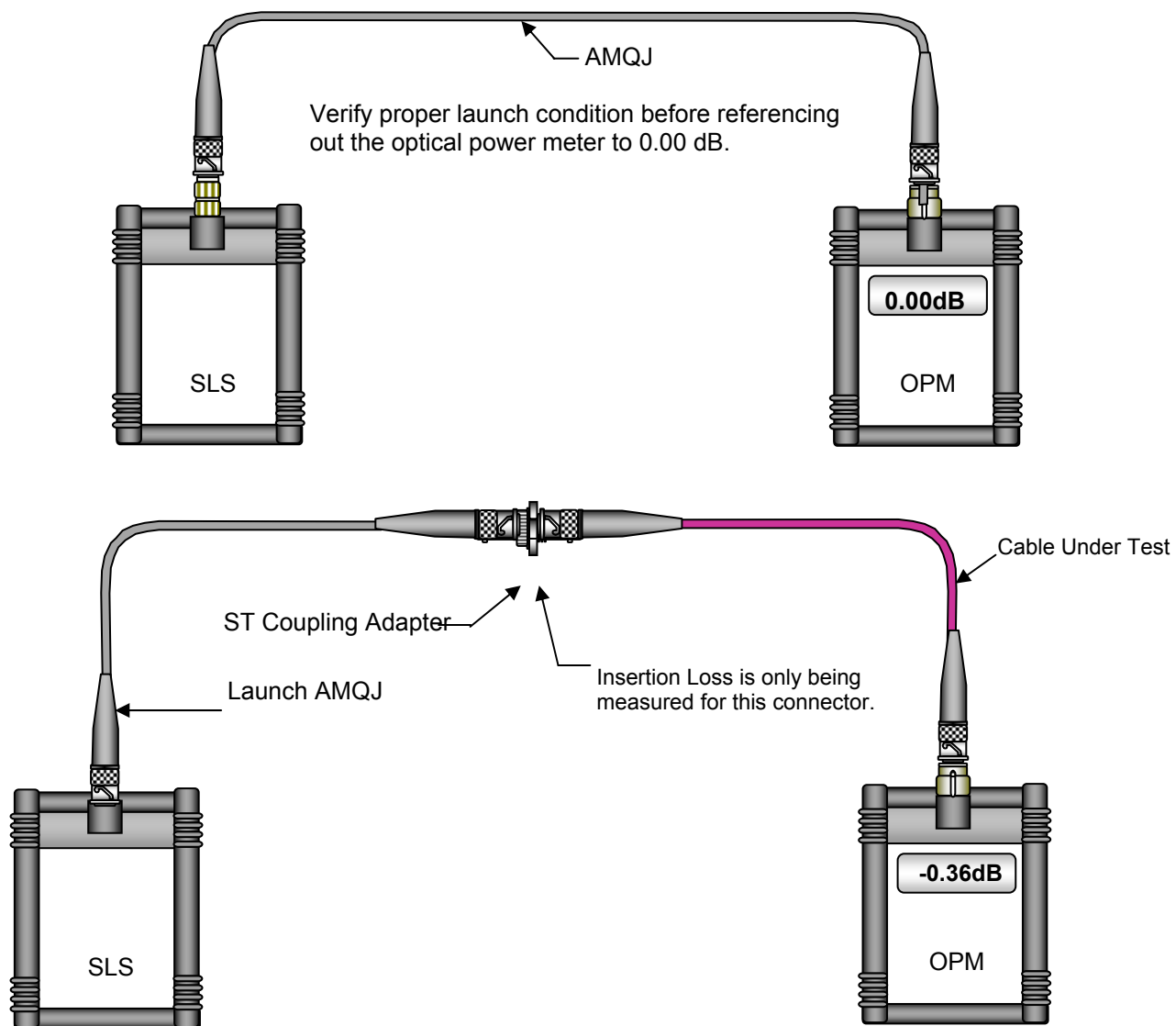


FIGURE 6 - CONFIGURATION 1 SETUP CONNECTOR IL OF SINGLE WAY CABLE ASSEMBLIES

NOTE: Adapter located on the OPM can be exchanged to correlate to the correct connector style if cable under test is configuration 2.

When no AMQJ exists an alternative method utilizes a jumper called a Golden Cable (a manufacturing unique high-grade, low loss cable assembly) to establish a baseline or reference power level. This method is not standardized per TIA/EIA Fiber Optic Test Procedures. It provides a practical approach of verifying the loss degradation of a cable assembly versus its original, beginning of life, performance. This method is not recommended as a "beginning of life" method verifying the optical performance of a cable assembly at its manufacturing location.

3.5.1.3 IL for Single Channel Cable Assemblies (Configuration 2)

Step 1 – Connect the optical test equipment and one AMQJ as shown in Figure 7. With source set to first wavelength, verify absolute output power of SLS. Then establish 0.00 dB reference level. The default is to connect the Launch-AMQJ directly to the OPM during the reference power measurement.

- Step 2 – Disconnect the AMQJ from the power meter. Insert the cable under test between the power meter and the launch-AMQJ with the appropriate coupling. The OPM will display the insertion loss of the cable assembly under test as a negative dB value.
- Step 3 – Unless using a dual wavelength, automated OLTS, repeat the measurement for additional wavelengths as required. When changing to a different wavelength, the light source and power meter will need to be re-referenced before performing test measurements.

NOTE: The test set up is for testing insertion loss (component loss) for one end of the cable assembly under test. This test does not test the insertion loss for the connector attached to the end of the OPM

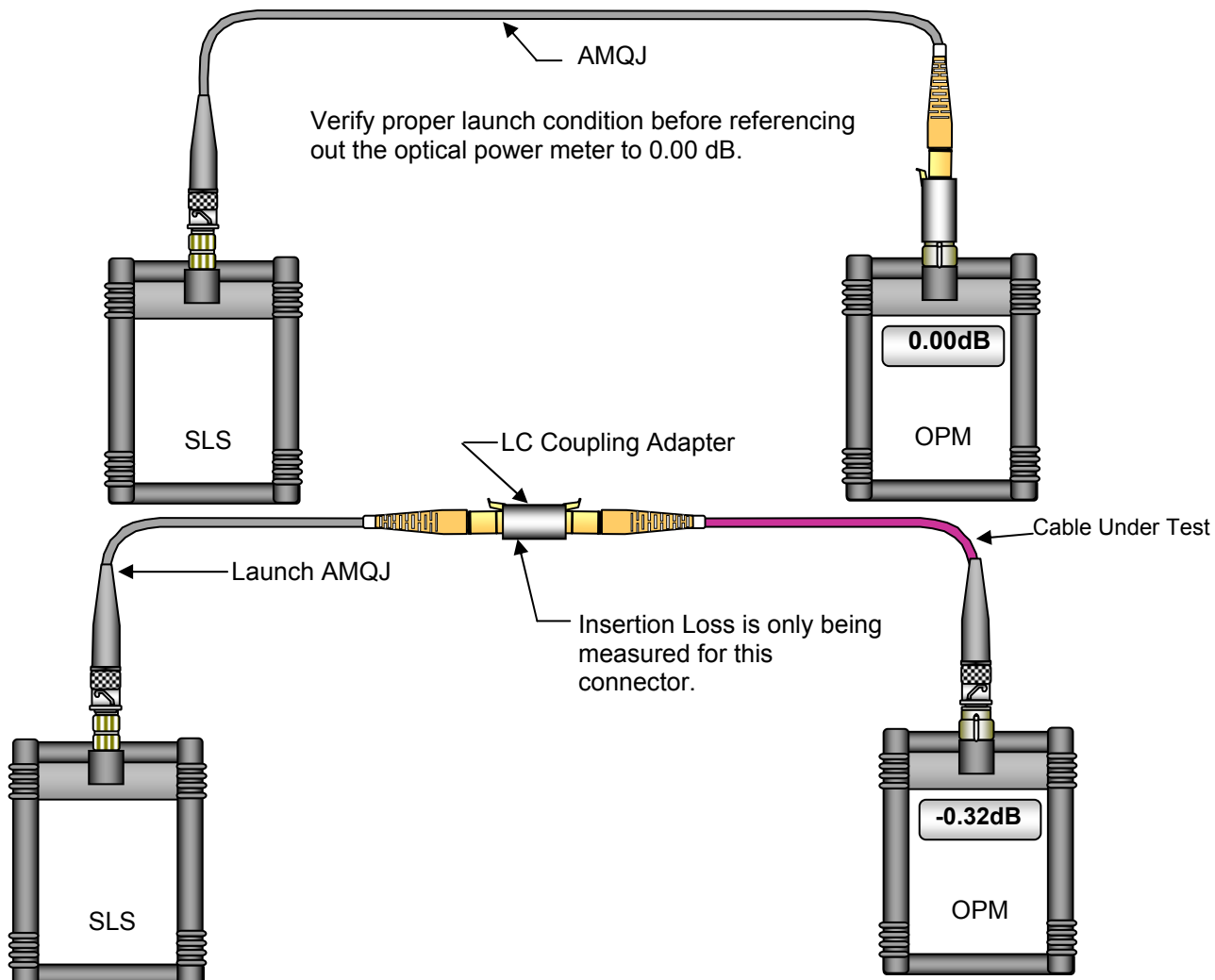


FIGURE 7 - CONFIGURATION 2 SETUP CONNECTOR IL OF SINGLE WAY CABLE ASSEMBLIES

3.5.1.4 IL for Multi-Channel Breakout Assemblies

The setup varies depending on which connector end of the breakout assembly is being measured for insertion loss (IL). This section includes three different methods that demonstrate the use of AMQJ's and Test Probe Cables.

3.5.1.4.1 Multi-Channel Connector End (Configuration 3)

- Step 1 – Connect the optical test equipment and two AMQJs as shown in Figure 8. With source set to first wavelength, verify absolute output power of SLS. Then establish 0.00 dB reference level.