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AEROSPACE RECOMMENDED PRACTICE

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Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-Connect Systems

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1. SCOPE:

1.1 Scope:

This ARP document will provide guidelines for optical performance testing of short haul fiber optic inter-connection systems used in aerospace vehicles. The focus of this document is to establish common pre and post installation test methods and troubleshooting methodologies.

1.2 Applicability:

This document establishes guidelines applicable to test fiber media which includes fiber optic cables, connectors (simplex, multi pin, ribbon), couplers, splices, optical switches and many other passive and active elements affecting optical power distribution through inter-connect hardware. Where there is conflict between this document and the air vehicle specification or contract, the air vehicle specification or contract shall take precedence. Where design is such that the methods herein cannot be implemented, users will submit relevant information or modifications to existing methods to the specified sponsor of this document for review.

2. APPLICABLE DOCUMENTS:

2.1 Government Documents:

2.2 Specifications and Standards:

The following specifications and standards form part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

2.2.1 Specifications:

MIL-PRF-29504, Termini
MIL-PRF-85045, Cable

2.2.2 Standards: Not Applicable

2.3 Other Government Documents:

The following other Government documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issue of those cited in the solicitation.

Not Applicable

2.4 Non-Government Documents:

TIA/EIA-455, Fiber Optic Test Procedures
AIR 5271, Components
ANSI Z136.2, American National Standard for the Safe Use of Lasers

2.5 Order of Precedence:

In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exception has been obtained.

3. DEFINITIONS:

3.1 General Fiber Optic Terms:

ABSORPTION: Loss of light in a fiber caused by intrinsic impurities, resulting from conversion of optical power into heat energy.

ACCEPTANCE CONE: The cone containing incident rays that couple into bound modes of the fiber. The half angle is equal to the acceptance angle.

ADD-DROP MULTIPLEXER (ADM): A component used to multiplex lower-speed electrical and/or optical signals into a high-speed optical channel. Supports time division multiplexing (TDM) or dense wavelength-division multiplexing (DWDM).

AMPLIFIED SPONTANEOUS EMISSION (ASE): The light emitted from the decay of the upper level of a lasing transition without stimulated emission. (Broad spectral emission and unpolarized.)

AMPLITUDE MODULATION (AM): Transmission technique where the information is encoded in the amplitude of the carrier.

ASYNCHRONOUS TRANSFER MODE (ATM): A high-speed transmission scheme providing bandwidth on demand for multimedia (data, voice, video).

ATTENUATION: The diminution of average optical power. Attenuation results from absorption, scattering, and other radiation losses. Attenuation in general is expressed in dB without a negative sign.

ATTENUATOR: An optical device that reduces the intensity of a light beam passing through it.

AVALANCHE PHOTODIODE (APD): A photodiode that produces current through internal amplification. (Avalanche multiplication)

BACK REFLECTION – OTDR: Back reflection is the return of part of the energy in the launched pulse to the OTDR by an event along the fiber. Also known as Fresnel reflection.

3.1 (Continued):

BACKSCATTERING – OTDR: Back scattering is the portion of returned energy that returns in a generally opposite direction to that of the launched pulse to the OTDR by microscopic imperfections along the fiber. Also known as Rayleigh backscattering. For example, the back-scattered signal from a 1-inch length of 100/140 micron multimode fiber at 850 nm wavelength is approximately -60 dB.

BANDWIDTH: Measure of information carrying capacity; the greater the bandwidth, the greater the information carrying capacity.

BEND LOSS: The result of macrobends (curvature of fiber) or microbends (small distortions in the fiber) producing increased attenuation by coupling light energy from the fiber core to the cladding.

BIREFRINGENCE: The property whereby the effective propagation speed of a light wave in a medium depends upon the orientation of the electric field (state of polarization) of the light.

BIT-ERROR-RATE(BER): The number of digital highs on a transmission link that are interpreted as lows, and vice versa, divided by the total number of bits received. (BER should be better than $1x10^{-9}$ in properly operating systems.)

BOUND MODES: In a multimode fiber, the power in bound modes is predominately contained in the core of the fiber.

BUFFER COATING: Protective material that covers and protects a fiber. (No optical function.)

CALIBRATED LAUNCH CABLE – OTDR: Is a serial numbered special jumper, serving to interconnect the OTDR with the aircraft harness connector for testing the harness. The launch terminus may be a pin or socket. The integrity and cleanliness of the launch terminus is checked by the OTDR on both Fresnel and Rayleigh operating modes according to the serial number, prior to launch terminus insertion.

CENTRAL WAVELENGTH: Wavelength of a source's peak power.

CHIRP: A change in the characteristic optical frequency of a device as a function of time (modulated diode laser) or position (chirped fiber Bragg grating).

CHROMATIC DISPERSION: A phenomenon caused by the wavelength dependence of group velocity in an optical fiber. Since any practical light source has a certain spectral width, chromatic dispersion results in pulse broadening. The coefficient describing chromatic dispersion per unit length is generally given in units of ps/(nm_km).

CLADDING: That dielectric material of low refractive index surrounding an optical fiber core that has a lower refractive index than that of the fiber core.

CLADDING BOUNDARY: Consisting of the inner and outer limits of the layer directly surrounding the core.

3.1 (Continued):

CLADDING LIGHT: Light propagating in the cladding.

CLADDING MODES: A mode in which the electromagnetic field is confined in the cladding and the core by virtue of these being a lower refractive index medium surrounding the outermost cladding.

COHERENCE: A phenomenon whereby the phases of the photons (or constituent wave trains) of a light beam maintain a definite relationship with each other. A narrow line-width laser is said to exhibit a high degree of coherence.

CONNECTOR: Hardware installed on cable ends to connect cables to a device or another cable.

CONTINUOUS WAVE(CW): Constant output from an optical source that is active but not modulated by a signal (DC).

CORE: The central region of an optical fiber with higher refractive index than that of the cladding, within which most of the optical power is to be transmitted.

CORE CENTER: For a cross section of an optical fiber, it is the center of that circle which best fits the outer most limit of the core area.

CORE DIAMETER: The diameter of the circle defining the core center.

CUTOFF WAVELENGTH: The shortest wavelength for which an optical fiber can only support the propagation of a single transverse mode.

dB: Decibel. Standard logarithmic unit for the ratio of two quantities. In fiber optics, the ratio is optical power and represents loss or gain.

DEADZONE – OTDR: The distance from an event, such as a connector, over which the OTDR signal is saturated and the OTDR is not able to make measurements.

DISTANCE ACCURACY – OTDR: The difference between the true distance in a fiber and the OTDR measurements value, using the true value of the effective group index of the fiber.

EFFECTIVE GROUP INDEX – OTDR: The effective group index of a fiber is the ratio of the pulse propagation speed in vacuum and in the fiber. The value for glass fiber is approximately 1.5.

EQUILIBRIUM MODE DISTRIBUTION: The condition in a multimode optical fiber in which relative power distribution among the bound modes is independent of length.

EVENT – OTDR: An abrupt discontinuity or index change in the fiber, such as a connector, a mechanical splice, a star coupler, a break, etc. A cleaved fiber end or a flat polished open connector back reflects approximately 4% (or -14dB) of the incident pulse energy. A break in a 100/140-micron multimode fiber back reflects from -30 to -14dB.

3.1 (Continued):

FAR FIELD REGION: The region at some distance from a source or aperture where the radiation pattern is independent of the distance. The far field is generally characterized by an angular distribution of light intensity.

FIBER OPTIC CABLE: Any installed jacketed optical fiber.

FIBER OPTIC SYSTEM: The assembly of all the interconnected fiber optic subsystems, including sources, detectors, cables, couplers and connectors.

FRESNEL MODE – OTDR: A low sensitivity operating mode of the OTDR for the detection of gap type connectors, reflective mechanical splices, reflective couplers and switches, fiber breaks and cracks, and for the measurements of length, distance, back reflection and return loss. The approximate sensitivity range for the Fresnel operating mode is -10 to -40 dB (relative to a -14 dB cleaved end). Also, refer to 'OTDR Trace - Fresnel'.

GAP TYPE CONNECTOR: The mated pair has an air gap between the glass end faces. The gap may range from less than one, to several microns. The gap can result from polishing connectors to a predetermined length as in SMA style connectors, or from having a concave polish or under cut profile on one or both endfaces of the mating fiber in multi-contact terminus style connectors. Gap type connectors are classified as "loud" reflective connectors - OTDR.

GRADED INDEXED FIBER: An optical fiber having an index profile in which the refractive index varies continuously as a function of radial distance from the longitudinal axis of the fiber.

INSERTION LOSS: The logarithm of the fraction of received power/transmitted power through a component in the link multiplied by 10. The insertion loss of a mated pair of connectors transmitting 90% of the incident energy is 0.46 dB. A coupling transmitting 50% energy has an insertion loss of 3.0 dB.

LAUNCH CONDITIONS – OTDR: Accurate and repeatable loss measurements in short haul, large core fiber, with concatenated connectors, require a special beam profile of the OTDR probe pulse.

LARGE CORE FIBER: Large core fiber is considered fiber with a nominal core diameter greater than 62.5 microns.

LOUD: A component, such as a connector, is referred to be "loud", if its return loss is less than approximately 30 dB.

LOSS ACCURACY – OTDR: The difference between the true insertion or return loss of a single isolated event and the OTDR measurements value, using the true value of a reference reflector.

MAP AND TEST OPERATION – OTDR: Is a operating mode that enables the maintainer to auto-test each fiber optic link in the air vehicle against a previously created map of the same, and identify changes or faults in the link.

3.1 (Continued):

MAXIMUM THEORETICAL NUMERICAL APERTURE: A theoretical value of numerical aperture calculated using the values of refractive index of the core and cladding is given by:

$$NA_{max} = SQRT(n_1^2 - n_2^2) \quad \text{(Eq. 1)}$$

where:

n_1 = maximum refractive index of the core
n_2 = refractive index of the innermost homogeneous cladding

MODE: A mode of an axially uniform waveguide describes an optical field distribution whose amplitude in a plane normal to the fiber axis does not vary with axial distance along the waveguide, other than for the effects of a uniform attenuation.

MULTI-MODE FIBER: An optical fiber, which can support one or more bound modes in addition to the fundamental mode.

NEAR FIELD REGION: The region close to the source, or aperture where the radiation pattern is dependent on the distance from the source, along the source axis. The near field is generally characterized by a spatial distribution of light intensity.

NUMERICAL APERTURE: The sine of the vertex angle of the largest cone of meridianal rays that can enter or leave an optical fiber system or element, multiplied by the refractive index of the medium in which the vertex of the cone is located.

OTDR: Optical Time Domain Reflectometer. Also referred to as an Optical Fiber Monitor (OFM). Utilizes pulses of light injected into the fiber and analyzes the reflected return light to determine the distance down a fiber a reflection (connector, break, etc.) was encountered.

OTDR TRACE - FRESNEL: In the Fresnel mode of operation, the trace consists of a flat baseline at the zero intensity level, and individual pulses extending from the baseline, representing loud events. This trace may be stylized by replacing the pulses with artificial symbols, such as sticks, for easier interpretation.

OTDR TRACE - RALEIGH: In the Fresnel mode of operation, the trace consists of a staircase shaped elevated baseline, and individual pulses extending from the baseline, usually at the edge of each step, representing quiet events. The insertion loss of an event is proportional to the vertical distance of the steps on either side of the event. The trace may be stylized for easier interpretation.

OPTICAL FIBER: A cylindrical optical waveguide made from dielectric material.

OPTICAL INSPECTION MICROSCOPE – OIM: Passive optical magnification of the polished end of connector ferrule for viewing of contamination or damage.

OPTICAL POWER: The rate of flow of radiant energy with time.

3.1 (Continued):

OPTICAL POWER METER – OPM: Measures optical power emanated from an optical fiber.

OVERFILLED CONDITION: An overfilled condition excites all the bound modes of a fiber, including cladding modes.

PC TYPE CONNECTORS: Physical Contact (PC) connectors, when mated, have their glass end faces in contact, without an air gap. This is achieved by convex polishing the glass in the terminus. PC connectors are classed as " quite ".

POWER BUDGET: The allocation of optical power and losses required by a system designer to meet the bit error rate under operating conditions in a fiber optic network. In more practical terms, the power budget is an expression of the optical power losses, combining elements of opto-electronic component performance and network topology, which allows assessment as seen by the receiver(s). (See Appendix)

QUIET: A component, such as a connector, is referred to be quiet, if its return loss is greater than approximately 35 dB.

RALEIGH MODE - OTDR: A high sensitivity operating mode of the OTDR for the detection of PC type connectors, quiet mechanical splices, quiet switches, splitters, stars, microbends, macrobends, quiet cracks and the fiber itself. The Rayleigh mode is also used to measure segmental or total link insertion losses. The approximate sensitivity range for the Rayleigh operating mode is -40 to -90 dB (relative to a -14 dB cleaved end). Also, refer to 'OTDR Trace - Rayleigh'.

REAL TIME – OTDR: In real time operation the OTDR screen refresh rate is at least 30 Hz to enable troubleshooting intermittent faults.

RECEIVER: An opto-electronic device that converts optical power into electrical power.

RECEIVER SENSITIVITY: The minimum level of optical power required at the receiver to achieve the maximum allowable bit error during digital transmission.

REFRACTIVE INDEX (n): At a point in a medium and in a given plane, the ratio of the velocity of light in a vacuum to the phase velocity of a sinusoidal plane wave propagating in that given plane.

REFRACTIVE INDEX PROFILE: The distribution of the refractive index along a diameter of a cross-section of an optical fiber.

RETURN LOSS – OTDR: The positive 10log of the fraction of reflected power of the OTDR pulse from a component in the link. The return loss of an open flat polished connector is approximately 14 dB, a pair of mated gap type connectors is 11 dB, and a pair of quiet PC type connectors is 40 dB.

RESOLUTION, ONE POINT - OTDR: One point resolution is the smallest distance change the OTDR can measure at a single isolated event.

3.1 (Continued):

RESOLUTION, TWO POINT - OTDR: Two-point resolution is the smallest distance between two adjacent events of equal back reflection the OTDR can measure.

SHORT HAUL - AEROSPACE: A description specified to systems, in which the propagation distance between source and detector depicts typical aircraft dimensions, i.e.: less than 150 meters.

SHORT HAUL - OTDR: An electro-optical instrument that launches optical pulses into the fiber under test, and measures the time delay and intensity of these pulses back reflected from an event, or back scattered from the fiber. The time delay is converted to distance by the effective group index of the fiber, and the intensity is displayed on the OTDR screen as a function of distance. This display is the OTDR trace of the fiber.

STABILIZED LIGHT SOURCE – SLS: Injects a steady and known amount of optical power into the fiber under test.

STEP INDEX FIBER: A refractive index profile characterized by a constant refractive index within the core and a sharp decrease, step function, in the refractive index at the core-cladding interface.

USABLE POWER: Power output from a transmitter that is of use to a receiver.

VIDEO INSPECTION PROBE – VIP: Active method of viewing polished end of connector ferrule utilizing CCD technology to display the magnified image on a video display and/or laptop computer for capture.

VISUAL FAULT FINDER – VFF: Visible laser used to inject intense light into an optical fiber to check for continuity and to find fiber breaks.

VCSEL: Vertical Cavity Surface Emitting Laser

WAVELENGTH: The distance covered in a cyclic period by the wave front of a harmonic plan wave in a vacuum.

3.2 Fiber Optic Cable Plant Topology:

The topology of a network refers both to its physical (cable plant) and logical (software) arrangement. Some typical topologies are shown in Figure 1. (See also: ASSC.120.2.81 Chapter 2)

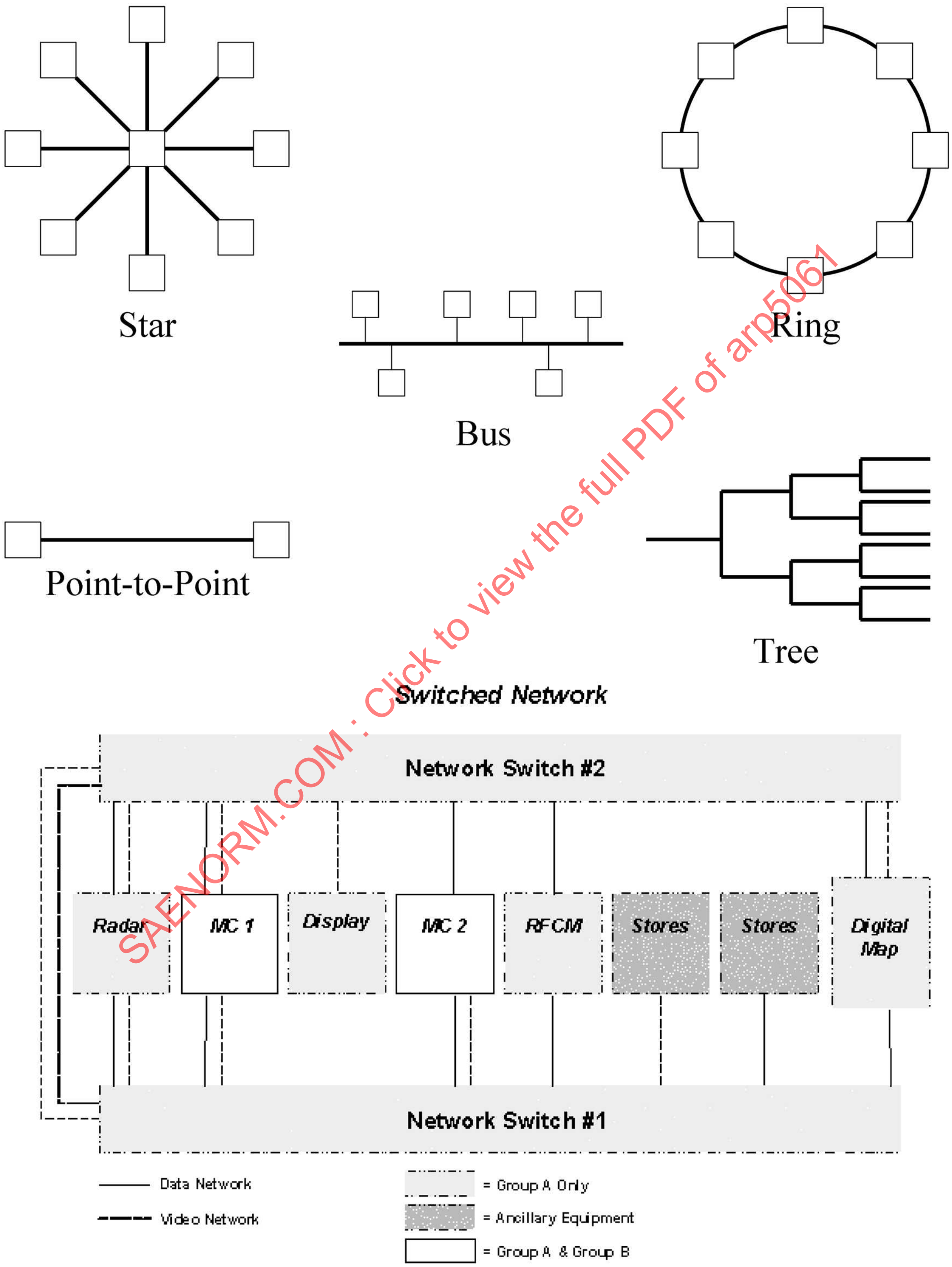

Star
Bus
Ring
Point-to-Point
Tree
Switched Network
Network Switch #2
Radar
MC 1
Display
MC 2
RFCM
Stores
Stores
Digital Map
Network Switch #1
Data Network
Video Network
= Group A Only
= Ancillary Equipment
= Group A & Group B

FIGURE 1

3.2.1 Point-To-Point Cable Plant: The point-to-point cable plant is the basic building block of each of the following cable plant topologies. Topologies that are more complex can be broken down into point-to-point segments for individual link loss measurements and troubleshooting. The point-to-point topology is simply a single fiber optic cable with a fiber optic connection on each end. Information is transmitted from one end of the cable and received at the other end of the cable. Point-to-point topologies can also be made up of a series of cables with intermediate connectors between the transmit point and the receive point. This series of cables and connectors is usually referred to as a concatenated cable.

3.2.2 Star Coupled Cable Plant: The unique attribute of a star coupled cable plant is the use of a Star coupler. A star coupler may be either transmissive or reflective and will have an equal number of input and output ports, creating an n-by-n star coupler with ports or fiber pigtails. A transmissive star coupler has n-inputs with n-outputs and the information at any of the inputs is equally divided among the outputs. A reflective star coupler has n-ports with the information at any one port available at all the other ports. Star networks also provide a level of increased reliability by providing a multiple of outputs with the same information at a single input into the star. Trouble shooting a star network with an OTDR may be more difficult than other cable plants due to the overlaying reflections from each output of the coupler. This difficulty can be overcome by having each pigtail of the coupler being of progressively longer lengths, thus shifting the returned reflections sufficiently that the OTDR can differentiate each port.

3.2.3 Ring Interconnected Cable Plant: A ring topology is a series of point-to-point connections between nodes in a network that are arranged in a closed loop. The ring topology can be trouble shot and tested in the same manner as a point-to-point cable plant.

3.2.4 Switch Coupled Cable Plant: The switches in a switched network route data from sources to destinations. To accomplish this, the switch examines the destination address in the frame header and then routes each frame to the proper destination. The switch controls the resources of the network by examining incoming frames in parallel. When contention for output resources occurs, the order in which frames depart the switch is based on their arrival time and priority/preference value. The switch also controls other network control functions such as providing the clock signal for the network. Here again, a switched network is a collection of point-to-point segments that can be easily trouble shot and tested between the switch and each node.

3.2.5 Bus Topologies: A bus topology utilizes a fiber as a central line with a series of three-port tee couplers from which each node is tapped. Each tee coupler typically has a large offset ratio where only a small percentage of the light is tapped off the bus to minimize losses through the network. If one of the couplers fails, the network is split into two networks where the nodes can still communicate within each section but not between the two sections.

3.2.6 Tree Topologies: Tree topologies can be most easily thought of as that of a typical cable television distribution system where there is a main ‘trunk’ line with ‘branches’ out to subdivisions, then to blocks, then to the home. A disadvantage of tree topologies is that if there is a break in one of the branches, all of the nodes down stream from the break are affected.

3.2.7 WDM Networks: WDM networks utilize the multiplexing of multiple wavelengths of light transmitted through a single fiber and then de-multiplexed at the receiving end of the network. A WDM coupler is used to combine the wavelengths from multiple transmitters and used to split the wavelengths back out to multiple receivers. This simplifies the cable plant to a point-to-point topology but creates more complex network components.

3.3 Fiber Optic Testing and Equipment:

This section is used to help define general understanding of the equipment requirements for procurement that are recommended for aerospace fiber optic test and measurement.

Short Haul Fiber Optic Links as they are installed in aerospace applications must be tested before, during and after installation and for on going maintenance purposes.

Built-In Test (BIT) on current systems is generally restricted to recognizing and reporting of a fault (interruption) within the fiber optic communications link. This go, no-go test does not reveal the nature of the fault and does not provide information where the fault is and how to correct it.

The repair and maintenance technicians utilize equipment listed in Table 1 to maintain and repair fiber optic systems.

TABLE 1 - General Purpose Fiber Optic Test Equipment

NOMENCLATURE	ACRONYM	FEATURE	APPLICATION
Visual Fault-Finder (Fiber Tracer)	VFF	Injects intense (laser) visible light into the optical fiber.	Check fiber continuity Find fiber breaks Verify fiber routing
Optical Power Meter	OPM	Measures optical power emanated from an optical fiber. This is the "Multimeter" of fiber optics.	Measure absolute power from transmitters. Measure absolute power at the receive end. Measure relative connector loss. Measure relative link loss.
Stabilized Light Source	SLS	Injects a steady and known amount of optical power into the fiber under test.	Connector Loss Measurements Link Loss Measurements.
Optical Time Domain Reflectometer	OTDR	Probes the fiber with a light pulse and analyzes the reflected return light. Allows for precise location of faults and other features in the network	Map and Test newly installed fiber links. Locate faults. Locate points of high loss.
Optical Inspection Microscope or Video Inspection Probe	OIM VIP	Magnifies the polished end of the connector ferrule for viewing.	Check connectors for contamination. Check Connector for damage such as scratches and/or cracks.

3.3 (Continued):

The complexity of Fiber optic cable and harness testing may range from a simple continuity test of a point-to-point link, to an elaborate mapping of a fiber optical network involving several optical power splitters with many branches. A point-to-point link usually is rather simple to test and generally involves the technician launching light into the link and measure the output power at the far end. In its most simple form, a visual light is injected and if the light is visible at the far end, it can be assumed that the link is continuous.

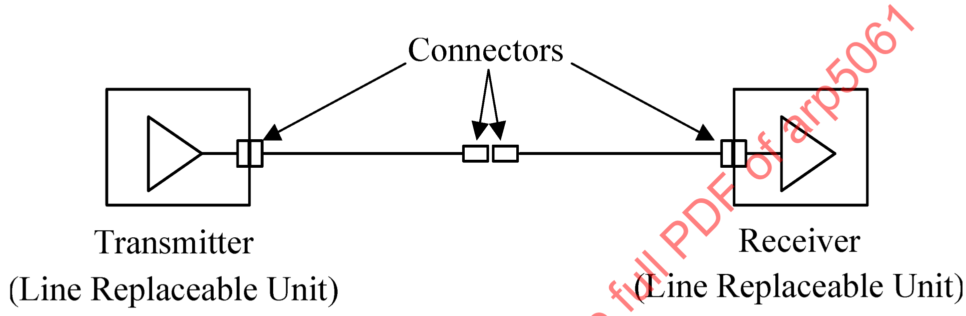


FIGURE 2

A very complex system is analyzed using (1) A light source and power meter or (2) with an OTDR which compares the network at hand with a previously stored map of a good network.

1. The optical loss of each path of the link is measured and compared to the maximum allowed loss given in a wiring plan.

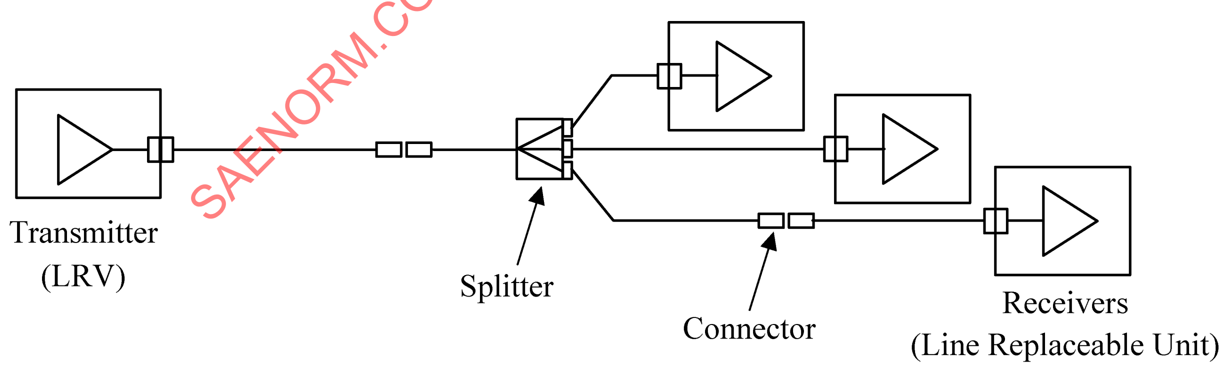


FIGURE 3

3.3 (Continued):

2. The OTDR is connected to the main end and returned signal is analyzed and compared with a previously stored map. In case of a fault, the exact location in distance from the launch end is available. The technician immediately knows where the problem is located. For that test to work, certain criteria, such as staggered branches, connector reflections etc., must be recognized when constructing the system. An OTDR is also used to verify the reflectance (reflected light) and return loss of connectors and other components in the system. It is important to note that the term return loss is often used incorrectly to describe the reflectance of a single interface or feature. Return loss is actually the sum of all the reflectance in a system. Keeping in mind that distinction, an OTDR can measure and record the reflectance of a single mated connector pair. The measured reflectance can then be compared to connector specifications to verify that the flight system is properly integrated. Consider the following example that illustrates how an OTDR may be used to perform connector mate verification tests using reflectance measurements. Cable plant connectors are manufactured and PC polished to a >40 dB reflectance requirement and integrated. Later upon testing it is found that the system Bit Error Rate is not as expected. An ODTR is used to check the system and the reflected signal from one mated connector pair is measured at 20 dB. Since the cable connector specification was >40 dB, there is an apparent anomaly at the mated connector. The connectors are de-mated, found to be dirty, cleaned, re-mated, and once again checked with the OTDR. The measured mate connector reflectance is now 41.3 dB and the system Bit Error Rate is as expected. In addition to reflectance measurements, Aerospace OTDRs have the ability to record and sum all the reflectance in a system and report that value as the return loss, an important system parameter in many applications.

3.3.1 Visual Fault Finder (VFF): The VFF injects an intense visible light into the optical fiber strand. The VFF should as a minimum have the following attributes:

- Optical Launch Power with wavelength in the visible range (approximately 635 nm)
- Optical interface that properly aligns the light injected into the fiber under test
- Battery operation
- Small and lightweight to be used in an aerospace environment
- Eye Safe

The maintenance technician can quickly detect if the light is continuous through the fiber. The absence of light indicates an interruption or fault within the fiber link. The VFF is a very simple tool that provides an indispensable and easy method to verify proper cable routing and continuity. A minimum of operator training is required. The VFF is the equivalent to the electrician's continuity tester -- the “buzz box.” The VFF may be used on Multimode and Singlemode optical fibers equally well. When viewing the output of singlemode fibers, however, the emanated light cone is rather narrow and the user must face the fiber within approximately 12° otherwise no light may be visible to the user.

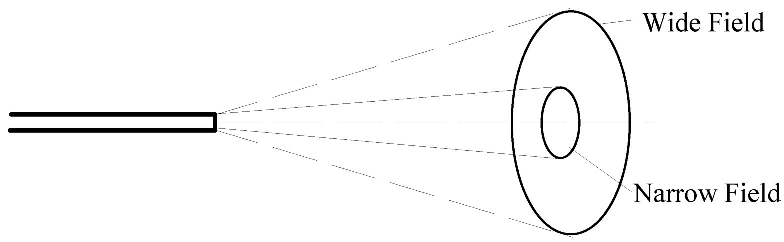


FIGURE 4

3.3.1 (Continued):

Light that is not guided within the fiber escapes through the cladding and buffer material. Light leakage is caused by fiber breaks, microbends such as pressure points on the cable. This feature can only be used when the cable jacket material is translucent to visible light. It should also be noted that in some tight tube jacketed fiber optic cable, the fiber may be damaged and yet the tight buffer tube maintains enough alignment that the fiber appears continuous. In these instances, the maintainer must be aware of the intensity of light emitted from the fiber.

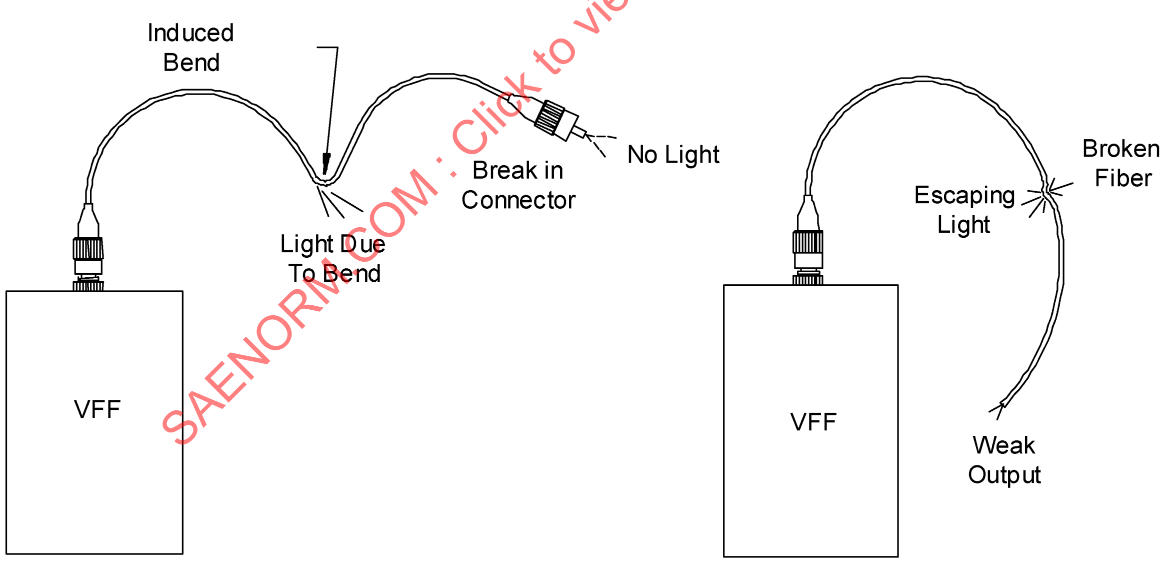


FIGURE 5

3.3.1.1 Visual Fault Finder Safety: The Visual Fault Finder (VFF) shall minimally comply with USA FDA CDRH 21 Subchapter J Class II 1mW max. and IEC 825-1:1993. The VFF shall be certified by the supplier to meet current eye safety standards.

3.3.2 Optical Power Meter and Stabilized Light Source: The Optical Power Meter (OPM) is used to measure the total optical power emanated from an optical fiber. The OPM is typically used for two main functions: (1) Measure and display absolute optical power in microwatts or dBm units, (2) Measure and display relative optical loss (or gain) in dB units.

The OPM converts the optical power into a corresponding electrical signal. A calibration factor is applied to this signal to correct for the response factor of the optical detector that is dependent on the wavelength of the applied optical signal. A user control should allow the operator to select the appropriate wavelength to be measured.

In the absolute power measurement mode, the application for the OPM is to measure transmitted power by an active device (transmitter) or received signal strength through a passive device.

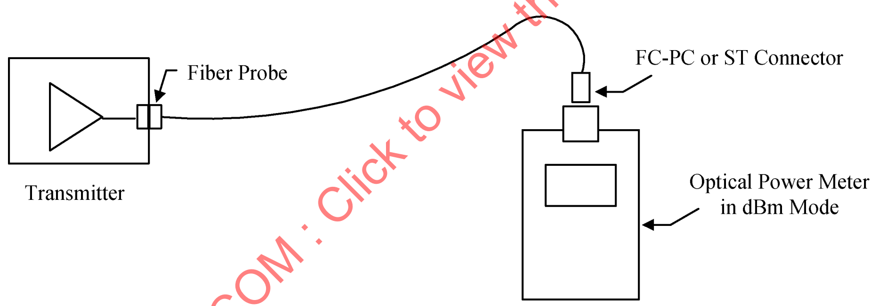


FIGURE 6

3.3.2 (Continued):

The proper functioning of the device is verified if the minimum specified amount of power is measured by a properly calibrated OPM.

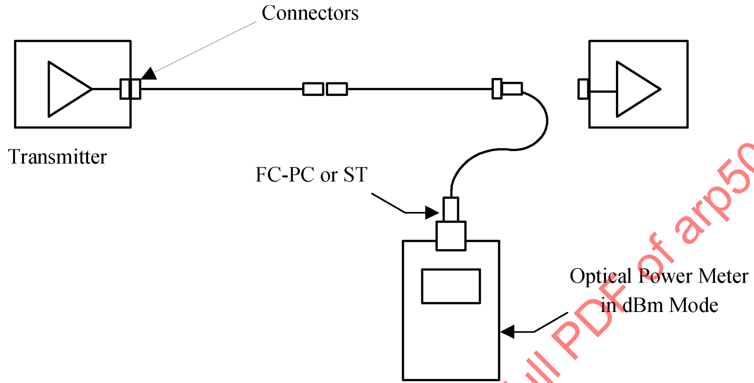


FIGURE 7

A minimum amount of power at the receiver must be available for the receiver to properly function. A calibrated OPM is used to measure the signal strength.

3.3.2.1 Logarithmic Units dB/dBm: The use of logarithmic units is convenient when making optical measurements. This section is intended to acquaint users unfamiliar with the logarithmic units with dB and dBm.

3.3.2.2 The Relative dB Unit: The decibel is the basic measurement unit used in fiber optics to express relative loss or gain. The logarithmic nature of the decibel allows a large or small ratio to be expressed in a simple manner. In addition, dB gain or loss values can be simply added together to arrive at the overall link loss, added or subtracted to the dBm input level, to calculate the absolute power at a given point in the link or to calculate the expected power level.

$$dB = 10 \bullet \log_{10}\frac{P_{out}}{P_{in}} \qquad \text{(Eq. 2)}$$

where:

P_{in} = optical power in linear watt units
P_{out} = optical power out in linear watt units
W unit = W, mW, nW, pW

3.3.2.2 (Continued):

The decibel is used to refer to ratios or relative units. For example, we can say that a certain optical fiber has a 10 dB loss (the power level is reduced to 10% of its input value) or that a particular connector has a 3 dB loss (the power level gets reduced by 50% at the connector). REMEMBER THAT A DECIBEL EXPRESSING LOSS IS A NEGATIVE UNIT. In fiber optics, it is common practice to omit the negative sign and speak of a loss of 3 dB. However, if you solved the decibel equation or read the power meter display, the result (transmittance) would be -3 dB. In talking, and even in data sheets, the negative sign is omitted, with little confusion being caused. Table 2 lists the transmittance with the equivalent loss and percentage of power.

TABLE 2 - Transmittance

Transmittance (dBm)	Loss (dB)	Gain (dB)	Power Remaining (%)	Power Loss (%)
10		10	1000	
0	0		100	
-1	-1		75	25
-2	-2		60	40
-3	-3		50	50
-4	-4		40	60
-5	-5		30	70
-6	-6		25	75
-7	-7		20	80
-8	-8		15	85
-9	-9		12	88
-10	-10		10	90
-20	-20		1	99
-30	-30		0.1	99.9

3.3.2.3 The Absolute dBm Unit: The decibel is a dimensionless unit referring to either gain or loss, depending on sign. The dB gives no indication of the absolute power level. The most common derived unit is the dBm. This is the decibel power level referred to 1 mW. An important relationship to remember is that 0 dBm = 1 mW. A negative or positive value doesn't mean anything either bad or good, like dB loss or gain. It is simply the absolute power level so be sure to check the transmitter or receiver specifications to find out if that power reading is acceptable.

$$dB = 10 \bullet \log_{10}\frac{P_{out}}{P_{in}} \qquad \text{(Eq. 3)}$$

where:

P_{out} = optical power in milliwatts (mw)

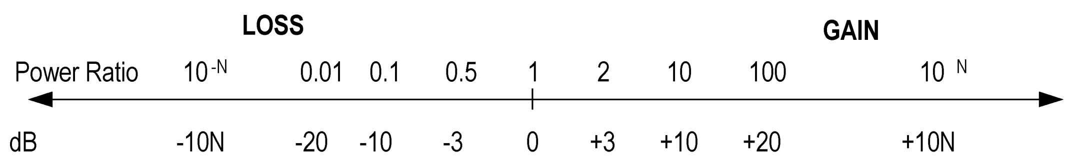


FIGURE 8

3.3.2.3 (Continued):

Typical power ranges encountered are:

- Laser based Systems: +3 dBm to -30 dBm (Singlemode, typical)
- LED based Systems: -10 dBm to -35 dBm (Multimode, typical)

3.3.3 Short Haul Aerospace OTDR: The short haul fiber optic Optical Time Domain Reflectometer should have centimeter spatial resolution, zero dead zone and real time operation. The OTDR is used to test point-to-point fiber optic links, star, ring, and other types of networks used in aerospace platforms. The Aerospace OTDR is different from telecom OTDRs in that it is specially designed to test short links that may vary from only one to several hundred feet and not miles of fiber as with the telecom OTDR. This short distance requires higher speed analysis and circuitry than that found in the typical OTDR used by the telecom industry. Areas of use include fiber optic cable harness manufacturing, environmental testing, installation, on-board monitoring and troubleshooting, fault isolation and repair. The OTDR should have operator friendly controls for ease of use. Currently, separate OTDRs are required for the specific cable plant to be tested, i.e., 50, 62.5, or 100-micron multimode or singlemode fiber.

3.3.4 Optical Inspection Microscope and Video Inspection Probe: This equipment is required to inspect the fiber optic connectors and termini for contamination or damage. Optical Inspection Microscopes have limited use in the field and are more suited for fabrication and repair of individual connectors and termini. The Video Inspection Probe is ideal for field use, as the probe allows inspection of the individual termini while installed in a connector. The use of the VIP is very helpful when cleaning and inspecting multiple position connectors. The VIP also enables the capture of the video image when used with a laptop or other portable computing device. This feature can be especially useful in remote installations where the available personnel may not be familiar with fiber optics and may need to send the electronic image to engineering or a central control location for review.

4. GENERAL REQUIREMENTS:

4.1 Cable Plant Husbandry:

The methods identified in this standard shall be used to ensure the proper operation and performance of the components that make up the cable plant interconnection topology. These tests need to be conducted during various phases of installation of cable topology, production and service as described in the following paragraphs.

NOTE: To reduce the risks associated with contamination, dust caps shall be installed on all unmated connectors, ports, and components housing fiber optic termini.

4.1.1 Pre-Service: This section refers to tests that at a minimum should be performed on the fiber optic components from pre-installation to delivery of the vehicle.

4.1.1.1 Cable Plant Acceptance Tests: Fiber optic cable and components shall undergo visual and optical testing prior to shipping from the fabrication facility and upon receipt at the unit facility. Cable assemblies shall be tested to ensure that they are mechanically and optically sound. Harness and connector components shall be subjected to visual and functional examination only.

4.1.1.2 Cable Plant Pre-Installation Tests: Just prior to airframe installation, it is recommended to perform a functional check on all fiber optic cable assemblies with a Visual Fault Finder (VFF). The purpose is to provide a quick and easy optical continuity check on the cable before installing on the airframe where any needed repair or replacement would be more difficult.

4.1.1.3 Cable Plant Installation Tests: After the cable is installed within the airframe, repeat a continuity light check. This action will provide quick assurance that fibers have not been damaged during the installation process.

4.1.1.4 Cable Plant Post-Installation Tests: After all fiber optic cable plant topology links have been installed, Fiber Integrity Tests (FIT) shall be conducted to verify that the end-to-end (system) attenuation of the fiber optic cable is within acceptable limits. Preferably, these tests will be performed as late in the production process as possible to ensure that the installation of following subsystems have not damaged the fiber optic components.

4.1.2 In-Service: In general, the fiber optic cable plant should not be disturbed unless as part of required maintenance, service or generation. Ideally, interconnects would not be de-mated unless there has been a section of the cable plant identified as suspect and troubleshooting is required. Unnecessarily disturbing the cable plant interconnect system can introduce contamination and cause maintenance induced damage. It is important to remember to clean the connectors prior to mating.

4.2 Troubleshooting:

4.2.1 Operational Level: The maintainer shall be capable of troubleshooting and fault isolating the fiber optic cable plant from a central area or from a point identified by on-board diagnostics (BIT). Fault detection and isolation of high loss areas of the fiber optic cable plant should be performed using a VFF, power meter and light source (often referred to as Optical Attenuation Test Set-OATS, Component Test Set-CTS, etc.), and OTDR as required to isolate the fault or area of excess attenuation. The troubleshooting matrix shown in Table 3 is provided as a simple guide.

TABLE 3 - Troubleshooting Guide

TEST	PROBLEM	LOOK FOR	TOOL	CORRECTION
Continuity	Open-No Light	Connector Unmated	Visual	Mate Connector
		Gross contamination at polished endface	OIM/VIP	1) Clean & Inspect Termini
		Broken fiber	VFF OATS OTDR	1) If fiber is broken near connector, splice in length of pre-terminated cable 2) Remove damaged section and splice in new section of cable 3) Bypass broken cable with replacement jumper
		Damaged termini	OIM/VIP VFF OATS OTDR	1) Splice in length of pre-terminated cable 2) Bypass broken termini with replacement jumper

4.2.2 Depot Level: The depot level technician shall have the same capability of operational level maintainer with the addition of being able to repair and re-terminate fiber optic cable with the appropriate termini and end face geometry to restore damaged fiber optic harnesses. When necessary the technician will also need to be able to fabricate test leads, adapter cables and ground support cables.

4.3 Test Equipment:

4.3.1 Optical Interfaces: The optical interface shall have a permanent attached dust cover that is easily detachable from the unit. Instruments shall have detachable adapters to accommodate various connector interfaces but specifically should be capable of interfacing with FC-PC, ST and MIL-29504 termini.

4.3.2 Environmental Specifications for Test Equipment: In general, fiber optic test equipment for aerospace applications shall meet at a minimum the environments specified in Table 4.

TABLE 4 - Environmental Specifications for Test Equipment

ENVIRONMENTAL PARAMETER	SPECIFICATION
Temperature	
Operating	-15°C to +65°C [1]
Storage	-45°C to +75°C
Humidity	0% to 95% RH
Power	Battery
Drop	
Instrument with Rubber cover	3 feet, all 6 faces plus 4 corners
In Carrying Case	10 feet, all 6 faces plus 4 corners
Vibration	As specified in transportation requirements
Water	
Unprotected Instr.	Splash proof. (Bellcore method)
In Carrying Case	Watertight, submersible for indefinite time.
Case Material	Resistant against most solvents, Acetone, Alcohol, Antifreeze, Hydraulic Fluid, Jet Fuel, etc.

NOTE: The VFF Temperature range may be lower due to visible laser component limitations.

4.3.3 Optical Time Domain Reflectometer (OTDR): The OTDR or Optical Fiber Monitor (OFM) can be used in cable harness manufacturing, pre-installation, installation, post-installation, acceptance, flight, and in operation testing for trouble shooting faults, isolation and repair. The OTDR trace uniquely characterizes the fiber optic link under test, it shows where each connector, or other components are, and shows the location and nature of a fault. In addition, avionics OTDRs should have the capability of mapping a fiber optic cable plant, making master traces for each link of the cable plant and storing them in the unit's memory. This enables subsequent tests of one link or the whole cable plant to be automatically compared to the map. Differences between map and test are recorded, or failure points are found and repaired. If repair is made, the map is updated. The OTDR is also used to find and identify intermittent faults, such as unstable or noisy connectors, loose components, cracks, vibrating cables, etc. The OTDR shall be able to be used in Real Time or Map and Test modes. When Mapping and Test of the cable plant has been performed, the map unique to that vehicle shall be stored in the OTDR memory and/or a general map for that Block of aircraft be stored in the on-board diagnostics history data file for review. For each mode the following are required:

- OTDR Use, Real Time: Requirements for real time operation include an OTDR, a calibrated launch cable, and a suitable power source.
- OTDR Use, Map & Test: Requirements for map & test operation include an OTDR, the unique aircraft map in the OTDR memory (or on-board diagnostics equipment containing the aircraft Block map), a calibrated launch cable, and a suitable power source.

4.3.3.1 OTDR Specifications: The overall preferred performance for OTDR aerospace use is listed in Table 5.

TABLE 5 - Aerospace OTDR Specifications

FEATURE	SPECIFICATION
Short haul, distance range:	0 to 1000ft (300 meters)
Fresnel deadzone:	2 inches
Rayleigh deadzone:	5 inches
Fresnel Operating Mode:	-10dB to -40dB
Rayleigh Operating Mode:	-40dB to - 90dB
Display Screen Refresh Rate:	30Hz
One point resolution:	0.2 inches
Two-point resolution:	2.0 inches
Loss Accuracy:	0.2 dB
Algorithms:	Real time, Compare, Subtract, Map & Test
Fiber Sizes	100/140, 62.5/125*

NOTE: * - May require separate unit for each fiber size.

4.3.3.2 OTDR Calibration: The OTDR must be calibrated against the US NIST (National Institute of Science and Technology) absolute standard. This calibration assures that all power measurements are accurate within a given range. It is recommended that the OTDR should have at a minimum an annual calibration schedule. It is even more important, however, that the units are frequently checked for proper operation as the optical interface can be contaminated or damaged – which leads to erroneous measurement results. Relative accuracy shall be demonstrated and certified by the manufacturer. The OTDR shall be easy to maintain and calibration should be possible with minimal intrusion into the instrument enclosure. Calibration shall be possible by following documented procedures.

4.3.4 Optical Power Meter and Stabilized Light Source:

4.3.4.1 Optical Power Meter: The Optical Power Meter (OPM) shall provide quick and accurate power readings suitable for any fiber type from Single-mode up to 280 um multimode fiber. The OPM is used to measure absolute optical power and relative optical loss (or gain) in any fiber optic cable plant installation. Specifically, aerospace installations require accurate measurements during manufacturing, installation, troubleshooting and repair of components and cable harnesses. The OPM is usually used in conjunction with either an LED or a laser source for measuring insertion loss. The Source injects a known quantity of light power into the fiber and the OPM measures the light power at the output of the cable. The result is the optical power loss measurement for a given cable.

4.3.4.1.1 OPM Specifications: When selecting an OPM for aerospace fiber optic test and measurements the OPM shall have at a minimum the following characteristics and the specifications listed in Table 6:

- Dynamic range +3 to -60 dBm (InGaAs Detector)
- Calibrated wavelengths at 850 nm, 1300 nm and (optional 1550 nm)
- Absolute dBm and relative dB measurement mode
- Capable of storing the reference reading at each wavelength
- Readout resolution of 0.01 dB
- Long Battery Life
- Detachable adapter caps to adapt to FC-PC, ST and MIL-PRF-29504 termini, etc.
- Small Size and rugged construction meeting appropriate environmental condition
- Splash proof packaging

TABLE 6 - Optical Power Meter Specifications

SPECIFICATION	OPTICAL POWER METER
Detector Type	InGaAs
Compatible Fiber Sizes	SM and MM up to 200µm core
Spectral Calibration	850nm, 1300nm, 1550nm
Calibration Accuracy	+0.25dB (NIST traceable)
Linearity	+0.05dB (Bellcore method)
Stability	+0.01dB
Longterm (24 hour)	
Stability	+0.05dBm
Temp. -15 to +65°C	
Power	Requires Batteries (>40 hours life)
Weight & Dimensions	150g (5.25oz)60x140x25mm
Instrument (with Batteries)	
Connector Interface:	Adapters available for: FC-PC, ST, SC, 29504 termini, AVIM, DIN, SMA

4.3.4.1.2 OPM Calibration: The OPM must be calibrated against the US NIST (National Institute of Science and Technology) absolute standard. This calibration assures that all power measurements are accurate within a given range. It is recommended that the OPM should have at a minimum an annual calibration schedule. It is even more important, however, that the units are frequently checked for proper operation as the optical interface can be contaminated or damaged – which leads to erroneous measurement results. Relative accuracy shall be demonstrated and certified by the manufacturer. The OPM shall be easy to maintain and calibration should be possible with minimal intrusion into the instrument enclosure. Calibration shall be possible by following documented procedures.

4.3.4.2 Stabilized Light Source: The LED or Laser Source is usually used in conjunction with an Optical Power Meter for measuring insertion loss. The Source injects a known quantity of light power into the fiber and the OPM measures the light power at the output of the cable. The result is the optical power loss measurement for a given cable. In general, multimode fiber shall be tested with LED Sources and singlemode fibers shall be tested with laser Sources.

4.3.4.2.1 Stabilized Light Source Specifications: When selecting an LED source for aerospace fiber optic test and measurements, the LED source must meet the specific launch conditions as required by this specification or as specified by the platform. In addition to the following characteristics, the preferred performance specifications for the SLS are listed in Table 7:

- Output Power for LED source: -10 to -20 dBm depending of wavelength
- Output power for Laser Sources: 0 to -10 dBm depending of wavelength
- Controlled launch condition for LED sources
- Battery Operated with minimum 24 hours of battery life
- Utilizes common off the shelf batteries
- Low Battery Indicator
- Removable adapter interface for easy cleaning of the fiber interface and to accommodate various connectors such as FC-PC, ST and MIL-29504 series termini
- Small Size and rugged construction meeting appropriate environmental conditions
- Splash proof packaging

TABLE 7 - Stabilized LED Light Source Specifications

FEATURE	SPECIFICATION	
Center Wavelength		
Nominal	1300nm	860nm
Range	1280 - 1340	840-880
Spectral Width (FWHM)		
(Maximum)	140nm	60nm
Stability (1 hour)	±0.05dB	±0.05dB
Power Output		
Into 100/140µm GI MM fiber 0.29NA	>-17dBm (20µW)	>- 13dBm (50µW)
Power Output Uncertainty		
(Calibrated launch level		±0.5dB
Into 100/140 GI MM fiber)		
Power	Battery (> 24 hours life)	
Weight (incl. Batteries)	150g (5.25oz)	
Dimensions	60x140x25mm	
Connector Interface	Interface with broad line of Adapters available for: FC-PC, ST, SC, 29504 termini, AVIM, SMA	

TABLE 7A - Stabilized Laser Light Source Specifications

FEATURE	SPECIFICATION	
Center Wavelength		
Nominal	1300nm	1550nm
Range	1280 - 1340	1520nm - 1570nm
Spectral Width (FWHM)		
(Maximum)	<10nm	< 10nm
Stability (1 hour)	±0.05dB	±0.05dB
Power Output		
Into SMF-28 SM Fiber	> -10dBm	> - 10dBm
Power Output Uncertainty		
(Calibrated launch level		±0.5dB
into SMF-28 fiber)		
Power	Battery (> 24 hours life)	
Weight (incl. Batteries)	150g (5.25oz)	
Dimensions	60x140x25mm	
Connector Interface	Interface with broad line of Adapters available for: FC-PC, ST, SC, 29504 termini, AVIM, SMA.	

4.3.4.2.2 SLS Calibration: The SLS must be calibrated against the US NIST (National Institute of Science and Technology) absolute standard. This calibration assures that all power measurements are accurate within a given range. It is recommended that the SLS should have at a minimum an annual calibration schedule. It is even more important, however, that the units are frequently checked for proper operation as the optical interface can be contaminated or damaged – which leads to erroneous measurement results. Relative accuracy shall be demonstrated and certified by the manufacturer. The SLS shall be easy to maintain and calibration should be possible with minimal intrusion into the instrument enclosure. Calibration shall be possible by following documented procedures.

4.4 Optical Launch Conditions:

Launch condition defines the stimulus used when making fiber loss measurements with a stabilized light source and optical power meter. It is understood that wavelength, fiber size and the reference connector may affect test results. Equally important, however, are the distribution of light within the fiber core (Near-Field) and the angular light distribution (Far-Field). The effect of varying launch conditions is especially dramatic on relatively short fiber optic links with many components and connectors within a short span of fiber. A short length of concatenated fibers will produce significantly different results depending on the Numerical Aperture of the light launched. The following graph shows how the loss can vary from 0.4 to 1.8 dB on a test sample. The test was conducted using 100/140 µm fiber cable. Four segments of 2 m, 5 m, 5 m, and 2 m lengths were concatenated. The first segment was used as the launch fiber. Mandrel wraps of various diameters were used to adjust the Far-Field pattern. The significance of this test is to show how the measured loss of a short fiber link can dramatically depend on launch condition.

The aerospace community determined a base line launch condition to assure commonality across all loss measurements. The specification defines 3 points on a Far-Field and Near-Field scan.

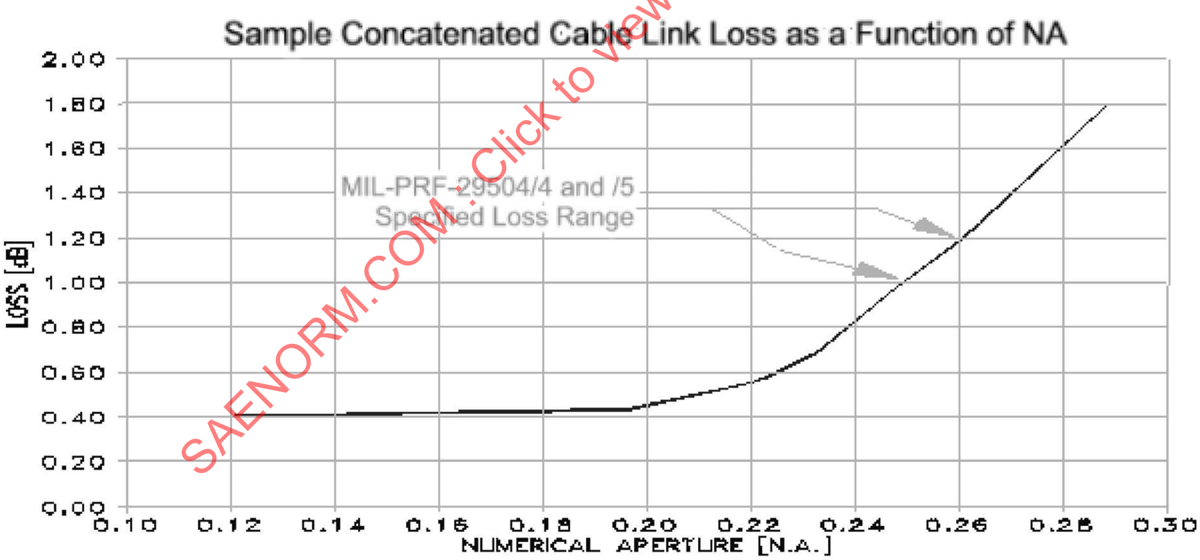


FIGURE 9

4.4.1 Launch Specification AS100 (M80) for 0.29 na: The launch conditions for 100/140-micron fiber with a numerical aperture of 0.29 shall be as shown in Table 8.

TABLE 8 - AS100 Launch Specification - 100/140-micron, 0.29 na

PARAMETER	SPECIFICATION	COMMENT
Wavelength (Center)	850nm ±30nm 1310nm ±30nm	Wavelength per system requirement Affects accuracy little in short systems.
Spectral Width (FWHM)	< 140nm	Not critical Any smaller spectral width shall be accepted. Non-Coherent light only for OPM tests Coherent light for OTDR test allowed.

TABLE 8A - AS100 Launch Specification - Far Field Pattern

Far Field Pattern	Intensity	Max (+)	Min (+)	Measured according to FOTP-47
	5%	.255	.245	
	15%	.225	.210	
	75%	.120	.100	
Far Field Skewing		< 3°		

TABLE 8B - AS100 Launch Specification - Near field Pattern

Near Field Pattern	Intensity	Max (+)	Min (+)	Measured according to FOTP-43, A
	5%	95	80	
	15%	85	70	
	75%	45	30	
Core Eccentricity		< 5µm		

4.4.2 Launch Specification AS62 (M90) for 0.275 na: The launch conditions for 62.5/125-micron fiber with a numerical aperture of 0.275 shall be as shown in Table 9.

TABLE 9 - AS62 Launch Specification - 62.5/125-micron, 0.275 na

PARAMETER	SPECIFICATION	COMMENT
Wavelength (Center)	850nm ±30nm 1310nm ±30nm	Wavelength per system requirement Affects accuracy little in short systems.
Spectral Width (FWHM)	< 140nm	Not critical Any smaller spectral width shall be accepted. Non-Coherent light only for OPM tests Coherent light for OTDR test allowed.

TABLE 9A - AS62 Launch Specification - Far Field Pattern

Far Field Pattern	Intensity	Max (+)	Min (+)	Measured according to FOTP-47
	5%	.275	.250	
	15%	.255	.230	
	75%	.130	.100	
Far Field Skewing		< 3°		

TABLE 9B - AS62 Launch Specification - Near Field Pattern

Near Field Pattern	Intensity	Max (+)	Min (+)	Measured according to FOTP-43, A
	5%	63	57	
	15%	59	53	
	75%	35	29	
Core Eccentricity		< 3µm		Core to ferrule circumference

4.4.3 Launch Condition Effect on Fiber Optic Components (62.5 µm Fiber): Fiber Optic Components may or may not be sensitive to varying launch condition. In Table 10, we list the dependency on launch condition for various components. Please note that this table applies to fiber links of approximately 100 m and shorter. The skewing and eccentricity parameters are assumed part of the reference connector of the test cable or test probe. This affects the initial launch into the test specimen.

It should be understood that the launch condition should be carefully controlled to maintain accurate test results.

TABLE 10 - Launch Parameter - Launch Condition Depenency on Various Components

Component	Wavelength l < 100m	Spectral Width	Far-Field	Near-Field	Skewing	Eccentricity
MM Fiber	Low	Low	High	High	Medium	Medium
SM-Fiber	Low	Low	N/A	N/A	High	Very High
Connector	Low	Low	High	High	Low	High
MM Fused Coupler / Splitter	Medium	Low	High	High	Low	High
SM Coupler / Splitter	High	Low	N/A	N/A	N/A	Very High
Attenuator Fused	Medium	Low	High	High	Low	High
Attenuator Bulk Optics	Low	Low	Medium	Medium	Low	High
Switch	Low	Low	High	High	Low	High

4.4.4 European Aerospace Launch Conditions: Eurofighter 200/280 µm Step Index fibre (extracted from JN1008)

Full launch techniques

In the full launch technique, all modes are excited and the light shall be incident on the launch end of the fibre in the form of a spot, centrally located on the fibre core and of a diameter at the 10% intensity points greater than that of the fibre core diameter. In addition, the numerical aperture NA of the launch beam shall be greater than the maximum theoretical NA of the fibre.

Additional requirements

1. Near field intensity of launch spot - The spot diameter at 80% intensity (measured as described in BS6558, Pt 1, Clause D.4.8) shall be 1,05 x the fibre core diameter

2. Angular dependence of the far field power from launch spot - When measured in accordance with the method described in Clause D.4.7 of BS6558 Pt 1, 1985, the angular dependence of the far field distribution shall vary by less than ±20% up to an angle of sin-1 (NA).

Practical realization

The above requirements may be met by using an incandescent tungsten-halogen light source and an 810 nm narrow-band filter using the arrangement illustrated by Figure 13 of BS6558, Pt 1, 1985. Alternatively, a large area LED with a uniformly emitting surface, and operating at (810 nm ± 30 nm), may be placed close to the fibre end to achieve similar over-filled launch conditions.

Cables, optical, single core 200/280 (extracted from prEN4532 Aerospace series Cables, optical, single core)

4.4.4 (Continued):

Full launch techniques

In the full launch technique, all modes are excited and the light shall be incident on the launch end of the fibre in the form of a spot, centrally located on the fibre core and of a diameter at the 10% intensity points greater than that of the fibre core diameter. In addition, the numerical aperture NA of the launch beam shall be greater than the maximum theoretical NA of the fibre.

Additional requirements

1. Near field intensity of launch spot - The spot diameter at 80% shall be 1, 05 x the fibre core diameter

2. Angular dependence of the far field power from launch spot - When measured in accordance with the method described in EN 187000, the angular dependence of the far field distribution shall vary by less than ±20% up to an angle of sin-1 (NA).

Practical realization

The above requirements may be met by using an incandescent tungsten-halogen light source and an 810 nm narrow-band filter using the arrangement illustrated EN 187000. Alternatively, a large area LED with a uniformly emitting surface, and operating at (810 nm ± 30 nm), may be placed close to the fibre end to achieve similar over-filled launch conditions.

ABS0963-001 - Cable, fibre optic, Type LF (62.5/125 µm graded index)

Tests shall be performed with an 85/85 ± 5% launch condition

4.4.5 Equipment Calibration to Specified Launch Condition: The launch condition of the fiber optic source employed shall meet the requirements according to the herein-published specifications. The user has generally the option of using a source with built-in launch conditioner or performs the launch conditioning externally to the source.

The minimum requirement is to verify the following:

- Wavelength
- Far-Field
- Near-Field

Optionally the test cables maybe analyzed for skewing and for core eccentricity.

4.4.5.1 Center Wavelength (FWHM Method): The Center Wavelength is defined as the center point of the distance between the lower and higher spectral boundary at the 50% power level. The center point may not necessarily coincide with the maximum peak power of the source.

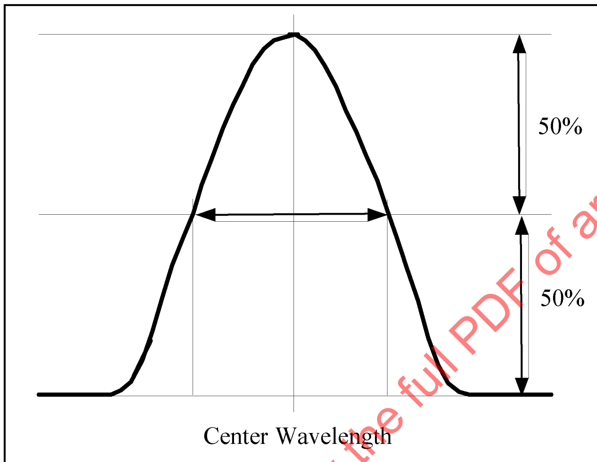


FIGURE 10

It is important that all measurements on multimode fiber be made with non-coherent light, i.e., Laser must not be used as a test source.

NOTE: FOR SHORT FIBER LINKS, SPECTRAL ACCURACY WILL NOT SEVERELY AFFECT MEASUREMENT RESULTS.

4.4.5.1.1 Test Apparatus: Recommended test equipment is any commercially available Fiber Optic Spectrum Analyzer (FOSA). Calibration of the FOSA shall be against the physical fundamental second harmonic of a HeNe Laser (1266 nm).

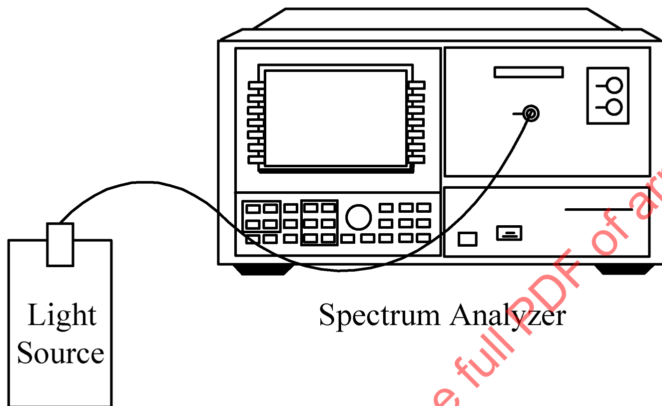


FIGURE 11

4.4.5.2 Spectral Width (FWHM Method): The Spectral width of the test source is defined as the Full spectral Width at Half the Maximum power level.

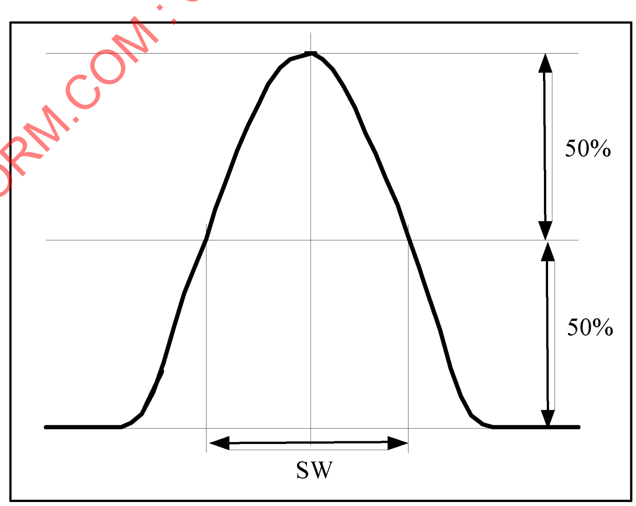


FIGURE 12

NOTE: FOR SHORT FIBER LINKS, SPECTRAL WIDTH WILL NOT SEVERELY AFFECT MEASUREMENT RESULTS.

4.4.5.2.1 Test Apparatus: Recommended test equipment is any commercially available Fiber Optic Spectrum Analyzer (FOSA). Calibration of the FOSA shall be against the physical fundamental second harmonic of a HeNe Laser (1266 nm).

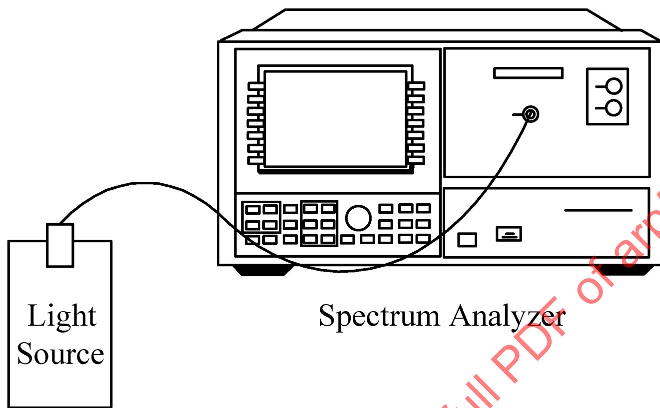


FIGURE 13

4.4.5.3 Scanning Method:

4.4.5.3.1 Far-Field Pattern: The Far-Field pattern is defined to fall within the specified curve template. The MAX and MIN values are absolute numbers and symmetrically applied to the curve.

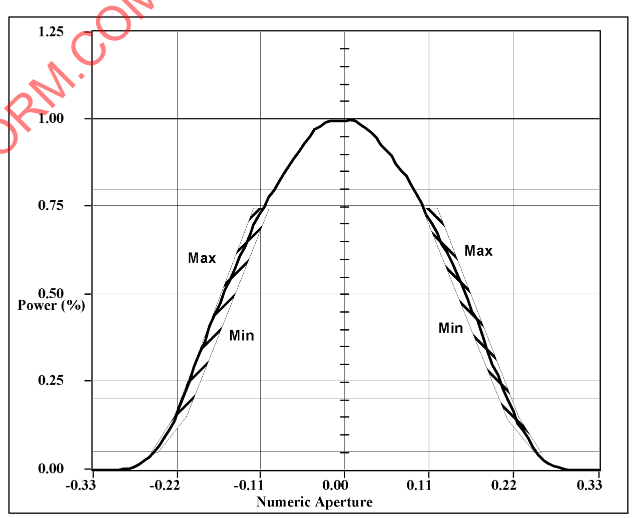


FIGURE 14

4.4.5.3.1.1 Test Apparatus: Recommended test setup and test method is per FOTP-47, Method A.

The output power of the fiber under test is angularly scanned from +30° to -30° (0.5NA). The pick-up fiber or defined aperture collects the light at each particular angle. The collected power must be measured by an external sensitive power meter.

Commercially available Far-Field scanners may be used when properly calibrated. The calibration is performed against accurate mechanical measurement tools.

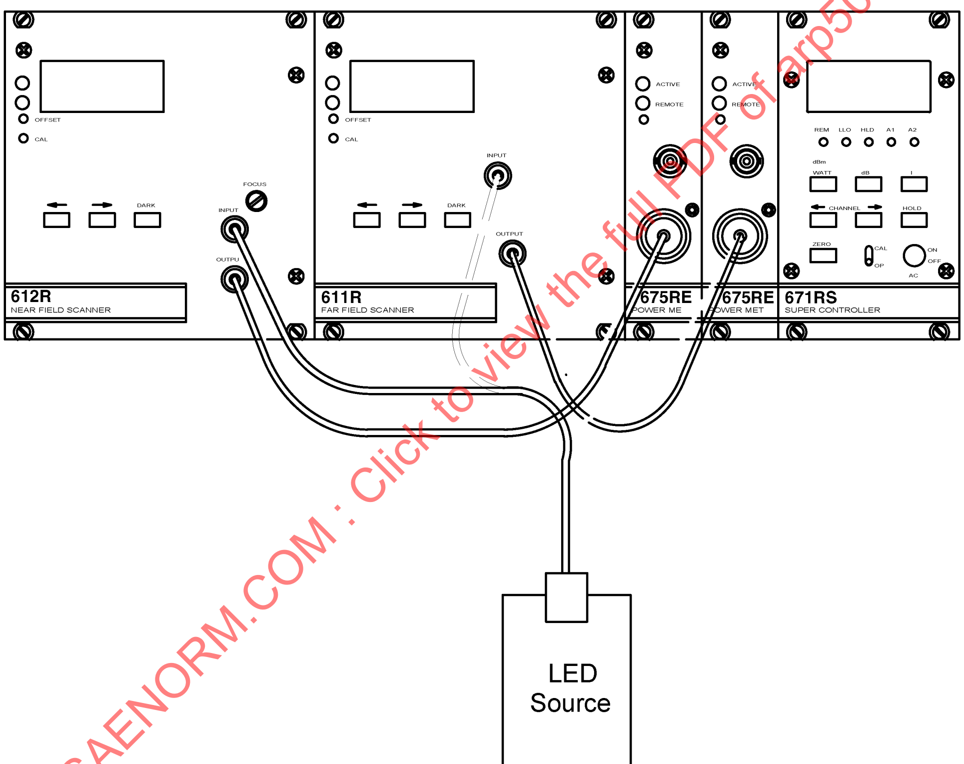


FIGURE 15

Using the far field test method, the ferrule is rotated to find the maximum deviation of the peak position.

4.4.5.3.2 Near-Field Pattern: The Near-Field pattern is defined to fall within the specified curve template. The MAX and MIN values are absolute numbers and symmetrically applied to the curve.

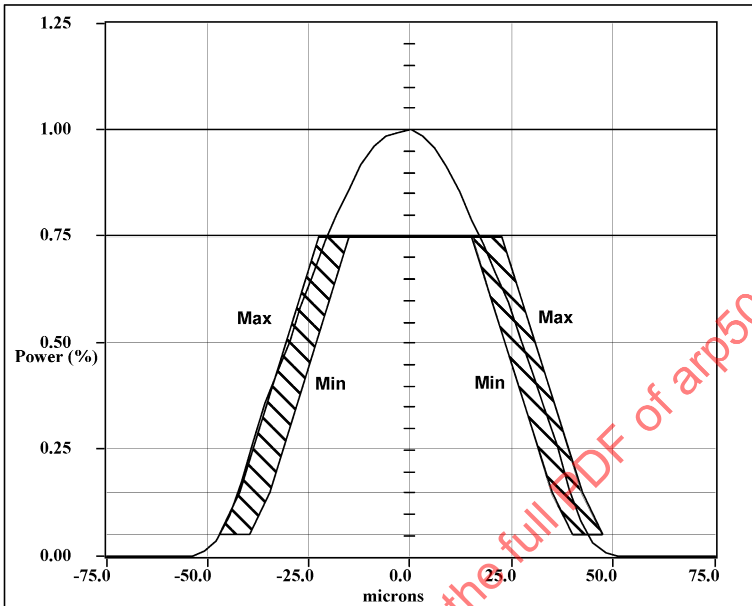


FIGURE 16

4.4.5.3.2.1 Test Apparatus: Recommended test setup and test method is per FOTP-43.

A precision receptacle positions the connector into the focal point of a microscope objective. The fiber end face is imaged with a known magnification. A motor controlled linear stage holds the pick-up fiber assembly. The stage is repeatable to 10 mm resulting in a virtual accuracy of 0.25 mm for the scan.

Commercially available Near-Field scanners may be used when properly calibrated. The calibration is to be performed using an optical comparator and a reference physical standard. Typically, the magnification of the lens is determined and then the linear stage is calibrated against the physical standard measurement.

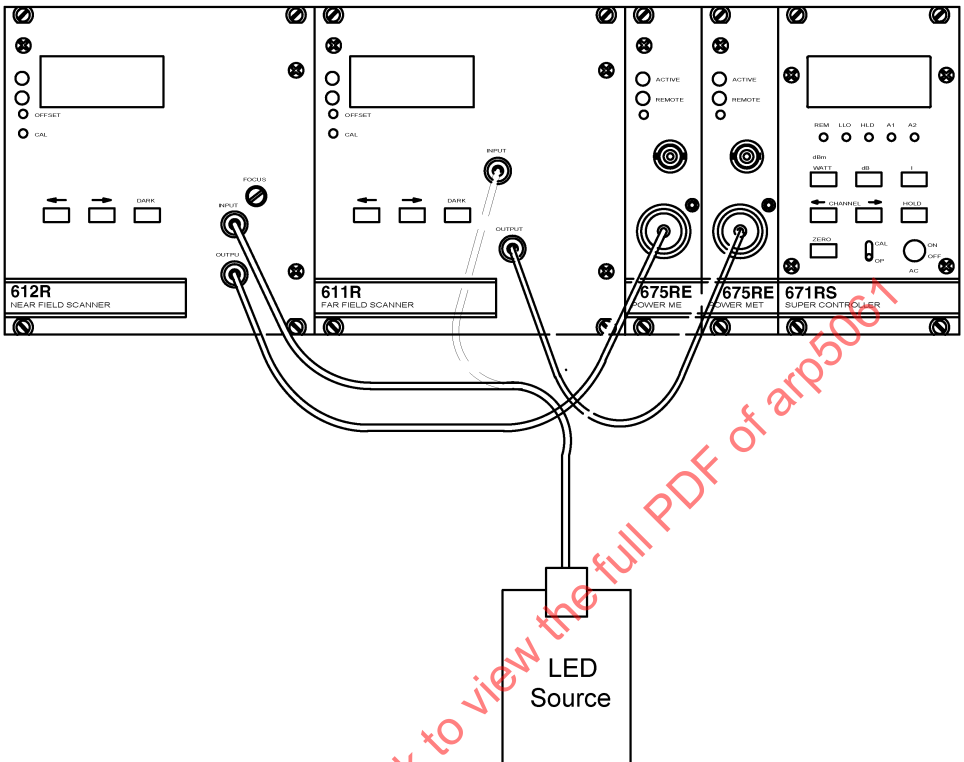


FIGURE 17

4.4.6 Visual Fault Finder-Visible Laser Source: The Visual Fault Finder (VFF) is used as a quick and effective trouble-shooting device. For use in aerospace applications the VFF should meet the following characteristics and specifications listed in Table 11:

- Small and lightweight (Pocket Size)
- Wavelength of 635 nm for enhanced visibility even in bright daylight.
- Must work with both multi-mode and single-mode fiber
- Long Battery life of 48 hours continuous operation
- Utilizes common off the shelf batteries
- Rugged construction - toolbox instrument
- Splash Proof (Water sealed preferred)
- Must meet current laser safety regulations

TABLE 11 - Visual Fault Finder Specifications

FEATURE	SPECIFICATION
Central Wavelength	
Nominal	635nm
Range	615nm-660nm
Spectral Width (RMS)	< 3nm
Stability[1]	
1 hour max. deviation	±0.5dB
10 hours max. deviation	±1.0dB
Power Output[1]	
Into SMF-28 Single mode Fiber	>-5dBm ±1dB
Environmental	
Operating	-15°C to +45°C
Storage	-35°C to +70°C
Power	Battery (>24 hours battery life)
Weight & Dimensions	
Instrument (with Batteries)	Instrument to be small pocket sized similar to a light pen.
Connector Interface	Adapters for FC-PC, ST, SC, MIL-29504 termini, AVIM, SMA

4.4.7 Quality Reference Jumpers: The ferrule/terminus shall be of reference quality. The fiber core to ferrule concentricity shall be as controlled by hand selecting ferrules to best fit at time of termination. Concentricity shall be determined by mating the probe terminus to a reference terminus and rotating one against the other. The difference between the maximum and the minimum power levels shall be less than 0.15 dB. The probe and single channel connectors should be inspected visually under 200x magnification minimum prior to performing optical tests. No nicks, scratches or cracks should be present.

4.4.8 Test Probes and Test Adapters:

4.4.8.1 Fiber Optic Test Probe: Simplex fiber optic cable assembly with an appropriate connector to mate with the source and receiver equipment, FC or ST type is recommended, and a "probe" interface to mate with the harness under test.

4.4.8.1.1 Fiber: The test probe fiber shall have the same optical properties (core cladding diameter, numerical aperture, attenuation, bandwidth, etc.) as specified in the harness being tested.

4.4.8.1.2 Buffer: The buffer(s) need not be the same as the harness under test and may be of standard telecommunication grade material. The buffer shall be removed for termination of the probe to obtain the lowest insertion loss.

4.4.8.1.3 Cable: The cable construction of the probe should be of aerospace quality, but need not be the same as the harness under test. The probe cable should be flexible and remain flexible over any temperature range that might be present in field-testing.

4.4.8.2 Fiber Optic Probe Adapters: An adapter that mates with the D38999 connector on each end of the harness under test providing alignment of the termini and support the probe to minimize angular alignment. There should be an adapter for every D38999 shell size and insert arrangement combination to be tested on the vehicle. For connectors containing both electrical and fiber optic contacts, the cavities in the adapters corresponding to the electrical contacts should be plugged to prevent any attempt to probe an electrical contact. The adapter shall have D38999 style retention clips to achieve positive locking of the probe within the adapter insert. The adapter for the D38999 connectors containing pin terminus should hold the alignment sleeve captive. There shall be separate adapters for mating to termini outside of the D38999.

4.4.8.3 Probe Terminus: The probe terminus shall have a spring member to pre-load the terminus ferrule during mating. The probe shall also have a terminus removal mechanism for easy removal of the probe during testing. The probe ferrule shall be made of ceramic to achieve the best ferrule alignment.

4.4.8.4 Calibration Adapter: A calibration adapter for connecting two probes together prior to making optical measurements shall be provided. This adapter enables accurate reference measurements of two probe jumpers. The calibration adapter houses a precision alignment sleeve for alignment of the two probe ferrules.

4.5 Fiber Optic Connector Cleaning:

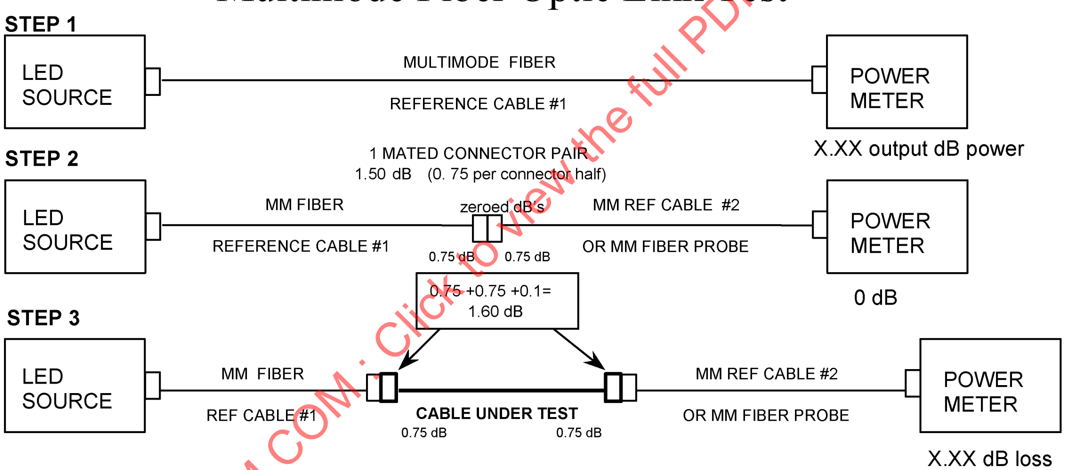
4.5.1 Pre-Demating Visual Inspection and Cleaning: Wipe or dislodge any gross contamination using appropriate methods for level of contamination. Connector plug and receptacle should be free of any loose dirt or liquid contamination. After demating connector, note any physical damage or contamination to insert, ferrules, and sealing grommets.

4.5.2 Pre-Mating Visual Inspection and Cleaning: Prior to mating connectors, clean both mating connector/ferrule halves using approved cleaning solution and methods for each application. Visually inspect ferrules for residual contamination after initial cleaning. Magnified inspection may not be required if proper cleaning procedures are followed. Repeated cleaning may be required if system attenuation is exceeded.

4.6 Link Loss Test Procedures:

4.6.1 Multimode: Common link loss test procedures are required to ensure equivalent measurement results are achieved between users. The following figure illustrates the recommended link loss procedure for testing fiber optic cable plants containing multimode fiber optic cables. Depending on the organization conducting the measurements, the first step of using a calibrated reference cable to determine the amount of optical power transmitted from the LED source may be performed at the depot or tool crib level on regular intervals or prior to checking out the LED source. This eliminates extra steps that the operation level maintainer may not have time or need to perform for troubleshooting. However, it is important that this step be performed and the results documented at some level.

Multimode Fiber Optic Link Test



STEP 1:

Turn on source and meter. Connect Multimode Reference cable #1 to source and power meter. Measure output power of source and verify that it is acceptable. The power output as read at the meter should be within a specified range based on the source to make sure the source is good.

STEP 2:

Remove MM REF #1 from power meter. Attach MM REF #2 to power meter and mate with MM REF #1. Verify that the loss in the source/MM REF #1/MM REF #2/power meter link is acceptable. Acceptable loss value should be slightly higher than the loss in the MM REF #1. This will verify that the reference cables and connectors are good. Suggest 1.50 dB delta as acceptable. Zero power meter after verifying that test cables and interfaces are good.

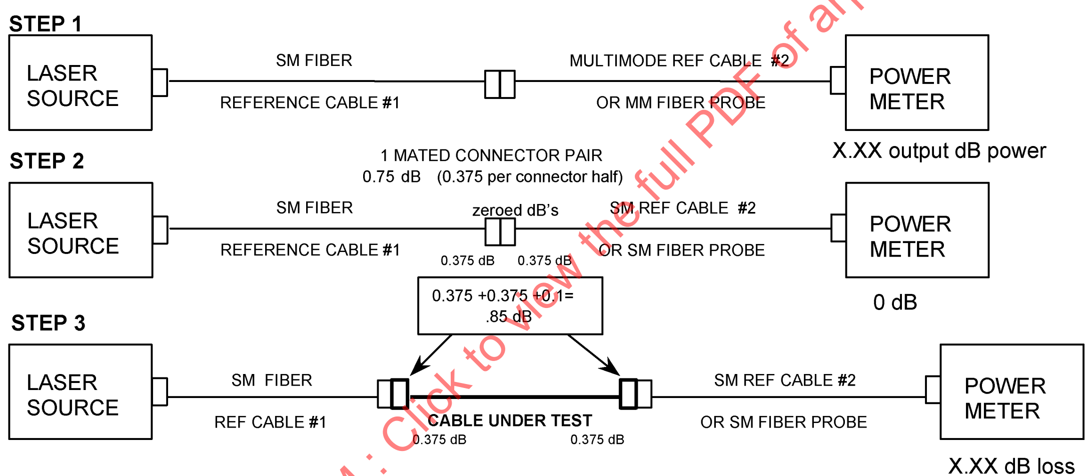
STEP 3:

Insert Cable Under Test (CUT) between MM REF#1 and MM REF#2. Read power meter output and verify that CUT is good. Suggest that acceptable CUT loss be less than two times half of a connector interface plus some factor (.1dB) for uncertainty. This would yield acceptable CUT loss being 1.60 dB or less.

FIGURE 18

4.6.2 Singlemode: The following figure illustrates the recommended link loss procedure for testing fiber optic cable plants containing singlemode fiber optic cables. Depending on the organization conducting the measurements, the first step of using a calibrated multimode reference cable to determine the amount of optical power transmitted from the Laser source may be performed at the depot or tool crib level on regular intervals or prior to checking out the Laser source. This eliminates extra steps that the operation level maintainer may not have time or need to perform for troubleshooting. However, it is important that this step be performed and the results documented at some level.

Singlemode Fiber Optic Link Test



STEP 1:

Connect MM REF #2 to power meter and SM REF #1. Connect SM REF #1 to source. Turn on source and meter. Measure output power of source and verify that it is acceptable. Note: Shows a method for determining the total power being output by the source. The power output as read at the meter should be within a specified range based on the source to make sure the source is good.

STEP 2:

Remove MM REF #2 and insert SM REF #2 in it's place. Verify that the loss in the source/SM REF #1/SM REF #2/power meter link is acceptable. Acceptable loss value should be slightly higher than the loss in the SM REF#1 to SM REF#2 connector pair. This will verify that the reference cables and connectors are good. Suggest 1.5dB or less be acceptable. Zero power meter after verifying that test cables and interfaces are good.

STEP 3:

Insert Cable Under Test (CUT) between SM REF#1 and SM REF#2. Read power meter output and verify that CUT is good. Suggest that acceptable CUT loss be less than two times half of a connector interface plus some factor (.1dB) for uncertainty. This would yield acceptable CUT loss being .85dB or less.

FIGURE 19

4.7 Safety:

4.7.1 Handling: When handling bare optical fibers, care should be taken to prevent fibers from puncturing the skin and breakage causing fragments to fly into the eye region. Safety glasses should be worn when working with fibers and the careful disposal of fiber ends should be followed as discussed further. Glass fibers are small enough to puncture and stay under the surface of the skin. Besides being an irritant, bits of glass fibers can be difficult to remove. It is particularly important to keep strays bits from around the eyes, where removal is even more difficult. During installation and repair, all snipped or cleaved pieces of optical glass fibers should be placed in appropriate disposal containers. Placing fibers on an adhesive tape strip can be dangerous and should not be used. In addition, all cables with exposed, bare fibers protruding should be adequately covered or positioned to preclude accidental puncture. Your best defense against injury by fibers is common sense. Eating and drinking around fibers is considered dangerous. Also, since fragments can stick to skin oils, thoroughly wash your hands before touching your face or eyes after working with fibers. The fiber waste must never be put in ordinary garbage for routine disposal.

4.7.2 Eye Safety: Unmated connectors and fibers may transmit non-visible radiation and direct viewing with the eye should be avoided. Do not inspect active fiber optic systems with optical magnifying scopes. Protective end caps and connector covers should always be kept on all unmated connectors. The most reliable form of protection for eyes is to prevent fragments from entering with protective eyewear. The clear lenses can stop a fiber end from piercing the eyeball or prevent minute fragments from entering the eye. Flying glass fragments are often the results of cutting and cleaving operations. What is worse is that the presence of these fragments often goes unnoticed due to their small size. Please refer to ANSI Z136.2, American National Standard for the Safe use of Lasers, for additional eye safety precautions.

4.7.3 Optical Power Source: Although the optical power present in installation can be fairly low, the small dimensions of fiber cores and semiconductors sources makes it possible for intensities to attain quite high values. If an optical cable is disconnected or broken and the exposed end is examined, there may be a risk of eye damage, particularly if a magnifier or other visual aid is used. All systems should be assumed on, until test equipment can verify the status of optical sources. Moreover, in applications that require higher intensity optical sources, system designers should include additional safety precautions to ensure the safety of maintenance personnel.

4.7.4 Laser: The lasers used as fiber sources operate at 850, 1300 and 1550 nanometers wavelengths, which are all in the infrared part of the light spectrum. These first two wavelengths along with the visible light are focused by the eye onto the retina. Retinal receptors are sensitive to the range of wavelengths between 400 and 700 nanometers, but not to wavelength outside the range. Herein lies the danger. Although a person cannot perceive the intense light from the laser, it is still being focused on the sensitive retinal tissue. At the focal point, energy density can be high enough to burn the tissue, resulting in loss of visual activity or in blind spots in the person's visual field. This is even though lasers for fiber use are actually of low power compared to other laser types. Lasers are classified into four general categories to their accessible radiation during normal use and maintenance. The class of an individual laser depends on its operating wavelength, its output power, and whether it is pulse or continuous wave. The concentration on low power infrared lasers is sufficient for fiber optic theory.

4.7.4.1 Class 1: Lasers are considered "eye-safe" in that no eye damage would result even from prolonged exposure to the direct beam. Because shorter wavelength light, especially wavelengths shorter than 550 nanometers, is more heavily absorbed by the retina, the maximum output power of Class 1 lasers generally increases with increasing wavelengths. As lasers emission at wavelengths greater than 1400 nanometers is absorbed by the cornea, no focusing onto the retina occurs and the Class 1 laser maximum output power increases dramatically.

4.7.4.2 Class 2: Lasers are those for which this aversion response will protect one from the output. Class 2 lasers include only those emitting visible radiation. Many fiber identifiers fall into this category. No Class 2 lasers are used in fiber systems.

4.7.4.3 Class 3: Lasers are medium power produce radiation that can cause eye damage when viewed directly, or when a magnified reflection is viewed. A diffuse reflection is usually not a hazard.

4.7.4.4 Class 4: Lasers are high power and are not used in communication/data cable plant applications. All lasers used with fiber communications systems are well below the energy levels that would cause skin burns, but the danger to eyesight is very real. The danger is highest at optical outputs where energy is coming directly from the laser.

5. NOTES:

INDEX OF PAGE CHANGES						
REVISION DATE AND LETTER	PAGES AFFECTED			REMARKS	REVISED BY	APPROVED
	REVISED	ADDED	REMOVED			

FIGURE 20

PREPARED UNDER THE JURISDICTION OF
SAE COMMITTEE AS-3, FIBER OPTICS & APPLIED PHOTONICS

APPENDIX A
FIBER OPTIC SUPPORT EQUIPMENT

NOTE: This is a compilation of historical test equipment, hand-tools, and consumables that have been used by the aerospace fiber optic community and is not intended to be a recommendation or promotion of any particular brand or manufacturer. The sole purpose of this section is to give the new user a historical reference of items that have been applied to fiber optics in aerospace systems.

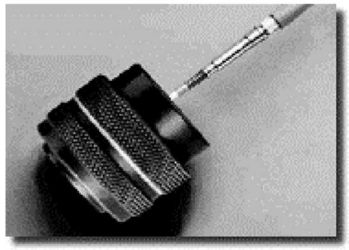
OPTICAL TIME DOMAIN REFLECTOMETER (OTDR):

Boeing A&M

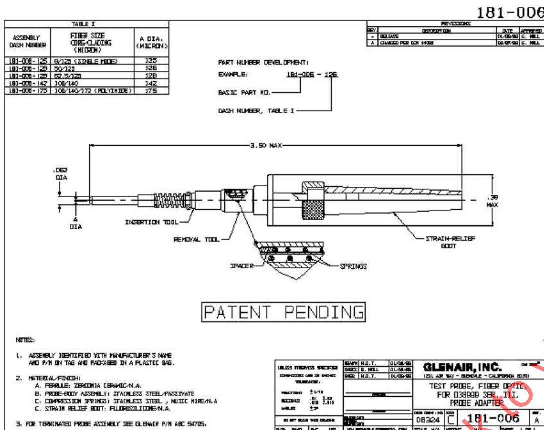
NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
OTDR	OPTOELECTRONICS	OFM-1020			Yes -

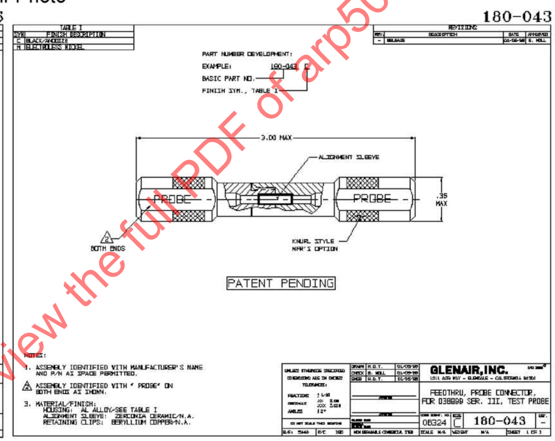
SPECIFICATIONS	
POWER REQUIREMENTS	115/220 vac @60-400hz 22-30 vdc
OUTPUT	Serial/Parallel Port/PCMIA Card
ENVIRONMENT	Operating -20C to 35C, Storage -45C to 75C
ACCURACY	+/-0.05db
DIMENSIONS	14"X18"X8"
COMMENTS	Recommended for use on several aerospace platforms.

OTDR TEST PROBES/ADAPTERS



Glenair Photo





NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
TEST PROBE	GLENAIR				Yes -

SPECIFICATIONS
POWER REQUIREMENTS None

OUTPUT
ENVIRONMENT
ACCURACY
DIMENSIONS

COMMENTS Used on Comanche EMD program.

DUAL WAVELENGTH LED SOURCE (DWLS)

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
DUAL WAVELENGTH LED SOURCE	RIFOCS	252A-M80			Yes -

SPECIFICATIONS		
ENVIRONMENT	Operating -15C to +55C, Storage -35C to +70C	
DIMENSIONS	2.8"x5.6"x1.4"	
WEIGHT	8.5 oz.	
POWER REQUIREMENTS	2AA alkaline batteries>24 Hours	
WAVELENGTH	850nm	1300nm
SPECTRAL (FWHM)	<55nm	<140nm
STABILITY (1 HOUR)	+/- .05dB	+/- .05 dB
POWER OUTPUT		
100/140 GI MM FIBER	-13dBm	-20 dBm
62.5/125 GI MM FIBER	-13dBm/	-20 dBm
50/125 GI MM FIBER	-14dBm	-21 dBm
9/125 GI MM FIBER		-38 dBm
CONNECTOR INTERFACE	UCI-PC	
ADAPTERS	APC-10 (FC-PC CONNECTOR INTERFACE) ATS-10 (ST ADAPTER)	

OPTICAL POWER SOURCE TEST PROBES/ADAPTERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
ADAPTER(S)	RIFOCS	APC-10			
SPECIFICATIONS FC-PC CONNECTOR INTERFACE					
ADAPTER	RIFOCS	ATS-10			
SPECIFICATIONS ST TYPE ADAPTER					

OPTICAL POWER METER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
OPTICAL POWER METER	RIFOCS	555B			Yes

SPECIFICATIONS

SENSOR TYPE	InGaAs (1mm)
POWER RANGE	+3 to -60dBm
CALIBRATION WAVELENGTHS	850/1300/1550 nm
ABSOLUTE ACCURACY	+/- 0.25dB @ Calibration Conditions
FUNCTIONS	dBm, dB, CAL
OPTICAL CONNECTOR INTERFACE	RIFOCS Snap-On Connector (SOC) Series
POWER	2AA Alkaline Batteries (>100 hours battery life)
ENVIRONMENT	Operating -15C to +55C, Storage -35C to +70C
WEIGHT	7.6 oz
DIMENSIONS	2.8"x5.6"x1.4"

OPTICAL POWER METER TEST PROBES/ADAPTERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
FIBER OPTIC TEST PROBE AND ADAPTER KIT	GLENAIR, INC.	600-083	06324		
CONTENTS					
PLUG ADAPTER, SIZE 17, SOCKET INSR		180-020NF06178S			
PLUG ADAPTER, SIZE 21, SOCKET INSR		180-020NF062116S			
PLUG ADAPTER, SIZE 23, SOCKET INSR		180-020NF062321S			
PLUG ADAPTER, SIZE 25, SOCKET INSR		180-020NF062529S			
RECP. ADAPTER, SIZE 11, PIN INSR		180-020NF07112PA			
RECP. ADAPTER, SIZE 17, PIN INSR		180-020NF07178P			
RECP. ADAPTER, SIZE 17, PIN INSR		180-020NF07178PA			
RECP. ADAPTER, SIZE 17, PIN INSR		180-020NF07178PB			
RECP. ADAPTER, SIZE 23, PIN INSR		180-020NF072321P			
RECP. ADAPTER, SIZE 23, PIN INSR		180-020NF072321PA			
RECP. ADAPTER, SIZE 25, PIN INSR		180-020NF072529P			
PROBE TO FC CONNECTOR CABLE ASSY ST		ABC 54705-A-A-3 ABC 54705-A-B-3			
FC ALIGNMENT SLEEVE ADAPTER, PROBE		180-024			

MISC. TEST PROBES, ADAPTERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
Adapter Set, Fiber Optic - DMU/DMC	MDA-ST. LOUIS	74D740310	76301		NO
Adapter Set, Fiber Optic	MDA- ST. LOUIS	74D740300 (not shown)	76301		

Note: The 74D740310 Adapter Set is used to test the fiber optic links internal to the Digital Map Set and the 74D740300 Adapter Set is used to test the fiber optic links on the aircraft associated with the Digital Map Set.

OPTICAL SOURCE / POWER METER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
Optical Attenuation Test Set (OATS)	WILCOM	T312B	51778		YES

Note: Used by USN.

VISUAL FAULT FINDER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
VISUAL FAULT FINDER	RIFOCS	160L	0XY53		
SPECIFICATIONS					
POWER REQUIREMENTS	2AA alkaline batteries >80 Hours Use				
WAVELENGTH	Nominal 635nm, Range 630-640nm				
SPECTRAL WIDTH (FWHM)	<2nm				
POWER OUTPUT (SMF-28 Fiber)	Range -5 to 0dBm (Class 3A)				
CONNECTOR INTERFACE	UCI (Various Adapters Available)				
ENVIRONMENTAL	Operating -10C to +50C, Storage -40C to +85C (0-95%RH Non Condensing)				
WEIGHT	7 oz.				
DIMENSIONS	Length 9.0 in. Diameter 1.0 in.				

This device is a Class 3A laser and may cause eye damage if directed into the eye. Do not utilize any magnification device to view fiber or termini emitting this light.

MICROSCOPE, INSPECTION

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
FIBERVUE, FIBER OPTIC MICROSCOPE	LEICA	31-22-70C			NO

NOTE: Used to inspect the end face polish of fiber optic contacts, connectors, and bare fiber. Has multiple holding fixtures for different size connectors, battery or ac powered, tripod or hand held use. It also has interchangeable lens to provide a wide variety of magnifications for general inspection to singlemode fiber inspection.

PROBE, VIDEO INSPECTION

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
VIDEO INSPECTION PROBE (VIP)	WESTOVER	FBP-S1			NO
29504/4 PIN ADAPTER	WESTOVER	FBPT-MIL-2P			
29504/5 SOCKET ADAPTER	WESTOVER	FBPT-MIL-2S			

BORESCOPE

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
BORESCOPE	EMCO	FOVIS-50/D			
SPECIFICATIONS					
POWER REQUIREMENTS					
MAGNIFICATION	120X-200X				
ENVIRONMENT					
WEIGHT					
DIMENSIONS					

HEAD MOUNTED DISPLAY

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
HEAD MOUNTED DISPLAY	EMCO				
SPECIFICATIONS					
POWER REQUIREMENTS					

PORTABLE BATTERY BELT

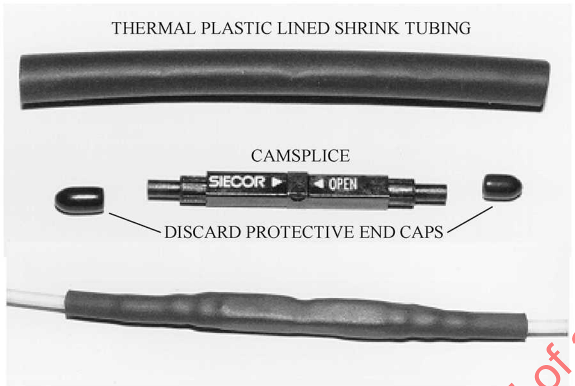
NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
PORTABLE BATTERY BELT	EMCO				
SPECIFICATIONS					
POWER OUTPUT					

HARNESS REPAIR

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
REPAIR SET, FIBER OPTIC	MDA/BOEING-ST. LOUIS	74D740301	76301		Yes

Note: Developed for Depot Level Maintenance for the termination (SMA and 38999) and repair (mechanical splice) of tactical aircraft fiber optic harnesses. Includes all tooling and consumable supplies required.

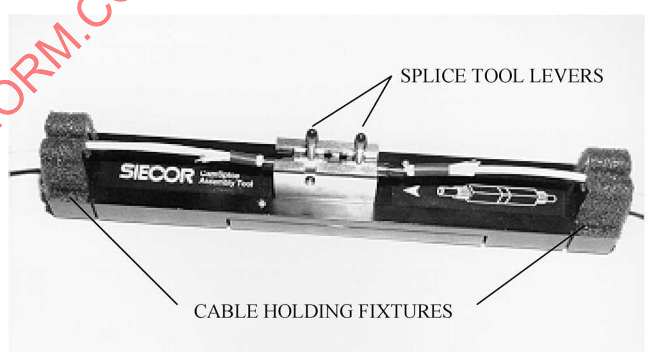
MECHANICAL SPLICES



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
CAMSPLICE	SIECOR	95-000-04			NO
SPLICE, CABLE, FIBER OPTIC	ASSEMBLED SPLICE KIT-MDA	74D740301-1017	76301		NO

Note: The SIECOR CamSplice was selected as the mechanical splice of choice through an extensive mechanical splice and cleaver evaluation. The CamSplice had fewer parts (2), was easy to use, met or exceeded environmental and mechanical requirements, and was compatible with the polyimide coated fiber. The CamSplice can be used with both the loose tube 5M2551 (Brand Rex OC-1260) and the Spectran tight tube buffered cable (BC04674).

MECHANICAL SPLICE TOOL



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
SPLICE TOOL	SIECOR	2104040-01			NO

Note: The SIECOR splice tool is not required to install the CamSplice. The splice tool is an aid used to hold the fiber optic cables being spliced to ease installation.

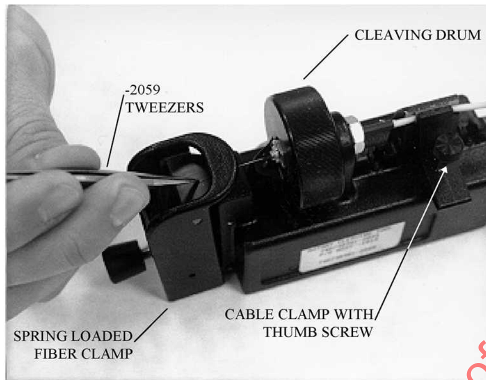
MECHANICAL SPLICES

The MS1041-172-1.0-1.8A Crimp-and Cleave Splice contains shrink tubing, (2) crimp sleeves, (2) retention cups, and a tube assembly which contains the capillary alignment fixture.

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
SPLICE	AURORA OPTICS	MS1041-172-1.0-1.8A			
SPECIFICATIONS Minimum Insertion Loss					

NOTE:
Not recommended for loose tube fiber.

FIBER CLEAVER



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
ROTARY CLEAVER	DANIELS MANUFACTURING CORP.	GHC100-2TA			YES

FIBER CLEAVER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
FIBER CLEAVER	THOMAS & BETTS CORP.	92208-AF	56501		

SPECIFICATIONS

NOTE: Not recommended for polyimide-coated fibers.

KEVLAR SHEARS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
KEVLAR SHEARS	CLAUSS	86-1/2S	71827	5110-01-419-5283	

SPECIFICATIONS	
LENGTH	6 1/2"
LENGTH OF CUT	5/8"

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
KEVLAR SHEARS	XURON/Ripley	9180			

SPECIFICATIONS	
LENGTH	5 7/8”
LENGTH OF CUT	5/8"

CABLE STRIPPER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
CABLE STRIPPER	IDEAL INDUSTRIES INC.	45-162	30119	5110-01-216-4464	No
SPECIFICATIONS					

TWEEZERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
TWEEZERS					No
SPECIFICATIONS GGG-T-870 CLASS1 STYLE1					

BUFFER STRIPPER

MILLER STRIPPERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
MILLER STRIPPERS	MILLER	FO-103-S			NO

Note: No adjustment is required for 125-micron acrylate coated fiber; however, adjustment is required when used with polyimide-coated fibers.

MICRO STRIPPERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
MICRO STRIPPERS	UTICA	MODEL MS			NO

Note: No calibration is required; however, it is important to insert the proper blade set and buffer alignment guide for the fiber optic cable that is being stripped.

CRIMPER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
CRIMPER	DANIELS MANUFACTURING	M22520/10-01		5120-00-117-4830	No

SPECIFICATIONS

DIE

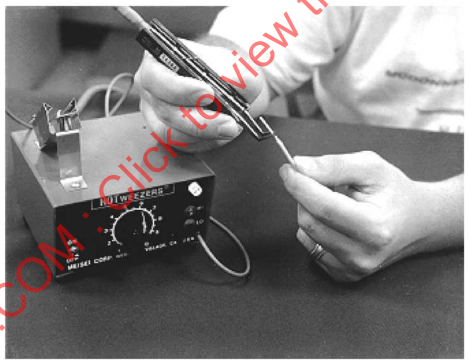
NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
DIE	DANIELS MANUFACTURING	X290	11851		No

SPECIFICATIONS

NO-NIK STRIPPERS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
NO-NIK	CLAUSS	.014 INCH			NO

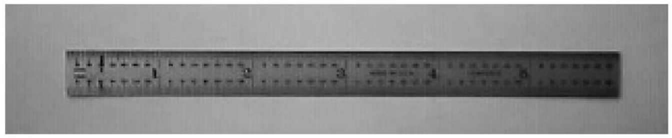
STRIPPERS, THERMAL



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
THERMAL STRIPPERS	MEISEI	M-10			NO

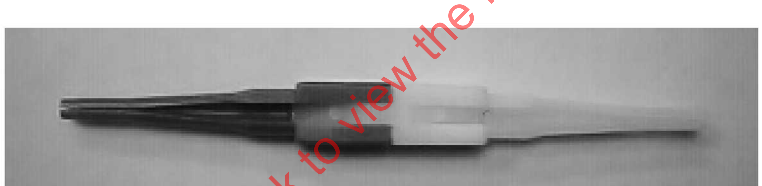
NOTE: The thermal strippers are used for stripping the buffer tube of older fiber optic cables. As an example, 5M1945 - Brand Rex OC-1011, used on AV8 and early F-18's and support equipment.

SCALE



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
SCALE					No
SPECIFICATIONS GGG-R-791 TYPE IV CLASS1					

INSERTION/EXTRACTION TOOL



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
INSERTION/REMOVAL TOOL		M81969/14-03		5120-00-915-4588	No
SPECIFICATIONS					

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
INSERTION/REMOVAL TOOL		M81969/8B-07	81349		No
SPECIFICATIONS					

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
INSERTION/REMOVAL TOOL		M81969/8B-08	81349		No

SPECIFICATIONS

INSERTION/EXTRACTION TOOL

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
INSERTION/REMOVAL TOOL		MS27495R16	96906	5120-00-409-5206	No

SPECIFICATIONS

INSERTION/EXTRACTION TOOL

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
INSERTION/REMOVAL TOOL		MS27495A16	96906	5120-00-018-0529	No

SPECIFICATIONS

PROTECTIVE CAPS/PLUGS

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
PROTECTIVE CAPS					No
SHELL SIZE 11		D38999/33W11R			
RECEPTACLE					
PLUG		D38999/32W11R			
SHELL SIZE 17		D38999/33W17R			
RECEPTACLE					
PLUG		D38999/32W17R			
SHELL SIZE 19		D38999/33W19R			
RECEPTACLE					
PLUG		D38999/32W19R			
SHELL SIZE 21		D38999/33W21R			
RECEPTACLE					
PLUG		D38999/32W21R			
SHELL SIZE 23		D38999/33W23R			
RECEPTACLE					
PLUG		D38999/32W23R			
SHELL SIZE 25		D38999/33W25R			
RECEPTACLE					
PLUG		D38999/32W25R			
MTC					
SPECIFICATIONS					
MATERIAL	METAL				

STRAP WRENCH

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
STRAP WRENCH					No
SPECIFICATIONS					

DISPOSAL, FIBER

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
FIBER DISPOSAL	CLAUSS	F1-8828			NO

NOTE: Preferred method of fiber optic waste disposal. Provides a safe way of handling the fiber scraps from splicing and terminating through final disposal after the container is full. Reduces chances of fiber splinters being picked up from double-backed tape and other temporary methods of containment.

LACING TAPE

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
LACING TAPE	GUDEBROD INC.				No
SPECIFICATIONS	MIL-T-43435B TYPE III SIZE III CLASS C				

EYE PROTECTION

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED

HEAT GUN

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED

DUSTING SYSTEM, CO_2

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
DUSTING SYSTEM, CO_2	CHEMTRONICS	ES-270	21267		No

SPECIFICATIONS
ENVIRONMENT 300 psig at 77F/25C

100% ultra pure CO_2
Replacement CO_2 cartridge Part Number is: ES 275

PADS, ALCOHOL

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
PADS, ALCOHOL	TEXWIPE CO.	TX801	21994	7920-01-036-4464	No

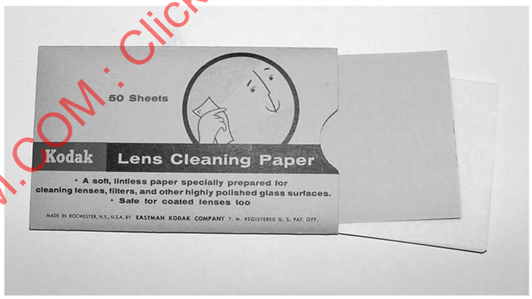
SPECIFICATIONS

DUSTING / FORCED AIR

NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
AeroDuster 134a	Miller-Stephenson	MS222N			NO

Note: Used to blow away particulate contaminates and to dry contacts/connectors after cleaning with solvent.

TISSUE, LENS



NOMENCLATURE	MANUFACTURER	PART NUMBER	FSCM	NATIONAL STOCK NUMBER	CALIBRATION REQUIRED
Tissue, Optical Wiping	KODAK	154-6027			NO

Note: Used to clean the end face of fiber optic contacts without scratching the optical surface. Used in combination with Isopropyl Alcohol. Equivalent alternative to prepackaged alcohol pads.