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AS6021 Aerospace Fiber Optic Cable Assembly Drawing Specification		

RATIONALE

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1. SCOPE

This SAE Aerospace Standard (AS) defines the items that shall be considered when creating a fiber optic cable assembly specification and source control drawing intended for installation on aerospace platforms.

1.1 Purpose

The purpose of this document is to provide guidance on criteria that shall be considered when specifying an aerospace fiber optic cable assembly. Users of this document are cautioned to not over-specify inspection and test requirements, as this may adversely affect price and/or lead time. It is helpful to cite widely recognized standards as an aid to provide specific requirements.

1.2 Field of Application

This document defines the required content of a comprehensive aerospace fiber optic cable assembly engineering specification (or source control document) and checklist. The specified requirements are applicable to end users, system integrators, subsystem suppliers and component vendors.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

ARP5061	Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-Connect Systems
AS5382	Aerospace Cable, Fiber Optic
AS5590	Connectors, Fiber Optic, Advanced, Circular or Rectangular, Plug and Receptacle, Environment Resistant, Removable Termini/Contacts, General Specification For
AS5675	Characterization and Requirements for New Aerospace Fiber Optic Cable Assemblies - Jumpers, End Face Geometry, Link Loss Measurement, and Inspection
AIR6031	Fiber Optic Cleaning

2.1.2 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, <http://quicksearch.dla.mil/>.

MIL-PRF-29504	Fiber Optic Terminus
MIL-PRF-49291	Optical Fiber
MIL-PRF-64266	Fiber Optic Connector
MIL-PRF-85045	Fiber Optic Cable
MIL-STD-1678	Fiber Optic Cable Systems Requirements and Measurements

2.1.3 Applicable References

TIA/EIA-440	Fiber Optic Terminology
ANSI/NCSL Z540.3	Requirements for the Calibration of Measuring and Test Equipment
ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

2.1.4 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or military standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.2 Definitions

ATTENUATION: Attenuation in fiber optics, also known as transmission loss, is the reduction in average optical power (or intensity of the light beam (or signal)) with respect to distance traveled through the fiber or fiber optic cable assembly/plant. Attenuation in general is expressed in dB without a negative sign.

ACCESSORY: Connector components such as backshells, strain relief, extenders, and adapters.

ACCESSORY CLOCKING: The angular relationship in degrees between the master connector key or keyway and the accessory.

BACKSHELL: The housing accessory on the back of a multichannel fiber optic connector that covers the area where the terminated fiber optic cables exit the back end of the connector.

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

BANDWIDTH-DISTANCE PRODUCT: A reference value, normalized to 1 km, used to predict the bandwidth capacity of other fiber lengths or concatenated fiber lengths over a specific distance. The bandwidth-distance product is determined by the physical construction of the fiber or cable and is expressed in frequency distance (usually as MHz-km or GHz-km). Bandwidth-distance product is given under specified launching and cabling conditions at a specific wavelength and is equal to the product of the fiber's length and the 3-dB bandwidth of the optical signal (or the maximum data rate of the optical signal). The bandwidth-distance product is typically limited by acceptable bit error rate.

BEND DIAMETER, MINIMUM, SHORT TERM: The short term bend diameter applies during handling, packing, unpacking, and installing.

BEND DIAMETER, MINIMUM, LONG TERM: The long term bend diameter applies to the completed installation.

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 fiber cladding.

BEND RADIUS: Fiber optic cable minimum bend radius (specified by the cable manufacturer or aerospace entity responsible for the performance, reliability, and durability of the installed cable) defines the minimum radius the cable can be safely bent without kinking it, damaging it, degrading its optical performance or shortening its short-term life (during packaging, shipping, and installation) and long-term operational life (while installed on the aerospace platform).

BREAKOUT LENGTH: Distance from where discrete fibers break out/branch out/fan out from the fiber bundle or ribbon.

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

CABLE ASSEMBLY: A cable, consisting of an optical fiber surrounded by layers of plastic and strength member material, that is terminated with a fiber optic terminus or connector at each end. The cable assembly is the optical interconnect medium for transmitting digital and/or analog communication signals using light rather than electricity.

CABLE PRECONDITIONING: A process whereby a fiber optic cable is removed from its spool and placed in temperature controlled chamber to remove intrinsic stress in the extruded cable jacket and/or inner tubing and/or the entire cable construction materials which in turn prevents uncontrolled cable shrinkage in the application environment.

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

CALIBRATION: Calibration is the comparison of a measurement system or device of unverified accuracy with a measurement system of known and greater accuracy, over the dynamic range of use, to detect any deviation (measurement uncertainty) from required performance specifications of the unverified measurement system or device over its dynamic range of use.

CALIBRATION TRACEABILITY: The calibration process includes the traceability of the measurement uncertainty through an unbroken calibration chain to the SI unit standards maintained by a nation's National Measurement Institute (NMI).

CENTRIFUGE: A centrifuge is a piece of equipment that puts an object (such as uncured epoxy in a tube or syringe) in rotation around a fixed axis, applying a force perpendicular to the axis. The centrifuge works using the sedimentation principle, in which the centripetal acceleration causes more dense substances to separate out along the radial direction (the bottom of the tube). By the same token, lighter objects (such as air bubbles) will tend to move to the top of the tube.

CHAFING: Repeated motions between cabling components, between cabling and equipment, between cabling and structure that result in wear causing mechanical failure and/or degraded or complete optical performance failure. Wear is the result of excessive rubbing, twisting, or bending.

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

CLADDING DIAMETER: The outside diameter of the cladding region.

CLAMPING LOSS: Bend loss induced by clamping the cable assembly on the aerospace platform.

CLEAVING: Cleaving entails inducing a defect on the outside diameter of the fiber with a diamond scribe or equivalent. To activate the cleaving process, after a mechanical defect is scribed on the outer surface of the fiber, the fiber is stressed longitudinally (tensile loading), which causes a crack to propagate across the fiber diameter. If proper tension is applied to the fiber as the nick is made, or immediately afterward, the fracture will propagate in a controlled fashion, creating the desired cleaved fiber endface. Rough cleaving is usually performed prior to fiber optic terminus polishing.

COEFFICIENT OF THERMAL EXPANSION (CTE): The coefficient of thermal expansion describes how the size of an object changes with a change in temperature. Specifically, CTE defines the fractional change in volume per degree change in temperature at a constant pressure.

CONNECTOR: Hardware installed on fiber optic cable ends to connect fiber optic cables to a device or another connector. Fiber optic connectors enable repeated mating and enable efficient coupling of optical power between two optical fibers or two groups of optical fibers.

CONTAMINANT: An unwanted constituent on the surface of a ferrule and fiber endface that requires removal.

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 transmitted.

CORE/CLAD CONCENTRICITY (or CORE-TO-CLADDING OFFSET): Core/clad concentricity defines how well the core is centered in the cladding glass region. Tighter core/clad concentricity tolerances help ensure that the fiber core is centered in relation to the cladding.

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.

DECONTAMINATION: Involves vacuum bake out for space-flight hardware. If ultraviolet instrumentation will be near hardware in final configuration, isopropyl alcohol rinse is used followed by a vacuum bakeout at 10^{-5} or less torr for 4 to 8 hours.

DIFFERENTIAL SCANNING CALORIMETRY (DSC): DSC defines the cured epoxy glass transition as a change in the heat capacity as the cured epoxy matrix transitions from the glass state to the rubber state. This is a second order endothermic transition (requires the application of heat to initiate and sustain the transition) so in the DSC the transition appears as a step transition and not a peak such as might be seen with a melting transition.

DISPERSION: Dispersion describes the chromatic or wavelength dependence of a parameter as opposed to the temporal dependence (temporal dependence is referred to as “distortion”). The term “dispersion” is also used to describe the relationship between refractive index, wavelength, and light signal propagation velocity.

ENDFACE GEOMETRY: Endface geometry defines fiber optic terminus end face parameters radius of curvature, apex offset, and fiber height.

ENDFACE INSPECTION: Endface inspection defines the process and equipment for inspecting the terminated fiber optic cable optical endface. Endface inspection pass/fail criteria are defined in the fiber optic cable termination process specification.

ENVIRONMENTAL STRESS SCREENING (ESS): ESS refers to the process of exposing a newly manufactured or repaired fiber optic cable assembly to stresses such as thermal cycling, vibration, and/or non-destructive pull testing in order to force latent defects to manifest themselves by failure during the screening process. The surviving population, upon completion of screening, can be assumed to have a higher reliability and lower infant mortality than a similar unscreened population.

EPOXY: Epoxy is a thermosetting polymer formed from reaction of polymer resin with polymer hardener.

EPOXY BUBBLE: A globular body of air or gas formed within liquid/unhardened epoxy.

EPOXY CURE SCHEDULE: The time and temperature profile used to convert the epoxy from a liquid/unhardened/uncured state to a solid/hardened/cured state.

EPOXY GLASS TRANSITION TEMPERATURE (T_g): Glass transition is a method to characterize a property of a cured epoxy material. The glass transition temperature is the temperature at which the cured epoxy goes from a hard, glass like state to a rubber like state. In aerospace fiber optics the best practice is to cure the epoxy to a glass transition temperature that exceeds the maximum application use temperature to avoid fiber movement inside the terminus or connector ferrule over the life of the aerospace platform. T_g is a phenomenon of cured epoxy which indicates percent cure (also called degree of cure), effectiveness of epoxy curing agents, effectiveness of epoxy cure schedule, and epoxy softening point at elevated temperature. T_g is characterized by a change in coefficient of thermal expansion, and a change in heat capacity, and a sharp decrease in elastic modulus.

EPOXY MIX RATIO: The ratio of polymer resin to polymer hardener whether measured by volume or weight.

EPOXY MIX RATIO TOLERANCE: The maximum allowable epoxy mix ratio error whether measured by volume or weight.

EPOXY POT LIFE: After the two epoxy parts are combined, the epoxy working time during which the combined epoxy can be applied or used.