AEROSPACE STANDARD

AS6021™	REV. A
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AS6021 Aerospace Fiber Optic Cable Assembly Drawing Specification

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE AS-3 Fiber Optics and Applied Photonics Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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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 (Tg): 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. Tg 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. Tg 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.

EPOXY SHELF LIFE: The maximum allowable time the polymer resin and polymer hardener can be stored prior to mixing and curing.

EPOXY SHELF LIFE EXPIRATION DATE: The date after which the epoxy must be scrapped.

EPOXY VOID: A body of air or gas formed within cured/hardened epoxy.

FATIGUE FACTOR: Fatigue factor (also called 'stress corrosion factor' or 'n') is a measure of the sensitivity of a fiber's tensile strength to a static load over time. The value for n is dimensionless, and is sometimes designated by how it's derived to be either "static" or dynamic.

FIBER OPTIC CABLE: A cable that is designed to transmit light waves between a light transmission source and a receiver. In signal applications, the transmitter and receiver include devices that are used to convert between optical and electronic pulses. Typical cables include a glass core, a layer of cladding having a lower refractive index to refract or totally reflect light inward at the core/cladding boundary, a buffer (coating), strength members, and outer jacketing to protect the inner cable from environmental damage.

FIBER PREPARATION: The act of preparing the fiber optic cable for cable termination. Steps typically include stripping back fiber cable jacket material, cutting strength member material, stripping inner cable materials, and/or stripping fiber coating material. Fiber preparation strip gauges and/or tooling blocks are typically used to define the critical cable strip length dimensions and dimensional tolerances.

FIRST ARTICLE TEST: A test that evaluates the first article for conformance to specified contract requirements before or in the initial stage of production.

HEAT CAPACITY: Heat required to change the temperature of one cubic centimeter of a substance one degree Celsius.

INSERTION LOSS: In a fiber optic cable assembly, insertion loss refers to the light transmission loss caused when a fiber optic component (a terminus, connector or splice) is inserted into a fiber optic cable. Insertion loss can result from absorption (intrinsic to the fiber or splice, or contaminants on the terminus endface), fiber-to-fiber core misalignment, or air gap between the fiber optic components. Insertion loss is the logarithm of the fraction of received power/transmitted power through a component in the link multiplied by 10. Generally, a lower insertion loss means a higher performance connection.

KEYING, CONNECTOR POLARIZATION CONFIGURATION: Mechanical features on fiber optic connectors that establish orientation, provide gross alignment, and prevent cross-mating.

KEYING, TERMINUS CONFIGURATION: An indexing feature that positions a fiber optic terminus in a specific orientation relative to the mating device.

LAUNCH CONDITION: Defines the stimulus used when making fiber optic loss measurements with a stabilized light source and optical power meter.

MODE FIELD DIAMETER (MFD): The mode field diameter (MFD) is an expression of distribution of the irradiance, i.e., the optical power per unit area, across the end face of a single-mode fiber. For a Gaussian power distribution in a single-mode optical fiber, the mode field diameter is that at which the electric and magnetic field strengths are reduced to 1/e of their maximum values, i.e., the diameter at which power is reduced to $1/e^2$ of the maximum power, because the power is proportional to the square of the field strength.

MULTICHANNEL CONNECTOR: A connector that contains two or more fiber optic termini.

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

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

POLARIZATION MODE DISPERSION (PMD): PMD is a property of singlemode fiber that can be caused by fiber birefringence, core asymmetry, and external mechanical and thermal stresses (PMD is a random phenomenon).

Light pulses launched into the fiber spread or broaden via the two orthogonal modes in the fiber separating, and traveling at different velocities in the fiber. PMD is expressed as ps/km$^{0.5}$.

PRECONDITIONING: Preconditioning is a post-fiber optic cable manufacturing process used to pre-shrink fiber optic cable prior to termination processing.

PROOF TEST: Proof testing (also called fiber tensile proof testing) is a technique to ensure minimum strength of optical fiber and eliminate the flaws whose sizes are dependent on the stress applied during proof testing. In proof testing predetermined load is applied on fiber by tensile loading. The fiber breaks at the weak points and the weak parts are eliminated from the fiber. The proof test will guarantee a minimum strength level (i.e., above proof testing stress) of the fiber and lifetime. Proof test is expressed in kpsi.

RETURN LOSS: In a fiber optic cable assembly return loss is the fiber optic light that gets reflected back at the connection point. Return loss is expressed in dB, with no negative sign. Return loss is the logarithm of the fraction of reflected power/transmitted power through a component in the link multiplied by 10. Generally, a higher return loss means lower reflection and a higher performance connection.

ROUGH CLEAVING: A process that is performed just prior to terminus polishing whereby the fiber protruding from the terminus endface is scribed and removed.

SCRIBING: Scribing is a process where a sharp diamond or sapphire implement forms a controlled nick on the fiber surface. The scribing process forms a mechanical flaw on fiber surface which in turn is used to initiate the propagation of a controlled crack across the diameter of the optical fiber.

TERMINUS: A fiber optic connection component that is terminated onto the end of simplex fiber optic cable and subsequently inserted into a cavity of a multiple fiber optic termini (or multichannel) connector.

THERMAL WORKMANSHIP: A non-optically monitored temperature cycling test that is conducted to detect cable assembly materials and workmanship defects prior to installation. Also may be known as burn-in.

WAVELENGTH: The distance (in micrometers or in nanometers), measured in the direction of propagation of a lightwave, between two successive points in the lightwave that are characterized by the same phase of oscillation.

3. AEROSPACE FIBER OPTIC CABLE ASSEMBLY SPECIFICATION REQUIREMENTS

3.1 Background

Aerospace fiber optic cable assemblies are specialized components designed to operate in non-mission critical, mission critical, and flight safety critical scenarios onboard aerospace platforms. As such aerospace fiber optic cable assemblies are designed, fabricated, tested, and installed in conformance with aerospace unique government and industry standards, best practices, specifications, and requirements.

3.2 Application Areas

Aerospace fiber optic cable assembly application area examples include digital fiber optic data and video communication and analog fiber optic signal transmission.

3.3 Utilization

The requirements specified in this standard and the associated applicable document standards shall be utilized by aerospace industry fiber optic cable assembly designers and manufacturers to ensure reliable, maintainable, and supportable performance over the expected life of the aerospace platform.

4. COMPONENTS AND MATERIALS

Components and materials shall be selected to meet the optical, environmental (temperature, humidity, thermal shock, etc.), and mechanical (shock, vibration, bending/routing, flexing, clamping, etc.) application requirements. Limits for the intended storage and operating temperature shall be clearly defined in the specification.

4.1 Fiber Specification

The fiber part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following fiber characteristics shall be specified:

Optical Characteristics

- Core/cladding diameter (SM and MM)
- Numerical aperture
- Minimum bandwidth-distance product (MM) (measurement method and wavelength shall be specified)
- Maximum transmission loss/attenuation (measurement method and wavelength shall be specified)
- Dispersion (SM)
- Mode field diameter (SM)
- Cutoff wavelength (SM)
- Operating wavelength

Composition

- Glass
- Coating material

Dimensions and Tolerances

- Glass and coating geometry
- Concentricity
- Tolerances

Other

- Proof test
- Fatigue factor (n)
- Minimum long term bend diameter
- Radiation hardness (if applicable)
- Fiber profile (step index, graded index, etc.)

4.2 Fiber Cable Specification

The cable part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following cable characteristics shall be specified:

- Maximum attenuation (wavelength (MM) wavelength band (SM) specified)
- Bandwidth-distance product (MMF only) (measurement method and wavelength shall be specified)
- Polarization mode dispersion (SMF only)
- Diameter (with tolerance specified)
- Operating temperature
- Storage temperature
- Storage conditions
- Short term minimum bend diameter
- Long term minimum bend diameter

- Cabled fiber geometry and dimensions
- Outgassing (for space applications only)
- Flammability
- Smoke
- Toxicity
- Preconditioning requirement (if applicable)
- Radiation (if applicable)

Fiber optic cable marking and labeling requirements shall be specified to ensure marking and labeling durability per the application requirement.

4.3 Terminus Specification

The terminus part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following terminus characteristics shall be specified:

- Ferrule material
- Loose, tight, or semi-loose cable or buffer construction compatibility
- Keyed or non-keyed
- Tunable (if applicable)
- Expanded beam (if applicable)
  - Lens type
  - Beam profile
  - Anti-reflection coating (if applicable)
  - Power threshold
  - Wavelength
  - Intermatability
- Strength member capture (e.g., internal, external, crimp, etc.) (if applicable)
- Cable size compatibility
- Pre-polish endface geometry (e.g., domed, angled, flat) (if applicable)

4.4 Connector Specification

The connector part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following connector characteristics shall be specified:

- Connector type
  - Simplex (LC, SC, ST, FC, SMA, etc.)
  - Multichannel circular or non-circular (e.g., ARINC, expanded beam, MIL, SAE-AS, etc.)
    - Number of channels, insert arrangement, and channel identification
- Relevant markings
- Gender (e.g., plug, receptacle, hermaphroditic, pin, socket (if applicable)).
- Mounting configuration (e.g., bulkhead/wall/panel mount, jamnut, or flange)
- Materials
  - shell
  - sealing components
  - insert
  - retention clips
- Plating (if applicable)
- Key configuration
- Shell size
- Sealing features
- Safety wire capability (if applicable)
- Any critical dimensions (e.g., for tightened mechanical tolerances) (if applicable)

4.5 Accessory Specification

The accessory part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following accessory characteristics shall be specified:

- Dimensions
- Type (e.g., banding style, conduit/convoluted tubing fitting, molded, sealed, strain relief boot, cable clamping, re-enterable, direct coupling, rotatable coupling, MIL-specified, etc.)
- Style (90 degree, 45 degree, straight, etc.)
- Clocking capability (if applicable)
- Materials
- Plating (if applicable)
- Shell size
- Strain relief (if applicable)
- Boot (if applicable)
- Bend restrictor (if applicable)

4.6 Protective Cap Specification

The protective cap part number (manufacturer's part number or the relevant military or industry specification) shall be specified in the fiber optic cable assembly specification or in a separate bill of materials. The following protective cap characteristics shall be specified:

- Cap type (temporary, permanent, or disposable)
- Dimensions
- Materials (cap, lanyard, attachment feature)
- Plating (if applicable)
- Shell size (if applicable)
- Lanyard attachment method (tear drop, eyelet, ring, crimp, etc.) (if applicable)

4.7 Cable Assembly Specification

4.7.1 Optical Requirements

The cable assembly specification optical requirements for each optical path shall define the following:

- Insertion loss (IL) or Assembly link loss pass/fail criteria
- Return loss (RL) pass/fail criteria (if applicable)
- Wavelength
- Launch condition
- Optical power (if high power then power handling requirement, e.g., continuous wave, pulse parameters)

4.7.2 Endface Coating Requirements

If applicable, the cable assembly shall specify fiber/ferrule endface coating performance (e.g., anti-reflective coating reflectivity, filter wavelength bandpass, angle of incidence).

4.7.3 Pinout Table/Connection Diagram

If applicable, a pinout table/connection diagram shall specify the location of termini, dummy pins, and sealing plugs.

4.7.4 Clocking Configuration

If applicable, the cable assembly shall specify the clocking configuration.

4.7.5 Cable Assembly Length

The cable assembly length (e.g., overall length, breakout locations, lengths and angles, fan out lengths, clamp marker location(s), etc. (if applicable)), and units and tolerances shall be specified. The measurement datum point(s) shall be specified. For simplex fiber optic cable configurations the cable assembly length shall be specified tip-to-tip.

4.7.6 Epoxy Specification

The cable assembly specification shall specify the epoxy manufacturer's name and part number or the relevant military or industry specification shall be specified.

4.7.7 Marking and Labeling Specification

The cable assembly marking and/or labeling material and location requirements shall be defined.

4.7.8 Non-Destructive Pull Test

If applicable, the cable assembly specification shall define a non-destructive pull test pass/fail value and test methodology.

5. MATERIAL PROCESSING

5.1 Terminus Processing (if applicable)

The terminus shall be processed per the terminus manufacturer's instructions.(e.g., cleaning, O-ring installation).

5.2 Connector Processing (if applicable)

The connector shall be processed per the connector manufacturer's instructions (e.g., pre-assembly or disassembly).

5.3 Cable Processing

The cable shall be processed per the platform integrator instructions (e.g., preconditioning, annealing, cutting to length, spooling, coiling, marking, labeling, etc.).

5.4 Accessory Processing

The accessory(s) shall be processed/assembled per the platform or subsystem integrator's instructions.

5.5 Non-Metallic Materials Processing (if applicable)

For space applications only, non-metallic materials processing shall be specified (ASTM E595 compliance or vacuum degas).

5.6 Epoxy Storage, Handling, and Shelf Life

Epoxy storage conditions and shelf life shall be specified. Epoxy handling shall be specified.

6. TERMINATION PROCESS

The termination process shall be specified and shall define:

6.1 Fiber/Cable Preparation (i.e., strip lengths)

Fiber and cable strip lengths shall be specified.

6.2 Epoxy Processing

- Mixing procedure (and epoxy mix ratio and tolerance)
- De-gassing or centrifuging (to remove air bubbles)
- Pot life
- Injection method (to avoid epoxy voids)
- Cure schedule (to achieve the required epoxy glass transition temperature and avoid over-stressing the fiber)
-or- terminus manufacturer's recommended process
-or- platform integrator recommended process
-or- subsystem integrator recommended process

6.3 Post Epoxy Cure Cleaving

If applicable, the post epoxy cure fiber cleaving process shall be specified.

6.4 Polishing Procedure

Terminus polishing procedures shall be specified.

6.5 Cleaning Procedure

The terminated cable terminus cleaning procedure shall be specified.

6.6 Endface Geometry Measurement

The terminated cable end face geometry criteria and test method shall be specified.

6.7 Endface Inspection Criteria

The terminated cable end face inspection criteria and test method shall be specified.

6.8 Optical Testing

The terminated cable optical test criteria and method shall be specified.

7. MULTICHANNEL CONNECTOR CABLE ASSEMBLY COMPLETION

7.1 Populating a Multichannel Connector

Populating a multichannel connector with termini shall be completed in accordance with the connection diagram/pinout table (including dummy pins and sealing plugs as required).

7.2 Accessories

Accessory types, materials, and orientation (if applicable) shall be defined.

7.2.1 Requirements for single cables in multifiber cable assemblies and cable housing multiple single cables shall be defined (if applicable).

7.3 Mounting Hardware

Mounting hardware types, materials, and installation (e.g., nut plates, seals, jam nuts, etc.) shall be defined (if applicable).

7.4 Heatshrink / Boot Material

Heatshrink tubing or boot materials and location shall be defined (if applicable).

7.5 Cable Protection

Cable protection (braiding, expandable sleeving, conduit, etc.) materials and location shall be defined (if applicable).

7.6 Potting / Molding

Potting and/or molding requirements shall be defined (if applicable).

7.7 Marking / Labeling Materials

Marking and/or labeling materials and application procedures shall be specified to ensure durability per the application requirement.

7.8 Marking / Labeling Locations

Marking and/or labeling locations shall be defined.

7.9 Special Tool

Special tools required for assembly, alignment, or terminus insertion/removal shall be defined.

8. ACCEPTANCE TEST COMPLIANCE

The cable assembly acceptance test procedures and pass/fail criteria shall be defined and agreed to between the cable assembly supplier and the recipient of the cable assembly. The cable assembly acceptance test procedure shall be approved by the platform or subsystem integrator.

8.1 First Article Testing

A first article test report shall be produced. First Article testing and approval ensures that the fiber optic cable assembly supplier can furnish a product that conforms to all contract requirements for acceptance. First article “testing” includes the necessary inspections and tests to ensure all product characteristics conform to drawings or specifications.

8.2 Endface Inspection

The terminated fiber optic cable shall be inspected using the appropriate definitions, procedures, and pass/fail criteria described in AS5675.

8.3 Insertion Loss Testing

Insertion loss or assembly link Loss shall be performed and recorded using the appropriate definitions and procedures described in AS5675.

8.4 Return Loss Testing (if applicable)

Return loss (RL) shall be performed and recorded using the appropriate definitions and procedures described in AS5675.

8.5 Non-Destructive Pull Test (if applicable)

If required by the platform or subsystem integrator, a non-destructive pull test with optical monitoring shall be performed to verify correct function of the terminated cable strain relief system (i.e., to ensure the fiber is isolated from external stress during connector mating and installation of the cable, and future cable assembly maintenance actions).

8.6 Terminus, Connector, and Protective Cap Cleanliness

The terminus, connector, and protective cap shall be clean prior to cable assembly packaging and shipping.

8.7 Thermal Workmanship (space applications only)

For space applications, thermal vacuum testing shall be performed.

8.8 Decontamination (space applications only)

For space applications decontamination shall be performed in accordance with specifications.

8.9 Environmental Stress Screening (ESS) (if applicable for production testing)

If required by the platform or subsystem integrator, ESS shall be performed to reduce the probability of infant mortality failure events. ESS requirements shall be defined by the platform integrator or subsystem integrator.

9. QUALIFICATION

If required by the platform or subsystem integrator, qualification requirements shall be specified and approved, and a qualification test report shall be produced. Qualification shall be performed to ensure the cable design and assembly process meet the specified optical, environmental, mechanical, durability, and reliability application requirements.

10. DOCUMENTATION

Documentation to be retained/archived by the cable assembly manufacturer shall include:

- Lot numbers
- Materials traceability
- First article test records
- Qualification records
- Acceptance testing results records

Documentation delivered by the manufacturer to the customer shall include acceptance testing results for each production unit and lot.

11. QUALITY ASSURANCE

The fiber optic cable assembly manufacturer shall have documentation requirements that are established, documented, implemented, and maintained.

12. PACKAGING AND SHIPPING

Procedures shall be in place to ensure that the cable assembly is packed in a manner to avoid damage during shipping, storage, and unpacking.

13. STORAGE

The cable assembly manufacturer shall provide product storage instructions to avoid damage during storage.

14. NOTES

14.1 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

APPENDIX A - CABLE ASSEMBLY LENGTH

The cable assembly length shall be specified as -0, +Application specific tolerance whereby the tolerance shall be no less than 12.5 mm (0.5 inch) for non-repairable fiber optic cable assemblies and 50 mm (2 inch) for repairable fiber optic cable assemblies.

APPENDIX B - CABLE ASSEMBLY OUTGASSING

All non-metallic materials shall be tested in accordance with ASTM E595. The test method requires a 100 to 300 mg sample to be exposed to 125 °C at 10^{-6} Torr for 24 hours. Afterward the Total Mass Loss (TML) has to be less than 1% and the Collected Volatile Condensable Materials (CVCM) must be less than 0.1%. In some cases if the TML is slightly higher but the CVCM meets the criteria, then a vacuum bakeout at elevated temperature (~100 °C) for 24 hours @ 10^{-2} Torr is required.