



AEROSPACE STANDARD

AS6479™

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Splicer, Fusion, Fiber Optic, Aerospace

RATIONALE

Successful use of fiber optic interconnects in high-performance platforms and applications depend on viable technologies for their repair and installation. Splicing is often desirable, either to repair a damaged interconnect or to install it, particularly where it is difficult or impossible to access all necessary locations for complete removal and replacement. However, reliable aerospace cable splices must endure conditions as adverse as those for which the original cable was specified. In addition, the splicing technology must be usable with a high degree of reliability under difficult aerospace working conditions. Mechanical splices have shown some promise for the repair of multi-mode aerospace fiber cables, but they face daunting difficulties in splicing single mode fiber cables, which are being ever more seriously considered for new and upgraded systems. Fusion splicing has long been accepted in the telecom industry for making the highest performance fiber splices, both single mode and multi-mode, but the technology has not yet been found adaptable to stricter aerospace requirements. This standard is intended to define fusion splicers suitable for these requirements.

1. SCOPE

This SAE Aerospace Standard (AS) defines fiber optic fusion splicers acceptable for the installation and repair of fiber optic interconnects in aerospace applications. Two different application environments are defined, depending on whether there is risk of flammable vapor or hazardous atmosphere being present. Equipment suited to flammable or hazardous environments may be over specified for factory, depot, or other relatively safe environments. To address these different application environments, two types of fusion splicer will be specified in applicable detail specifications:

Type I. For hazardous environments specifically including potentially flammable or explosive atmospheres.

Type II. For environments in which it is established that there is no risk of flammable or explosive vapors being present.

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.

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SAE WEB ADDRESS:

Full document details: SAE AS6479

For more information on this standard, visit
<https://www.sae.org/standards/content/AS6479/>

Documents
Document Sharing Hub

2.1.1 Military Specifications

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-28800F Test Equipment for Use with Electrical and Electronic Equipment, General Specification for

2.1.2 Military Standards

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

MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-472	Military Standardization Handbook – Maintainability Prediction
MIL-STD-1472F	Human Engineering
MIL-STD-130N	Identification Marking of U.S. Military Property
MIL-STD-461F	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-464C	Electromagnetic Environmental Effects, Requirements for Systems
MIL-STD-810G	Test Method Standard
MIL-STD-882	System Safety
MIL-STD-1678-2	Fiber Optic Cabling Systems Requirements and Measurements, Part 2 (Optical Measurements)
MIL-STD-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
NAVAIRINST 2400.1	Spectrum-Dependent Systems: Those electronic systems, subsystems, devices and/or equipment that depend on the use of the
OPNAVINST 2400.20F	Electromagnetic Environmental Effects (E3) and Spectrum Supportability Policy and Procedures

2.1.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI Z136.2 Standard for the Safe Use of Lasers

2.1.4 IEEE Publications

Available from IEEE, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE-STD-315 Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)

2.1.5 TIA/EIA Publications

Copies are available from IHS Global Inc., tel. 800-854-7179 (U.S. and Canada), +1-303-397-7956 (Outside U.S. and Canada), <http://global.ihs.com>.

TIA/EIA-455 Fiber Optic Test Procedures

TIA/EIA-455-6B Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices

TIA/EIA-455-34 (FOTP-34) Interconnection Device Insertion Loss Test (ANSI/TIA/EIA-455-34A 95)

2.1.6 International Electrotechnical Commission (IEC), CENELEC, and British Standards Institution (BSI) Publications

Available from International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC 1000-4-2 Electrostatic Discharge Requirements

IEC 60950 Safety of information technology equipment

2.1.7 UL Publications

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL1950 Safety of Information Technology Equipment, Including Electrical Business Equipment

2.1.8 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D4169 Standard Practice for Performance Testing of Shipping Containers and Systems

2.1.9 National Fire Protection Agency (NFPA) Publications

Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

NFPA 1994 Standards for Chemical, Biological, Radioactive, and Nuclear Protective Ensembles

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

2.2.1 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

AS5750 Loss Budget Specification for Fiber Optic Links

MA5405 Splices, Fiber Optics, For Aerospace Inter-Connection Systems

AIR6031 Fiber Optic Cleaning

2.2.2 Military Specifications

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

A-A-59799 Commercial Item Description: Fusion Splicer and Cleaver, Optical Fiber

MIL-PRF-24623/6 Splice, Fusion, Fiber Optic Cable, Protector

MIL-PRF-24623/7 Splice, Mechanical, Simplex Fiber Optic Cable, Aircraft

MIL-PRF-49291 Optical Fiber, (Metric) General Specification for

MIL-PRF-85045 Cables, Fiber Optic, (Metric) General Specification for

2.2.3 Military Standards

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

MIL-STD-1678 Fiber Optics Test Methods and Instrumentation

MIL-STD-46855 Human Engineering Requirements for Military Systems, Equipment, and Facilities

NAVAIR 01-01A-505-4 Installation & Testing Practices, Aircraft Fiber Optic Cabling

NAVAIRINST 4200.25D Management of Critical Application Items Including Critical Safety Items

2.2.4 Aeronautical Radio (ARINC) AEEC Committee, Fiber Optics Subcommittee (FOS) Publications

Available from ARINC, 2551 Riva Road, Annapolis, MD 21401-7435, Tel: 410-266-4000, www.arinc.com.

ARINC 805 Fiber Optic Test Procedures

ARINC 806 Maintenance and Repair of Fiber Optic Cables

2.2.5 TIA/EIA Publications

Copies are available from IHS Global Inc., tel. 800-854-7179 (U.S. and Canada), +1-303-397-7956 (Outside U.S. and Canada), <http://global.ihs.com>.

TIA/EIA-440B Fiber Optic Terminology

TIA/EIA-455-8 (FOTP-8) Measurement of Splice or Connector Loss and Reflectance Using an OTDR (ANSI/TIA/EIA-455-8-2000)

TIA/EIA-455-20 (FOTP-20) Measurement of Change in Optical Transmittance

TIA/EIA-455-171 (FOTP-171) Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies (ANSI/TIA/EIA-455-171-A)

TIA-526-7 (OFSTP-7) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

TIA-526-14 (OFSTP-14) Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant

2.2.6 European Union Publications

Directive 1999/92/EC Risks from explosive atmospheres

Directive 94/9/EC ATEX (Atmospheres Explosibles) Products Directive

2.2.7 IEEE Publications

Available from IEEE, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE standard 1349 Electrical Motors in Class I, Division 2, Hazardous Atmospheres

2.2.8 Instrument Society of America Publications

ISA-TR12.13.03 Guide for Combustible Gas Detection as a Method of Protection

2.2.9 International Electrotechnical Commission (IEC), CENELEC, and British Standards Institution (BSI) Publications

Available from International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

EN 50014 Electrical apparatus for potentially explosive atmospheres. General requirements

EN 50016:2002 Electrical apparatus for potentially explosive atmospheres. Pressurized apparatus "p"

EN 50018:2000 Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'

EN 50020:2002 Electrical apparatus for potentially explosive atmospheres. Intrinsic safety 'i'

EN 60079-0:2004 Electrical apparatus for explosive gas atmospheres. General requirements

IEC 61010-1:2010 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements

EN 61779 Electrical apparatus for the detection and measurement of flammable gases

2.2.10 National Fire Protection Agency (NFPA) Publications

Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

NFPA 70 National Electrical Code

NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors

2.2.11 Telcordia Publications

Copies are available from Telcordia Technologies, Inc., 1 Telcordia Dr., Piscataway, NJ 08854-4151, tel. 732-699-2000.

GR-765-CORE Single Fiber Single Mode Optical Splices and Splicing Systems

2.2.12 UL Publications

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

- 1203 Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
60079-0 Electrical Apparatus for Explosive Gas Atmospheres -- Part 0: General Requirements

2.2.13 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

- DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.3 Definitions

ACCESSORY: An accessory is an assembly or a group of parts or a unit that is not always required for the operation of a test set or unit as originally designed but serves to extend the functions or capabilities of the equipment; for instance headphones for a radio set supplied with a loudspeaker, an external power unit for use with a set having a built-in power supply, or a remote control unit for use with a set having integral controls.

APPROVED EQUIPMENT TEST PROCEDURE: The test procedure furnished by the Government or furnished by a contractor in accordance with the requirements of the contract or order and approved by the Government in accordance with the contractor order.

ATE: For the purpose of this specification, the terms “automatic test equipment” (ATE) and automatic checkout equipment (ACE) are synonymous.

BENCH-TOP EQUIPMENT: Bench-top equipment is designed to be used on a fixed bench or table or on a mobile cart. Equipment that exceeds 5 kg in weight and has no handles, or exceeds 20 kg with or without a handle, is considered to be bench-top equipment.

BIT: For the purpose of this specification, the term “built in test” (BIT) identifies the test approach using either “built in test equipment” (BITE) or self-test capability or both.

BITE: Any device that is part of, or permanently mounted in, the prime equipment and used for the express purpose of testing that equipment, either independently or in association with external test equipment.

CALIBRATION INTERVAL: The maximum length of time between calibration services during which a specified percentage of equipment is expected to remain within acceptable performance levels under normal conditions of handling and use.

CERTIFICATION TIME: Certification time includes all time required to check the equipment parameters on all range and function settings and all inputs and outputs. Certification time does not include the time to repair and readjust the equipment as a result of a malfunction.

COMPONENT BATTERIES: Batteries used as components designed for extended use and reliability equal to or exceeding that of other components (such as resistors or capacitors) that are incorporated into the equipment.

CONFIGURATION: Configuration is used to identify two or more units from a single purchase description that differ in class or other electrical or mechanical characteristics.

DESTRUCTIVE CORROSION: Destructive corrosion is any type of corrosion that in any way interferes with mechanical or electrical performance of the equipment or associated parts.

DIMENSIONS: Dimensions are specified in units of width, height, and depth of the equipment in its normal operating orientation, and may be specified as maximum or partial, or both. Maximum dimensions include all handles, latches, knobs, and other major protuberances, and are the interior dimensions of the smallest rectangular box into which the equipment (less detachable cords, cables, or accessories) may be fitted. Partial dimensions, when specified, include major protrusions except removable handles, connectors, bumper feet, latches, and cover. Partial depth, when specified, is defined in a and b:

- a. Portable bench-top equipment. From the front surface of the front panel (less removable bezels, handles, or cover) to all rear protrusions except controls, bumper feet, connectors, latches, or handles.
- b. Rack-mounted equipment. From the rack-mounting surface (normally, the rear surface of the front panel) to the rearmost permanent protrusion, including any connectors or controls, but not including cable retractors, slide-out track parts not fixed to the equipment, or cable clearances.

ENCLOSURE: Enclosure and case are interchangeable terms that may apply to any item of equipment.

EQUIPMENT/UNIT: Equipment is an instrument, with the parts, accessories, components, or any combination thereof, required for performing a specified operational function. Unless otherwise specified the equipment consists of a single instrument or a mainframe and plug-in configuration. When a mainframe and plug-in configuration is supplied, the combined weight will not exceed the maximum weight allowed by the detail specification or purchase description. Accessories, such as sensors, leads, bridges, loads, and adapters, will be provided with a storage case. Certain equipment may be complete within itself and may not require the addition of parts, accessories, or components to perform a specified operational function. The term 'units' is used to denote multiple items of equipment.

FAILURE: Equipment failure as used herein is any departure from the required performance or operation outside of the required bounds (not correctable by normal use of the operating controls), or deviation from the criteria of 4.5 after the test is initiated.

INTERMITTENT AND SHORT-TIME OPERATION: Intermittent and short-time operation are alternating periods of operation for the specified time followed by 15 minutes of non-operation.

LOT: The size of a lot is that quantity of units from each individual production run that is specifically set aside for delivery to the Government (i.e., if a given production run consists of 1000 units of which ISO are set aside for delivery to the Government, the lot size would be ISO). Portions of separate production runs will not be combined into a single lot but will be treated as individual lots.

NONREPAIRABLE SUBASSEMBLY: A component, module, or subassembly is nonrepairable if the physical nature of the item is such that the item cannot be economically or feasibly repaired due to the excessive cost of material and labor required to affect such repair. This excessive cost is normally considered to be 65% or greater of the acquisition cost of the item. Examples of nonrepairable subassemblies are: (a) an integrated circuit, (b) a printed circuit card wherein the components and card are sealed in a hard thermosetting plastic compound, and (c) a module wherein all printed circuit cards or components are sealed in a hard thermosetting plastic compound or the module is hermetically sealed.

PERFORMANCE REQUIREMENTS OF THE TEST EQUIPMENT: Wherever referenced in this specification, the performance requirements of the test equipment means the satisfactory performance of all electrical and mechanical characteristics under the conditioning, destructive, and accelerated tests specified by the detail specification or purchase description for simulating anticipated field service demands as closely as possible.

PERFORMANCE TESTS, LEVELS A, B, AND C: Level A and Level B performance tests are characterized by the degree of testing performed for ability to splice optical fibers. Level A testing is intended to be a minimal amount of testing per unit, that is performed on each unit of a lot, or before or after most stress tests. Level B testing is more extensive but is limited to certain samples of the lot, and used to conclude each assessment Group. Level C testing is a complete battery of tests of all aspects of the equipment's ability to splice fiber optic cables.

PORTABLE EQUIPMENT: Portable equipment is designed to be easily carried between locations of use. Equipment of 5 kg or less in weight that can be safely moved without handles, or 20 kg or less and provided with a handle, is considered to be portable. Portable equipment may be designed for portable as well as bench-top use.

PROCURING ACTIVITY: The Military, Federal, or non-government organization contracting for equipment.

PURCHASE DESCRIPTION: Purchase description as used herein may include an acquisition document referred to as a Salient Characteristic or Purchase Document that details equipment performance characteristics.

RUGGEDIZED: Physical and operational characteristics that allow equipment to withstand rough handling and extreme or hostile environments.

SATISFACTORY OPERATION CHECK: A satisfactory operation check employs a maximum number of active circuits of the equipment with a minimum requirement for external input or evaluation equipment to ensure that all basic functions of the equipment are operational.

SATISFACTORY OPERATION TEST: A satisfactory operation test employs the necessary external input and evaluation equipment to determine if the equipment splices optical fiber cables properly.

SELF-TEST: A self-test is a test or series of tests, performed by a device upon itself that shows whether or not the device is operating within designed limits. This includes test programs on computers and ATE that check out their performance status and readiness as well as Pre-Operational Self-Test (POST).

SPECIAL TOOLS: Special tools are tools not listed in the National Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Service).

STANDBY: Equipment is considered to be in a standby condition when at least one part of its circuitry is energized regardless of the power switch setting.

3. SAFETY

3.1 Fiber Handling

When handling bare optical fibers, care should be taken to prevent pieces of fiber from puncturing the skin or breakage causing fragments to fly into the user's eye. Safety glasses should be worn when working with fibers, and fiber ends should be disposed of carefully. 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 quite difficult to remove, being nearly invisible in tissue. It is particularly important to keep strays bits out of the eyes, where removal is even more difficult. During fiber cable installation and repair, all snipped or cleaved pieces of optical glass fibers should be stowed in appropriate disposal containers. Placing fibers on an adhesive tape strip can be risky and should not be done. In addition, all cables with protruding bare fibers should be adequately covered or positioned to preclude accidental puncture. The best defense against injury by fibers is common sense. Eating and drinking around fibers must also be considered risky. Since fiber fragments can stick to skin due to its oil, thoroughly wash your hands before touching your face or eyes after working with fibers. Waste pieces of optical fiber must never be put in ordinary garbage for routine disposal.

3.2 Eye Safety from Radiation

Although the optical power present in most fiber installations can be fairly low, the small dimensions of fiber cores and semiconductor sources makes it possible for radiant intensities to attain quite high values. If an optical cable is disconnected or broken and the exposed end is examined, there may be risk of eye damage, particularly if a magnifier or other visual aid is used. All systems should be assumed to be 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.

Please refer to ANSI Z136.2 for additional eye safety precautions.

3.3 Lasers

The lasers used as fiber sources typically operate at 850, 1300, and 1550 nm wavelengths, which are all in the infrared part of the light spectrum. These first two wavelengths along with visible light are focused by the eye's lens onto the retina. Retinal receptors are sensitive to the range of wavelengths between 400 and 700 nm, but not to wavelengths outside that range. Herein lays 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, the 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 possible even though lasers for fiber use are actually of low power compared to other laser types. Lasers are classified into four general categories depending on their operating wavelength, output power, and whether they are pulse or continuous wave.

It should be noted that multimode fiber systems normally use light emitting diodes (LEDs) as sources, not lasers. Being both lower in power and incoherent in emission, LEDs do not pose the safety issues that lasers do.

3.3.1 Class 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 nm, is more heavily absorbed by the retina, the maximum allowable output power of Class 1 lasers generally increases with increasing wavelength. As laser emission at wavelengths greater than 1400 nm is absorbed by the cornea, no focusing onto the retina occurs and the Class 1 laser maximum allowable output power increases dramatically.

3.3.2 Class 2

Class 2 lasers are those for which the aversion response will generally protect a person from the output. Class 2 lasers therefore include only those emitting visible radiation. Many fiber identifiers fall into this category. Class 2 lasers are very uncommon in fiber systems, however.

3.3.3 Class 3

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

3.3.4 Class 4

Class 4 lasers are high in radiant power and are not usually used in communications/data cable plant applications. 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 output ports, where power is coming directly from the laser.

3.4 High Voltage

Fusion splicers splice optical fibers by creating a high voltage plasma between two electrodes, which heats and melts the glass fibers in order to weld them together. Generally fusion splicers are designed with safety covers and interlocks, so that the high voltage cannot be activated when the electrodes are accessible to the user, but it is vital to keep the potential in mind. Do not touch the electrodes whenever the equipment is powered on. The user could suffer severe electrical shock if the high voltage were somehow activated while he was touching the electrodes.

3.5 System Safety and Reliability

3.5.1 System Safety

The design of the equipment should eliminate or minimize hazards to personnel in accordance with MIL-STD-882. If such hazards cannot be eliminated, design controls, special operating procedures or the use of safety and warning devices should be implemented or recommended. Warning provisions, inspection provisions, and/or procedures should be provided such that failures can be detected and corrected. Design of equipment should minimize the probability of operator or maintainer induced failures of the equipment while performing operations, maintenance, or testing in accordance with technical data, operation handbooks, or test procedures.

- 3.5.1.1 The equipment should comply with the safety requirements of IEC 60950. All accessible surfaces of the equipment shall be at ground potential. All externally exposed metal parts, shields, control knobs, switches, handles, connectors, or bushings shall be grounded to the chassis.
- 3.5.1.2 The operation of the equipment shall not cause ignition of an ambient-explosive gaseous mixture with air (Type I) (see 5.5.6.9).
- 3.5.1.3 The equipment shall not contain materials that promote the premature failure of the equipment or that present a health hazard under normal use or storage conditions as specified below.
- Organic materials: The equipment shall not contain materials prone to organic decay or that act as a nutrient for the growth of multi-celled organisms (see 5.5.6.7).
 - Flammable materials: The splicer shall not contain materials that ignite into flames at operating or storage temperatures (see 4.4.2, 4.4.3, and 5.5.5.1.1).
 - Explosive materials: The splicer shall not contain materials that explode at operating or storage temperatures (see 4.4.2, 4.4.3, and 5.5.5.1.1).
 - Toxic Materials: Toxic materials shall not be contained in the equipment or generated under normal or fault conditions in accordance with the following: decomposition or deterioration of materials contained in the equipment shall not liberate toxic, corrosive, or explosive fumes. Combination of materials contained in the equipment with surrounding materials, including the atmosphere, shall not be detrimental to the health of the equipment operator due to the generation of toxic materials. Explosion or implosion of any part of the equipment shall not release toxic materials.

4. REQUIREMENTS

4.1 General

4.1.1 Detail Specifications

The product requirements shall be as specified herein and in accordance with the applicable detail specification. In the event of any conflict between the requirements of this general specification and the detail specification, the latter shall govern.

4.1.2 Qualification

A qualified product shall be one that has been tested and has passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable Qualified Products List (see 5.2).

4.1.3 Design and Construction

Unless otherwise specified the fusion splicer shall be designed and constructed to provide the following functions:

- Hold two prepared fibers and associated aerospace cables safely and securely for splicing
- Automatically align the two fibers to a precision of 1 µm or better
- Automatically check the two fiber ends for quality of preparation sufficient to make a low-loss splice
- Automatically weld the two fibers together using a high-voltage electric arc or plasma in such a way as to make a low-loss splice
- Automatically calculate and display a splice loss estimate

- Have the capability of applying a tension test to the splice before the fibers are released
- Include features to exclude adverse environments which would otherwise induce poor-quality performance
- When specified, include features to insure safe operation in explosive or flammable atmospheres
- Embed all components necessary for automatic processing and control, fiber imaging, fiber alignment, high voltage generation and control, environment sensing for self-calibration, display monitor, and user interface and control
- Include accessories as necessary for power supply
- Be adapted to suitable tools and methods for cable and fiber preparation and cable restoration post-splicing

The fusion splicer shall be designed and constructed for use in all environments where a user's hands can work, as detailed below, and ruggedized to endure all specified mechanical and environmental stresses and conditions.

4.1.4 Markings

All markings intended for the user (i.e., touch locations, movement directions, connection points, etc.) shall be of size, color, and clarity to insure unambiguous understanding under all specified conditions, per MIL-STD-46855.

4.1.5 Workmanship

The product shall be of quality workmanship sufficient to insure reliable operation and easy maintenance for at least 12 months when used under normal working conditions.

4.1.6 Reliability

Each item associated with the equipment shall have a documented MTBF of 500 splice operations or greater, other than for normal wear or expendable items.

4.2 Splicing Capabilities

4.2.1 Types of Fibers

The fusion splicer shall be capable of making low-loss splices on the following types of fibers:

- Single mode
- Bend-resistant single mode
- Multi-mode, step index
- Multi-mode, graded index
- Multi-mode, radiation-hardened

4.2.2 Core Size Range

The fusion splicer shall be capable of making low-loss splices on silica fibers with core sizes from 5.8 to 200 μm .

4.2.3 Silica Cladding Size Range

The fusion splicer shall be capable of making low-loss splices on silica fibers with cladding diameters from 125 to 230 μm .

4.2.4 Coating Size Range

The fusion splicer shall be capable of making low-loss splices on fibers with coating diameters from 155 to 900 μm .

4.2.5 Non-Strippable Coating Types

The fusion splicer shall be capable of making low-loss splices on fibers with the following functionally “non-strippable” coatings (i.e., without removing the coating from the fiber before fusion splicing):

- Amorphous carbon (hermetic)
- Polyimide (155, 170, or 172 μm)

4.2.6 Primary Buffer Coating Materials

The fusion splicer shall be capable of making low-loss splices on fibers with the following types of primary coatings (strippable):

- Standard telecom-type acrylate (250 μm nominal)
- High-temperature acrylate (245 $\mu\text{m} \pm 15 \mu\text{m}$)
- Silicone (250 μm)

4.2.7 Secondary Buffer/Coating (Jacket) Types

The fusion splicer shall be capable of making low-loss splices on fibers with the following types of secondary buffer coatings or jackets:

- Loose tube
- Semi-loose
- Tight buffer

4.2.8 Secondary Buffer/Coating Materials and Diameters

The fusion splicer shall be capable of making low-loss splices on fibers with secondary buffer coatings or jackets of the following materials and diameters:

- ETFE (ethyltetrafluoroethylene) (450 $\mu\text{m} \pm 25 \mu\text{m}$, 500 $\mu\text{m} \pm 30 \mu\text{m}$, or 900 $\mu\text{m} \pm 50 \mu\text{m}$)
- Hytrel
- Nylon
- PTFE (polytetrafluoroethylene) loose tube (900 μm)

4.2.9 Cable Strength Members

The fusion splicer shall be capable of making low-loss splices on fiber cables with the following types of strength members:

- Fiberglass, braided
- Aramid yarn, braided
- Aramid yarn, straight or low-pitch helically wound

4.2.10 Cable Jacket Sizes (Simplex Cables)

The fusion splicer shall be capable of being fixtured to accept fiber cable jacket diameters of 1.2 to 3.0 mm while making low-loss splices on the fibers.

4.2.11 Cable Jacket Materials

The fusion splicer fixtures shall grip the outer jacket of cables/fibers being spliced without causing any damage to cable, fiber, or equipment. In any loose-tube or semi-loose configuration the equipment shall grip the fiber with sufficient force to secure the fiber sufficiently to insure proper results.

4.2.12 Insertion Losses

Under laboratory conditions the fusion splicer shall splice fibers with mean insertion loss of 0.03 dB or better (single mode fiber) or 0.02 dB or better (multimode) as defined below.

TABLE 1 - SPLICE LOSS REQUIREMENTS

Specification	9/125 μm SMF	62.5/125 μm MMF	100/140 μm MMF	200/230 μm MMF
Median or "typical"	0.02 dB	0.01 dB	0.01 dB	0.01 dB
Mean	0.03 dB	0.02 dB	0.02 dB	0.02 dB
Max	0.10 dB	0.05 dB	0.05 dB	0.05 dB

NOTE: Any one machine may not be required to splice all of the above fibers and meet the insertion loss requirements. See the detail specification for requirements applicable to any one machine.

4.2.13 Splice Loss Estimation

The fusion splicer shall calculate and display an insertion loss estimate following every splicing cycle. It is understood that this will be inferred from indirect measurements, not obtained from a direct measurement of throughput.

The accuracy of the measurement shall meet the criteria below:

For splice losses <0.15 dB: at least 90% of estimates shall be within +0.03 dB of true loss
For splice losses >0.15 dB: at least 90% of estimates shall be within +25% of true loss

4.2.14 Intrinsic Splice Strength (independent of the capacity of the splicer to test it)

The tensile (breaking) strength of completed bare fiber splices, measured under laboratory conditions using homogeneous fibers (cut from the same spool), shall be as follows.

- Mean: >100 kpsi
- Minimum: >50 kpsi
- Yield: >90%

4.3 Functional Requirements

4.3.1 Pre-Screen

The equipment shall automatically pre-screen the fiber ends before processing them and not splice unless both are judged acceptable. If one or both fibers are judged unacceptable the equipment shall give the user a clear visible indication of:

- which fiber is faulty
- the nature of the fault
- the option to override the judgment and continue

4.3.2 Post-Splice Assessment

After splicing, the equipment shall automatically inspect the splice, make a loss estimate, and make the following information available to the user:

- pass/fail according to preset criteria
- splice loss estimate
- date and time
- splicing profile used
- other information TBD
- image of each splice

The data shall be stored in non-volatile memory and be exportable.

NOTE: For single mode splice loss estimates over a predetermined value not exceeding the maximum allowable loss, the device shall warn the user and recommend either re-arc or re-splice to achieve a lower splice loss estimate, or else allow a manual override. For single mode splice loss estimates over the maximum value, the device will warn the user to “reject”, “start over”, or equivalent message. These values may be factory set or selected by the end user. This pass/fail value shall be protected using a password or similar means of security.

4.3.3 Tension Test

The equipment shall have the capability automatically to tension test the completed splice to a level of 4.4 N (1 pound-force) for at least 1 second to confirm its integrity. The function shall be capable of being activated or deactivated by the user. The tension level shall be adjustable to a lower level if desired.

The equipment shall also have the capability to perform this test with manual/user intervention.

4.3.4 Cable Preparation Length

The equipment shall be capable of splicing cable with cutback as short as 50 mm (cable jacket-to-cable jacket), post-splice.

4.3.5 Fiber Preparation Length

The equipment shall be capable of splicing fiber with an exposed length (bare of any coating except polyimide or amorphous carbon) as short as 24 mm, post-splice.

4.3.6 Self-Test

The equipment shall incorporate a self-test mode which automatically tests and confirms proper operating conditions on every power-up. The equipment shall give the user a visible indication that the self-test mode is in process and, after it is complete, whether or not it has been performed successfully.

4.3.7 Arc Power Compensation

The equipment shall incorporate the capability automatically to compensate arc current or power for electrode and environmental conditions, particularly altitude or barometric pressure. In automatic mode the equipment shall routinely measure barometric pressure and compensate arc power accordingly. In manual mode the equipment shall offer the user on each power-up the option of calibrating arc power by the “burn-back” method, by inserting properly prepared fiber ends by which to determine whether, or how much, automatically to adjust arc power.

4.3.8 Arc Counter

The equipment shall keep a count of all arcs fired on a pair of electrodes and warn the user to check and/or replace them when a predetermined limit has been reached. The “change electrodes” warning shall be capable of being overridden by the user. Beyond a specified arc count the equipment shall be capable of being configured to not continue operating without the user physically changing the electrodes or manually overriding with a password.

4.3.9 Electrode Life

The equipment shall be capable of making at least the following number of fiber splices compliant with 4.2 on a set of new electrodes under controlled benign conditions:

TABLE 2 - ELECTRODE LIFE REQUIREMENTS

Fiber Cladding Diameter (μm)	Minimum Number of Arcs
125	3000
140/172	2000
230	1000

4.3.10 User Interface

All message displays, user prompts, commands, and messages shall be in simple everyday language and compliant with MIL-STD-1472.

4.3.11 Splice Data Storage

The equipment shall have the capability internally to store the data/results from at least 2000 splices. This shall include at least one image of every splice.

4.3.12 Cover Interlock

There shall be an interlock switch with the cover such that the splicer cannot be operated unless the cover is properly closed.

4.3.13 Electrical Power

The equipment shall operate from the input power sources specified below while meeting the requirements of 4.2.

4.3.13.1 Nominal and Alternate Power Sources

The equipment shall operate from the following power sources:

- 50 Hz, 60 Hz, and 400 Hz single-phase 120/240 VAC per Table 3.
- 11 to 13.5 VDC external or internal power source.
- Optional: 28 VDC or other DC power source, internal or external, as specified.

Equipment designed to operate from both external and internal power sources shall conform to specified performance and accuracy requirements when operated from the external source with the internal battery removed. There shall be an external indication of the selected power range.

TABLE 3 - AC POWER SOURCES

Voltage (V_{rms})			
	Steady-State	Transient	Interruption
Nominal	120 (108 – 132)	84 – 108 132 – 156	0 – 84
Alternate	240 (216 – 264)	168 – 216 264 – 312	0 to 168
Frequency (Hz)			
	Steady-State	Transient	Interruption
Nominal	50 (47.5 – 52.5)	45 – 47.5 52.5 – 57	0 – 45
	60 (57 – 63)	54 – 57 63 – 66	0 - 54
Alternate	400 (380 – 420)	360 – 380 420 – 440	0 - 360

4.3.13.2 Steady-State Conditions (AC)

The performance and accuracy of the equipment shall not be affected when it is operated under either or both of conditions a and b. Tolerance values are derived from, and referenced to, the nominal values specified for voltage and frequency.

- The steady-state voltage tolerance shall be $\pm 10\%$.
- The steady frequency tolerance shall be $\pm 5\%$.

4.3.13.3 Transient-State Conditions (AC)

Operation of the equipment during voltage and frequency transients shall be in accordance with a and b for transients that recover to within the steady-state tolerance band within 500 ms. The equipment performance may be impaired during the transient. Transient values are derived from, and referenced to, the nominal values specified for voltage and frequency.

- Voltage transients within the range of ± 10 to $\pm 30\%$ shall not cause the operation of the equipment to be impaired for longer than 30 seconds following the transient and not cause loss of information stored in a volatile memory.
- Frequency transients within the range of ± 5 to $\pm 10\%$ shall not cause the operation of the equipment to be impaired for longer than 30 seconds following the transient and not cause loss of information stored in a volatile memory.

4.3.13.4 Interruption of Power Source (AC)

Voltage or frequency interruptions shall not cause damage to the equipment. A power source interruption is defined to be voltage falling into the range of 0 to 70% of nominal or frequency falling into the range of 0 to 90% of nominal. Equipment performance is not required during interruption of the power source.

4.3.13.5 DC Power Sources

The equipment shall be designed to operate from accessory batteries, either internal or external.

4.3.13.5.1 When operating from external DC power the equipment shall accept a voltage in the range of 11 to 13.5 VDC unless otherwise specified.

4.3.13.5.2 Batteries may be either rechargeable or disposable, but if the former are specified, it/they shall be supplied with a stand-alone recharger. Custom batteries having a single supplier are discouraged.

4.3.13.5.3 Batteries shall be removable and replaceable by the user. Units that are energized by standard-size batteries (AA, C, D, etc.) are preferred but not required.

4.3.13.5.4 When operated on a battery(ies) the system shall be capable of performing at least 80 splices compliant with 4.2 under laboratory conditions.

4.3.13.5.5 Battery Restrictions

The use of lithium and mercury batteries is restricted and shall not be used in equipment unless specifically required and approved by the Procuring Activity. If a restricted type of battery is approved, technical manuals shall reference alternate (non-restricted) battery types and all necessary modifications necessary to use the substitute batteries. The equipment shall incorporate safety precautions of UL1950, and a label containing the following caution and information shall be affixed to the outside of the unit:

THIS UNIT CONTAINS LITHIUM BATTERIES

Battery Manufacturer:

Battery Part Number:

For lithium batteries, or for mercury batteries:

THIS UNIT CONTAINS MERCURY BATTERIES

Battery Manufacturer:

Battery Part Number:

4.3.13.5.6 Battery State Indicator

An indicator shall be provided to indicate when the capacity of batteries used for primary power is low. The approximate remaining operating time for the low battery state shall be specified in the equipment operating manual.

4.3.13.6 Power Consumption/Dissipation

Maximum or nominal power consumption or dissipation shall be as specified in the detail specification, purchase order, or contract.

4.3.13.7 Power-On Indication

Visual indication shall be provided on the front panel to indicate when the equipment is energized.

4.3.14 Automatic Power-Down

When left operating with no user action or input for a defined period of time the equipment shall automatically power down, either OFF or to a low-power-consuming hibernation mode.

4.3.15 Volume

The fusion splicer, exclusive of power adapter and accessories, shall have a volume, including environmental-protective cover, no greater than 45 cubic inches.

4.3.16 Weight

The fusion splicer, exclusive of power adapter and accessories, shall have a weight, including environmental cover, no greater than 2.0 pounds.

4.3.17 Attachability

The equipment shall be capable of casual/simple attachment to unrelated structures for support. The attachment shall cause no harm to common aircraft mounting points such as cable clamps, holes in bulkheads, or fuselage surfaces.

4.3.18 Orientations

The equipment shall be capable of proper operation compliant with 4.2 in any orientation, including sides vertical, back or front vertical, or upside down. The splicer shall be operable hand-held (not on any fixed mount or surface).

4.3.19 Working Volume

The equipment shall be capable of being operated properly, compliant with 4.2, in a working volume no larger than 350 cubic inches.

4.3.20 Modularity

The fusion splicer shall be separable into modules, a splicing portion separate from an electronic controller and power supply/adapter (modular). When thus separated, and interconnected by suitable umbilical cable(s) up to 16 feet in length, the modules shall function as well as if conjoined and still meet the requirements of 4.2.

4.3.21 Restricted Materials

Unless otherwise specified or allowed in writing by the Procurement Authority, the equipment shall not contain hexavalent chromium in concentrations greater than 0.1% by weight in any homogeneous material. The following restricted materials shall not be used under any circumstances throughout its life cycle, including its manufacture, operation, maintenance, and disposal:

- Asbestos
- Class-I Ozone-Depleting Substances (ODS)
- Class-II ODS
- Polychlorinated Biphenyls (PCBs)
- Mercury
- Hexavalent chromium

- Radioactive materials
- Lithium electrochemical cells (containing metallic lithium)

4.3.22 Display Monitor Visibility

When tested per 5.8.8.3, all informational displays associated with the equipment shall be visible in ambient lighting ranging from dark environments (~0.01 lx) to full daylight (~10 000 lx) per MIL-STD-46855.

4.3.23 Chem/Bio Gear

When specified, the equipment shall be capable of being operated properly by a user outfitted in chem/bio/arctic gear per MIL-STD-46855.

4.4 Environmental and Mechanical Requirements

4.4.1 Explosive Atmosphere

When specified (Type I) the fusion splicer shall be certifiably safe working in hazardous atmospheres.

4.4.2 High and Low Temperature Storage

The equipment shall operate properly after storage from -51 to +71 °C. The equipment shall not contain materials that explode or ignite into flames during storage.

4.4.3 High and Low Temperature Operating

The equipment shall operate properly from -10 to +55 °C. The equipment shall not contain materials that explode or ignite into flames at operating temperatures.

4.4.4 High Humidity

The equipment shall operate properly during exposure to extreme humidity (5 to 95% RH, non-condensing).

4.4.5 Altitude

The equipment shall operate properly at up to 4600 m altitude.

4.4.6 Vibration

4.4.6.1 Random vibration (non-operating)

The equipment shall operate properly after exposure to shipping vibration (10 to 500 Hz).

4.4.6.2 Sine Vibration (operating)

When specified, the equipment shall operate properly during exposure to sine vibration (10 to 500 Hz). Because fiber cable splicing is performed by a person using equipment manually, it is understood that it cannot be done when the equipment is vibrating per 5.5.5.3.2; the equipment can only be idling, powered on, during the vibration exposure, not actually splicing.

4.4.7 Shock

The equipment shall operate properly after exposure to shock (30 g).