AEROSPACE STANDARD

AS6506™	REV. A

Issued 2018-09
Revised 2019-07
Reaffirmed 2024-10

Superseding AS6506

Fusion Splice for Aerospace Fiber Optic Cables

RATIONALE

Aerospace fiber optic cables frequently need to be spliced, both for original installation and for repair. Standards exist for mechanical splices in fiber cables, but none has yet been created for fusion spliced cables. Fusion splices can offer superior performance in insertion loss, return loss, and mechanical and environmental stability, suitable for long-term/permanent installation in aircraft. The industry needs agreed-upon performance standards for fiber optic cable fusion splices in aerospace service.

This revision corrects an error in paragraphs 4.5.3 and 4.5.5. The original language of 4.5.5 failed to specify that it was intended to apply to the cumulative changes in insertion loss over all the tests in any one test group. Paragraph 4.5.3 applies to the change in insertion loss in any one test. Obviously the requirement of 4.5.3 should be smaller than that of 4.5.5: 0.05 dB versus 0.10 dB, but the numbers were reversed. This revision corrects the error.

AS6506A has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This document defines performance standards which fiber optic cable splices must meet to be accepted for use in aerospace platforms and environments.

2. REFERENCES

The documents listed in 2.1 are relevant to the requirements of this document. The documents listed in 2.2 are provided for information purposes only and do not form a part of the requirements of this document.

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 the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

SAE Executive Standards Committee Rules provide that: “This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user.”

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2024 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AS6506A/

Documents Document Sharing Hub
Full document details: SAE AS6506A

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 + 1 724-776-4970 (outside USA), www.sae.org.

AIR1351	Manufacturers' Identification of Aerospace Electrical and Electronic Wiring Devices and Accessories
AIR6282	Fiber Optic Harsh Environment Test Methods Cross Reference Document
ARP5061	Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-Connect Systems
AS4373	Test Methods for Insulated Electric Wire
AS5675	Characterization and Requirements for New Aerospace Fiber Optic Cable Assemblies – Jumpers, End Face Geometry, Link Loss Measurement, and Inspection
AS6479	Splicer, Fusion, Fiber Optic, Aerospace
MA5405	Splices, Fiber Optics, For Aerospace Inter-Connection Systems

2.1.2 Military Standards

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, https://quicksearch.dla.mil.

MIL-STD-130N	Identification Marking of U.S. Military Property
MIL-STD-810G	Test Methods Standard
MIL-STD-1678	Fiber Optics Test Methods and Instrumentation
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
SD-6	Provisions Governing Qualification

2.1.3 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI Z136.2	Standard for the Safe Use of Lasers

2.1.4 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.

EIA-364-10	Fluid Immersion Test Procedure for Electrical Connectors
EIA-364-14 TP-14B	Ozone Exposure Test Procedure for Electrical Connectors
TIA/EIA-440B	Fiber Optic Terminology
TIA/EIA-455	Fiber Optic Test Procedures
TIA/EIA-455-1	Cable Flexing for Fiber Optic Interconnecting Devices
TIA/EIA-455-2	Impact Test Measurements for Fiber Optic Devices

Documents
Document Sharing Hub
Full document details: SAE AS6506A

TIA/EIA-455-3	Temperature Effects Measurement Procedure for Optical Fiber, Optical Cable, and Other Passive Components
TIA/EIA-455-4	Temperature Life Test for Fiber Optic Components
TIA/EIA-455-5	Humidity Test for Fiber Optic Components
TIA/EIA-455-6	Cable Retention Test Procedure for Fiber Optic Cable Interconnecting Devices
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-455-11	Vibration Test for Connecting Devices and Cables
TIA/EIA-455-12	Fluid Immersion Test for Fiber Optic Components
TIA/EIA-455-13	Visual and Mechanical Inspection of Fibers, Cables, Connectors, and Other Devices
TIA/EIA-455-14	Shock Test (Specified Pulse)
TIA/EIA-455-15	Altitude Immersion
TIA/EIA 455-16	Salt Spray (Corrosion) Test for Fiber Optic Components
TIA/EIA-455-20	(FOTP-20) Measurement of Change in Optical Transmittance
TIA/EIA-455-26	Crush Resistance of Fiber Optic Interconnecting Devices
TIA/EIA-455-32	Fiber Optic Device Discontinuities
TIA/EIA-455-34	(FOTP-34) Interconnection Device Insertion Loss Test (ANSI/TIA/EIA-455-34A 95)
TIA/EIA 455-35	Fiber Optic Component Dust (Fine Sand) Test
TIA/EIA-455-36	Twist Test for Connecting Devices
TIA/EIA-455-49	Measurement for Gamma Irradiation Effects on Optical Fibers and Cables
TIA/EIA-455-56	Test Method for Evaluating Fungus Resistance of Optical Waveguide Fibers and Cables
TIA/EIA-455-71	Measurement of Temperature Shock Effects on Components
TIA/EIA-455-98	Fiber Optic Cable External Freezing Test
TIA/EIA-455-107	Return Loss for Fiber Optic Components
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

Documents
Document Sharing Hub
Full document details: SAE AS6506A

2.1.5 Other Standards

DOT/FAA/AR-00/12 Chapter 1, “Vertical Bunsen Burner Test”

2.2 Related Publications

The following documents are provided for information purposes only and are not a required part of this SAE 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 + 1 724-776-4970 (outside USA), www.sae.org.

AIR6031 Fiber Optic Cleaning

ARP5061 Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-connect Systems

AS5750 Loss Budget Specification for Fiber Optic Links

2.2.2 Military Specifications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://quicksearch.dla.mil.

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

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

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

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

2.2.3 ARINC 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

2.2.4 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

2.2.5 ASQ Publications

Available from American Society of Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203. Tel: 800-248-1946 (United States or Canada), 001-800-514-1546 (Mexico) or + 1-414-272-8575 (all other locations), www.asq.org.

ASQC Z1.4 Sampling Procedures and Tables for Inspection by Attributes

Documents
Document Sharing Hub
Full document details: SAE AS6506A

2.2.6 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.

EIA-364 Electrical Connector/Socket Test Procedures Including Environmental Classifications

2.2.7 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

NCSL Z540 General Requirements for Calibration Laboratories and Measuring and Test Equipment

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 stray 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. Your best defense against injury by fibers is common sense. Eating and drinking around fibers must also be considered risky. And 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, such as safety goggles, to ensure the safety of maintenance personnel.

Please refer to ANSI Z136.2, American National Standard for the Safe Use of Lasers, 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 lies the danger. Although a person cannot perceive the intense light from the laser, it is still being focused on the sensitive retinal tissue. At the focal point, 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.

Documents
Document Sharing Hub
Full document details: SAE AS6506A

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.

4. TECHNICAL REQUIREMENTS

The splices shall comply with the requirements herein. In the event of a conflict between this standard and the detail specification which defines the unique technical requirements, the detail specification shall govern. However, some requirements, as noted below, are mandatory; they cannot be waived in any detail specification under this standard. Unless otherwise specified by contract or purchase order, product purchased to this standard will be supplied to the latest revision in effect at issuance of the contract or purchase order.

This specification covers design and performance requirements of fused fiber optic splices for optical interconnection systems in aerospace vehicles and provides a guide to qualification of such devices. Fusion splices and splice cable restorations are expected to out-perform mechanical splices; therefore, the optical requirements (see 4.5) are generally 5 to 10 times more demanding.

Fiber optic cable design characteristics are uniquely related to various aerospace vehicle applications. Likewise, fusion splices are necessarily designed for specific cable types. Evaluation of the splice performance shall be performed with the cable type for which it was intended as defined in the splice detail specification. Typically, fiber optic cable splices have unique assembly instructions. Splices that are qualified to the same detail specification must be assembled using the same procedure and tools. All assembly instructions shall be presented and documented in accordance with this specification.

4.1 Part Number Structure

The part number structure for each splice shall be as follows:

AS6506: Procurement standard

AS6506/1: Detail specification

AS6506/1-001: Assembly type and size

4.2 Condition of Listing

Splices will be specified in this document when requested for the purpose of specifying the splice in an end-user, government, or non-government standards body optical distribution system.

Documents
Document Sharing Hub
Full document details: SAE AS6506A

4.3 Visual and Mechanical Examination (see 6.1)

4.3.1 Materials

Materials shall be as specified in the detail specification. When the detail specification does not specify a material, the material properties shall be in compliance with the manufacturer's engineering drawing. The manufacturer shall certify that all materials are in compliance with this specification and all relevant engineering drawings. If a change in material occurs after initial qualification, the manufacturer is required to perform an engineering analysis to determine if requalification is necessary. An Engineering Analysis Report shall be provided to the Qualifying Activity at the next periodic qualification inspection.

4.3.2 Design and Dimensions

Design, dimensions, and markings shall be as specified in the detail specification. The splice, as specified in the detail specification, or its packaging, at a minimum shall be marked with the part number (see 4.1) and the manufacturer's symbol. The manufacturer's symbol shall be listed in AIR1351.

The splice diameter shall be no larger than two times the cable diameter, and the length of any rigid portion of the splice shall be no longer than 75 mm.

4.4 Assembly Instructions (see 6.2)

Each splice or its package shall be provided with concise, clearly written instructions containing the following information as applicable:

a. Title

b. Splice specification part number (see 4.1)

c. Cable specification or part number(s) for which it is qualified

d. Manufacturer's part number

e. National stock number (if available)

f. Detailed assembly instructions including illustrations

g. Piece part numbers when applicable for replacement

h. Detailed accessory drawings sufficient to enable proper use

i. Accessory part numbers when applicable for replacement

j. Installation tools (cleaving, crimping, polishing pucks, etc.)

k. Address, email address, and telephone number of manufacturer

4.5 Optical Performance (see 6.3)

4.5.1 Insertion Loss (IL)

Unless otherwise specified, the splice when assembled shall not exceed an insertion loss of 0.05 dB when tested in accordance with 6.3.2.

Documents
Document Sharing Hub
Full document details: SAE AS6506A

4.5.2 Return Loss (RL)

The return loss of the splice when assembled shall be no less than 60 dB when tested in accordance with 6.3.3.

4.5.3 Temporary Change in Optical Transmittance

Unless otherwise specified, the temporary change in optical transmittance of the splice due to exposure to any mechanical or physical test (i.e., during the extremes of exposure) shall not exceed 0.10 dB when tested in accordance with 6.3.4.

4.5.4 Intermittent Optical Discontinuity

Momentary changes in optical transmittance shall not exceed 0.5 dB in magnitude and 1 μs in duration when tested in accordance with 6.3.5.

4.5.5 Permanent Change in Optical Transmittance

The permanent change in optical transmittance of the splice after exposure to any mechanical or physical test shall not exceed 0.05 dB when tested in accordance with 6.3.4.

4.6 Temperature Cycling

One of two requirements shall apply and cannot be waived in any detail specification: either temperature cycling (4.6) or thermal shock (4.24).

The splice shall be subjected to temperature cycling in accordance with 6.4, and it shall comply with the optical performance requirements of 4.5.3 and 4.5.5. As an alternative, at the direction of the Qualifying Authority the thermal shock test (4.7) may be performed instead.

4.7 Tensile Strength

The splice shall be subjected to the tensile strength test (see 6.5) and will comply with the minimum tensile strength requirement specified in the detail specification. The splice shall comply with the change in optical transmittance requirements of 4.5.3 continuously throughout the test and with 4.5.5 after the test.

4.8 Altitude Immersion

The splice shall be subjected to altitude immersion in accordance with 6.6 and comply with optical performance requirements of 4.5.3 and 4.5.5. There shall be no incursion of water into the splice as inspected per 6.26.

4.9 Cable Flexing

The assembled splice shall be subjected to the cable flexing test in accordance with 6.7 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.10 Cable Twist

The assembled splice shall be subjected to the cable twist test in accordance with 6.8 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.11 Impact

When specified, the splices shall be subjected to the impact test in accordance with 6.9 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

Documents
Document Sharing Hub
Full document details: SAE AS6506A

4.12 Crush

When specified, the splices shall be subjected to the crush test in accordance with 6.10 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

4.13 Axial Compressive Loading

When specified, the splices shall be subjected to the axial compressive loading test in accordance with 6.11 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

4.14 Thermal Aging

The splice shall be subjected to the thermal aging test in accordance with 6.12, at the maximum operating temperature specified in the detail specification and will comply with the optical performance requirements of 4.5.3 and 4.5.5.

NOTE: The splice must not be tested at any temperature higher than the maximum rated temperature of the fiber optic cable on which it is installed. Failure of the cable, if any, does not constitute failure of the splice.

4.15 Freezing Water Immersion (Ice Crush)

The splice shall be subjected to the freezing water immersion test in accordance with 6.13 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.16 Humidity/Thermal Cycling

The splice shall be subjected to the humidity test in accordance with 6.14 and will comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.17 Salt Spray

Salt spray endurance is applicable only for splices with metal parts. If applicable, the splice shall be subjected to the salt spray test in accordance with 6.15 and will comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

4.18 Sand and Dust

If applicable, the splice shall be subjected the blowing sand and dust test in accordance with 6.16 and will comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

4.19 Fluid Immersions

The splices shall be subjected to the fluids immersion test in accordance with 6.17 and will comply with the optical performance requirements of 4.5.3 and 4.5.5. There shall be no physical damage which might affect compliance with any other detail of this standard.

4.20 Vibration/Temperature Cycling

The splice shall be subjected to vibration/temperature cycle testing in accordance with 6.18 at the maximum and minimum operating temperatures specified in the detail specification. The splice shall comply with the change in optical transmittance requirement of 4.5.3 continuously throughout the test and with 4.5.5 after completion of the test.

NOTE: Unspliced optical cables themselves, even MIL-spec (e.g., MIL-PRF-85045) exhibit changes in optical transmittance in some environments such as extreme temperature variation. It is vital to isolate transmittance changes due to the cable from those which may be due to the splice by including an unspliced “control cable” in such tests and interpreting any changes in transmittance in the spliced cables in light of parallel changes in the unspliced cable.

AVA Documents
Document Sharing Hub
Full document details: SAE AS6506A

4.21 Flammability

When specified the splice shall be subjected to the flammability test in accordance with 6.19. This test shall only be performed ***after*** the splice has been examined for any degradation from preceding tests in the group. The splice shall be self-extinguishing within 5 seconds after removal from the flame. Flame from combustion of the cable shall not be considered a failure of the splice. There are no optical requirements.

4.22 Nuclear Radiation

When specified the splice shall be subjected to the gamma radiation test in accordance with 6.20 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.23 Fungus

When specified the splice shall be subjected to the fungus test in accordance with 6.21. There shall be no growth of fungus which might affect the ability of the splice to complying with any detail of this standard. There are no optical requirements during this exposure.

4.24 Thermal Shock

This requirement is an alternative to the temperature cycling requirement 4.6. At least one is mandatory; the second is optional.

The splice shall be subjected to thermal shock in accordance with 6.22, and it shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.25 Vibration and Discontinuities

The assembled splice shall be subjected to the vibration test in accordance with 6.23 and will comply with the optical performance requirements of 4.5.4 (no optical discontinuities) during the exposure and 4.5.5 afterward.

4.26 Mechanical Shock

The assembled splice shall be subjected to the mechanical shock test in accordance with 6.24 and shall comply with the optical performance requirements of 4.5.4 (no optical discontinuities) during the exposure and 4.5.5 afterward.

4.27 Ozone

When specified the assembled splice shall be subjected to the ozone exposure test in accordance with 6.25 and shall comply with the optical performance requirements of 4.5.3 and 4.5.5.

4.28 Post-Test Examination

At the end of each test group, and more frequently when specified or if damage or degradation becomes apparent, the splice shall be subjected to careful visual examination in accordance with 6.26. There shall be no evidence of cracking, crazing, change in dimensions, change in color or finish, looseness of parts, or any other degradation that could affect function.

After Group 1, or whichever group includes the altitude immersion test, the post-test examination shall include dissection. No water may be found to have penetrated into the splice which could cause adverse effects or wick into the cable strength members.

Documents
Document Sharing Hub
Full document details: SAE AS6506A