The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE MA5405

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Splices, Fiber Optics, For Aerospace Inter-Connection Systems

1. SCOPE:

1.1 Purpose:

This specification covers design and performance requirements of fiber optic splices for optical distribution systems in aerospace vehicles and provides a means of procurement of such devices.

1.2 Specification Approach:

Fiber optic cable design characteristics are uniquely related to various aerospace vehicle applications. As a result, the splice is constructed for specific cable types. Evaluation of the splice performance shall be with the cable type as defined in the splice detail specification (see Section 3). Typically, fiber optic 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.

1.3 Part Number Structure:

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

MA5405/1-001

MA5405: Procurement Specification
MA5405/1: Assembly Type
MA5405/1-001: Assembly Type and Size

1.4 Condition of Listing:

Splices will be specified in this document when requested for the purpose of specifying the splice in a user, government, or non-government standard body optical distribution system (see Section 7).

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS1241	Fire Resistant Phosphate Ester, Hydraulic Fluid for Aircraft
AMS 1432	Fluid Deicing/Anti-icing, Runway, Taxiway, Potassium Acetate Base

2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
TT-I-735	Isopropyl Alcohol
DoD-STD-1678	Fiber Optic Test Methods and Instrumentation
MIL-H-5606	Hydraulic Fluid, Petroleum Base Aircraft, Missile, and Ordnance
MIL-DTL-5624	Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST
MIL-PRF-7808	Lubricating Oil, Aircraft Engine, Synthetic Base
MIL-A-8243	Anti-icing and Deicing, Defrosting Fluid
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-DTL-83133	Turbine Fuel, Aviation Grade, JP-8
MIL-PRF-83282	Fire Resistant, Synthetic Hydrocarbon Base, Metric
MIL-PRF-85570	Cleaning Compound, Alkaline
MIL-PRF-87252	Coolant Fluid, Hydrolytically Stable, Dielectric (POA)

2.1.3 ASTM Publications: Available from ASTM, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

ASTM D 1153	Methyl Isobutyl Ketone (for use in organic coatings)

2.1.4 EIA Publications: Available from Electronic Industry Alliance, 2500 Wilson Boulevard, Arlington, VA 22201-3834.

EIA-455	Fiber Optic Test Procedures

2.2 Definitions:

2.2.1 COMPONENT MANUFACTURER: A component manufacturer is a manufacturer that produces components (i.e., splices, etc.) in accordance with the component specification.

2.2.2 PURCHASING ACTIVITY: A purchasing activity is an organization which procures components for a system or subsystem manufacturer that produces assemblies from those components. A purchasing activity is not a distributor or component manufacturer unless designated so by the system or subsystem manufacturer.

2.2.3 THIRD PARTY INSPECTORATE: A Third Party Inspectorate (TPI) is a test laboratory and/or a monitoring activity independent of the component manufacturer.

3. TECHNICAL REQUIREMENTS:

The splice shall comply with the requirements herein. In the event of a conflict between the procurement specification and the detail specification which defines the unique technical requirements, the detail specification shall govern. The splice shall be tested in accordance with Table 1 after being assembled in accordance with the assembly instruction (see 3.3).

3.1 Material Properties (see 5.1):

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 engineering drawing. The manufacturer shall certify that all materials are in compliance with this specification and all engineering drawings. If a change in material occurs after initial qualification has been demonstrated, the manufacturer is required to perform an engineering analysis to determine if requalification is necessary. An Engineering Analysis Report shall be provided to the TPI at the next periodic qualification inspection (see 4.1).

3.2 Design Dimensions (see 5.2):

Dimensions shall be as specified in the detail specification. When the detail specification does not require specific dimensions, the dimensions shall be in compliance with the manufacturer engineering drawings. If a change in dimensions occurs after initial qualification has been demonstrated, the manufacturer is required to perform an engineering analysis to determine if requalification is necessary. An Engineering Analysis Report shall be provided to the TPI at the next periodic qualification inspection (see 4.1).

TABLE 1 - Qualification Tests

Inspection	Requirement Paragraph	Test Paragraph	Sample Size	Quality Conformance
Group 1				
Material Properties	3.1	5.1	5	*
Design Dimensions	3.2	5.2	10	*
Assembly Instructions	3.3	5.3	N/A	*
Group 2 (Footnote 1)			5	
Insertion Loss	3.5.1	5.5.3		
Vibration/Temperature Cycle	3.6	5.6		
Optical Performance	3.5	5.5		
Tensile Strength	3.7	5.7		
Optical Performance	3.5.1	5.5		
Group 3			5	
Insertion Loss	3.5.1	5.5.3		
Heat Aging	3.8	5.8		
Humidity	3.9	5.9		
Salt Spray	3.10	5.10		
Optical Performance	3.5	5.5		
Group 4 (Footnote 1)			28	
Insertion Loss	3.5.1	5.5.3		
Fluid Immersion	3.11	5.11		
Optical Performance	3.5	5.5		
Group 5 (Footnote 1)			5	
Flammability	3.12	5.12		

TABLE 1 - Qualification Tests (Continued)

Inspection	Requirement Paragraph	Test Paragraph	Sample Size	Quality Conformance
Group 6			5	
Insertion Loss	3.5.1	5.5.3		
Altitude Immersion	3.4	5.4		
Freezing Water/Immersion	3.13	5.13		
Optical Performance	3.5	5.5		

Footnote 1: Required for initial qualification and every alternate periodic qualification (see 4.4).

3.3 Assembly Instruction (see 5.3):

Each splice shall be provided with concise, clearly written instruction containing the following information in the order shown.

a. Title
b. Splice specification part number
c. Cable specification part number(s)
d. Manufacturer assembly part number
e. National stock number (if available)
f. Detail assembly instructions
g. Piece part drawing sufficient to enable proper use
h. Piece part numbers when applicable for replacement
i. Detail accessory drawings sufficient to enable proper use
j. Accessory part numbers when applicable for replacement
k. Tools (cleaving, crimping, polishing pucks, etc.)
l. Address and telephone number of manufacturer

Each splice shall be assembled in accordance with the instructions.

3.4 Altitude Immersion (see 5.4):

The splice shall be assembled in accordance with assembly instruction (see 3.3), subjected to altitude immersion test in accordance with 5.4, then comply with insertion loss requirements of 3.5.

3.5 Optical Performance (see 5.5):

3.5.1 Insertion Loss: The splice assembly shall not exceed insertion loss limits specified in the detail specification when tested in accordance with 5.5.3.

3.5.2 Change in Optical Transmittance: The permanent change in optical transmittance of the splice due to exposure to mechanical and physical tests shall be less than 0.5 dB when tested in accordance with 5.5.4.

3.6 Vibration/Temperature Cycle (see 5.6):

The splice shall be assembled in accordance with assembly instruction (see 3.3) and subjected to vibration/temperature cycle test in accordance with 5.6 at the maximum operating temperature specified in the detail specification. The splice shall comply with insertion loss requirements of 3.5 continuously throughout the test and comply to the change in optical transmittance after the test (see 3.5.2).

3.7 Tensile Strength (see 5.7):

The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the tensile strength test (see 5.7), and comply with the minimum tensile strength requirement specified in the detail specification. The splice shall comply with insertion loss requirements of 3.5 continuously throughout the test and comply to the change in optical transmittance after the test (see 3.5.2).

3.8 Heat Aging (see 5.8):

The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the heat aging test in accordance with 5.8, at the maximum operating temperature specified in the detail specification and comply with the optical performance requirements of 3.5. Failure of the cable does not constitute failure of the splice.

3.9 Humidity (see 5.9):

The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the humidity test in accordance with 5.9, and comply with the optical performance requirements of 3.5.

3.10 Salt Spray (see 5.10):

The salt spray test is applicable only for splices with metal piece parts. The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the salt spray test in accordance with 5.10, and comply with the optical performance requirements of 3.5.

3.11 Fluid Immersion (see 5.11):

The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the fluid immersion test in accordance with 5.11, and comply with the optical performance requirements of 3.5.

3.12 Flammability (see 5.12):

The splice shall be assembled in accordance with the assembly instruction (see 3.3) and subjected to the flammability test in accordance with 5.12. The splice shall be self-extinguishing within 5 s after removal from the flame. Flame as a result of the cable shall not be considered.

3.13 Freezing Water Immersion (Ice Crush):

The splice shall be assembled in accordance with the assembly instruction (see 3.3), subjected to the freezing water immersion test in accordance with 5.13, and comply with the optical performance requirements of 3.5.

4. QUALITY ASSURANCE PROVISION:

Qualification is required to confirm that products procured to this specification are in compliance with requirements (see 4.3 and 4.4). Qualification does not assure that the manufacturer's processes are under control, only that at the time of examination the products tested met the requirement of the specification.

4.1 Third Party Inspection:

To ensure a balanced partnership between component manufacturers and purchasing activities, the test data shall be generated by a TPI. The TPI is not legally bound to the component manufacturer except for inspection services rendered. To the maximum extent possible, the TPI shall be an independent test activity and perform the tests independently of the component manufacturer. The TPI may monitor unique tests as appropriate. The TPI shall certify what data was monitored and generated in accordance with this specification and that the products met all requirements at the time of testing. At a purchasing activity request, the TPI shall provide confirmation of compliance for those component manufacturers reviewed. Upon request by the purchasing activity, a summary of the data shall be made available by the TPI. The summary will reflect any recorded failures and subsequent submissions. The TPI will not approve or disapprove the corrective actions needed for product compliance. Detail test data must be obtained from the component manufacturer.

4.2 United States Government Acquisitions and Purchasing Activities:

For acquisitions of products for direct or indirect United States government end usage, the purchasing activities or government contracting officers, when this specification is adopted, are required to use following TPI activity:

Naval Air Warfare Center, Aircraft Division, Patuxent River
Code 4.4.4.1, Bldg. 1461
48298 Shaw Road, Unit 4
Patuxent River, MD 20670-1900

Interested component manufacturers are required to submit a request for qualification action prior to developing test data.

4.2.1 Commercial Acquisition: Purchasing activities for commercial acquisitions are not required to use the government TPI activity.

4.3 Initial Qualification Inspection:

Initial qualification shall be performed sequentially in each test group as specified in Table 1.

4.4 Periodic or Requalification Inspection:

The component manufacturer is required to generate test data to verify periodic inspection qualification every three years after initial qualification or whenever a major change in design or materials has occurred. If a design or material change does occur, the component manufacturer is required to perform an engineering analysis and to generate appropriate TPI test data to confirm the product is still in compliance with the specification at the time of the change (requalification). The component manufacturer is required to periodically qualify to the technical requirement of Table 1 except the group 2, 4, and 5 tests need only be documented on alternate periodic inspection qualifications beginning with the first reporting period.

4.5 Qualification Test Sample:

Unless otherwise specified in the detail specification, the total number of specimens listed in Table 1 for each type splice described in the detail specification shall be tested. The specimens shall be divided as shown in Table 1 for qualification testing.

4.6 Quality Conformance Inspection:

For each production lot each splice shall be examined in accordance with the quality conformance tests (*) specified in Table 1.

5. ???:

5.1 Material Properties Certifications Analysis (see 3.1):

The component manufacturer shall review all material properties requirements in the detail specification and engineering drawing and provide individual certifications for each material. When a material is considered proprietary, the material shall be coded for certification purposes. A summary approach for certification may be used rather than detail certifications for each material. If material changes or changes in the properties of previously approved materials have occurred, an Engineering Analysis Report must be developed.

5.2 Design Dimensions Test (see 3.2):

Measure the splice dimension to the next smallest digit specified by detail specification or engineering drawing. Record the dimensional results. For those dimensions specified on the engineering drawing, a coded system may be used for reporting purposes. If a dimensional change occurs, an Engineering Analysis Report must be developed.

5.3 Assembly Instruction Analysis (see 3.3):

The assembly instruction shall be reviewed to determine if all information in 3.3 is provided and in the order shown. The splice shall be assembled in accordance with the instruction for testing in accordance with Table 1.

5.4 Altitude Immersion (see 3.4):

5.4.1 Altitude Chamber: The altitude immersion test chamber shall be a sealed chamber capable of maintaining an absolute pressure of 2.54 cm of mercury or lower.

5.4.2 Test Container: The test container for positioning the splice assembly shall have the following minimum dimensions: 2 in wide, 9 in long, and 3 in deep. A salt solution shall be placed in the container to a depth that will completely cover the assembly at all times during the altitude immersion test. The salt solution shall be prepared by dissolving 5 ± 1 parts by weight of non-iodized commercial table salt in 95 parts by weight of distilled water. No material shall be added to, and no contaminant shall be present in the container or solution which may prevent wetting of the test sample by the solution.

5.4.3 Sample Preparation (see 3.4): The test samples shall be placed in the container in the chamber in such a manner that the splice assembly will be entirely immersed in the salt solution. The uppermost point of the splice shall be 2.54 cm minimum below the surface of the solution. The exposed ends of the fiber optic cable for the test sample shall be unsealed and above the salt solution. The cable shall be arranged so as to prevent any high insertion losses which might incorrectly indicate a splice failure.

5.4.4 Altitude Immersion Cycling (see 3.4): The chamber shall be sealed. The chamber pressure shall be changed from room ambient to an absolute pressure of 2.54 cm (75,000 ft) +0.0 -0.5 cm of mercury within 5 min and shall be maintained at this level for 30 min, minimum. The chamber pressure shall be cycled (or returned) to room ambient pressure within 1 min and shall be maintained at room ambient pressure for 30 min, minimum. The foregoing shall constitute one cycle. Two additional cycles shall be performed (three cycles total). The splice assembly shall remain fully immersed in the salt solution during the three cycles and for the subsequent optical performance measurements (see 3.5).

5.5 Optical Performance Test (see Optical Performance Document):

The graded index multi-mode optical test shall be performed at 850 nm and 1310 nm using the launch conditions specified in Tables 2 and 3. The step index multi-mode optical test shall be performed at 850 nm and 1310 nm using the launch conditions specified in 5.5.2. The single mode optical test shall be performed at 1310 nm and 1550 nm using the launch conditions specified in 5.5.2.

5.5.1 Launch Conditions for Graded Index Multi-mode Fiber: The light launch conditions used during the optical test shall be made in accordance with EIA-455-50 using a (Gausian) distribution meeting the requirements specified in the table below.

TABLE 2 - Near Field Intensity (% of Core Diameter)

Relative Intensity	Low	High
5%	80	95
15%	70	85
75%	30	45

TABLE 3 - Far Field Intensity (% of Numerical Aperture)

Relative Intensity	Low	High
5%	84.5	87.9
15%	72.4	77.6
75%	34.5	41.4

5.5.2 Launch Conditions for Step Index Multi-mode and Single Mode Fiber: For single mode fiber no special launch conditions are required with the exception that the power source shall be 10 dB minimum above the minimum sensitivity of the receiver. The launch conditions for step index multimedia fibers shall be 100% of core diameter. These launch conditions may be achieved by the following method, or equivalent:

a. Select a light source of the appropriate wavelength and spectral bandwidth as described in EIA-455-50. The output power of the source and the sensitivity of the detector shall be set to allow 3 dB of loss due to a mandrel wrap plus the loss of the unit under test and still be at least 10 dB above the minimum sensitivity of the detector.

b. Select a launch cable with a fiber that matches the core size, core type (step), and NA of the cable under test, with connectors to mate to the connector on the light source and the connector on the cable under test.

c. Mode equalize the launch cable by installing a mandrel. The mandrel size and number of wraps shall be established to induce 3 dB minimum and a maximum of 5 dB of loss from the unwrapped cable, follow the general information on mandrel wraps in EIA-455-50.

5.5.3 Insertion Loss: Insertion loss measurement shall be measured in accordance with EIA-455-34 Method A unless otherwise specified on specification sheet. Any optical power detection method may be used if the method is sufficiently sensitive to measure the differential power levels as specified in the individual mechanical and environment requirements of Section 3 and if the method provides repeatable readings (less than 3% variation).

5.5.4 Change in Optical Transmittance Test (see 3.5.2): The change in optical transmittance of each splice shall be measured in accordance with EIA-455-20, utilizing a monitor fiber reference to evaluate the change in transmittance due to exposure of the cable to environmental and physical tests. The reference fiber shall be used to calibrate the light source power output just prior to making all measurements. Any optical power detection method may be used if the method is sufficiently sensitive to measure the differential power levels as specified in the individual mechanical and environment requirements of Section 3 and the method provides repeatable readings (less than 3% variation). A pretest optical power measurement shall be made and the specimen shall then undergo inspection testing. All optical power measurements, subsequent to the pretest measurement, shall be referenced to the pretest value and the change in dB calculated.

5.6 Vibration/Temperature Cycle Test (see 3.6):

5.6.1 Test Chamber: A test chamber shall be used which can maintain a temperature -55 +0 -3 °C and the maximum operating temperature specified in the detail specification. The chamber shall be designed to permit a temperature change rate of 17 °C per minute in the region of the splice. The vibration fixture with mounting clamps approximately 12 in apart shall position near the center of the chamber. The clamps shall be designed to rigidly hold the fiber optic cable. The clamps will be designed to prevent slippage or damage to the cable while permitting continuous optical transmission through the cable and splice. The chamber and fixture shall be designed to assure the mounting location is free from resonance over the test frequency range specified in 5.6.2.

5.6.2 Test Procedure: The cable assembly shall be mounted between the two cable clamps with the fiber optic cable leads exiting the chamber and connected to the optical source. The cable assembly shall be continuously monitored optically in accordance with 5.5. The splice shall be subjected to a simple harmonic motion having an amplitude of 0.076 cm (0.152 cm maximum total excursion). The frequency shall vary uniformly between approximate limits of 10 and 2000 Hz. The entire frequency range, from 10 to 2000 Hz and return to 10 Hz shall be traversed in approximately 1 min. The motion shall be applied for a period of 18 h in each of two axes mutually perpendicular to each other and to the axis of the cable. Prior to initiating the vibration, the chamber's temperature shall be stabilized at -55 +0 -3 °C. When the vibration is initiated, the chamber shall be maintained at -55 +0 -3 °C for 30 min, then the temperature raised at an appropriate 17 °C per minute until the maximum operating temperature specified in the detail specification is reached. The maximum operating temperature shall be maintained for 30 min then the temperature will be lowered to -55 +0 -3 °C at an appropriate 17 °C per minute rate.

5.7 Tensile Strength Test (see 3.7):

5.7.1 Test Equipment: The testing device shall require the following:

a. Clamps, jaws, or other holding devices that will not distort the splice while holding the fiber optic cable ends.

b. A mechanism to separate the holding devices at a constant rate of speed of 1 in/min ± 1/4 in/min.

c. A gage to register the amount of tension being exerted between the cable ends.

d. An oven capable of maintaining the splice at a maximum operation temperature while being separated.