



AEROSPACE RECOMMENDED PRACTICE

ARP5602™/10

Issued 2008-11
Reaffirmed 2025-11

A Guideline for Aerospace Platform Fiber Optic Training and Awareness Education
Aerospace Fiber Optics Engineer Knowledge Competencies

RATIONALE

The Aerospace industry has always required the highest standards of workmanship to be maintained. To ensure that the Aerospace fiber optics industry adopts these same high standards, it's essential that minimum training and certification requirements be established. This document outlines the minimum training requirements for all personnel working as aerospace fiber optics engineers in accordance with aerospace industry best practices.

ARP5602/10 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This document establishes training guidelines applicable to fiber optics engineer technical training for individuals involved in the manufacturing, installation, support, integration and testing of fiber optic systems. Applicable personnel include:

Managers

Engineers

Trainers/Instructors

Third Party Maintenance Agencies

Production

2. 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 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

AS50881 Wiring Aerospace Vehicle

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SAE WEB ADDRESS:

Full document details: SAE ARP5602_10

For more information on this standard, visit
<https://www.sae.org/standards/content/ARP5602/10/>

Documents

Standard, visit Sharing Hub

2.2 ANSI Publications

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

ANSI Z136.1-2007	American National Standard for Safe Use of Lasers
ANSI Z136.2-1997	American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources
ANSI/TIA-440-B-2004	Fiber Optic Terminology

2.3 IEC Publications

Available from International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland, Tel: +44-22-919-02-11, www.iec.ch.

IEC 60825-1	Laser Safety Equipment Classification (Safety of laser products)
IEC 60825-2	Safety of Optical Fibre Communication Systems
IEC 60825-4	Laser Guards

2.4 NASA Publications

Available from NASA, Documentation, Marshall Space Flight Center, AL 35812, www.nas.nasa.gov.

NASA-STD-8739.5	Fiber Optic Terminations, Cable Assemblies, and Installation
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2.5 NAVAIR Publications

Commanding Officer, Naval Air technical Data and Engineering Service Command, Naval Air Station, North Island, P. O. Box 357031, Building 90, Distribution, San Diego, CA 92135-7031

NAVAIR 01-1A-505.4	INSTALLATION AND TESTING PRACTICES AIRCRAFT FIBER OPTIC CABLING
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2.6 U.S. Government Publications

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

FED-STD-1037C	Glossary of Telecommunications Terms
MIL-PRF-29504B	TERMINI, FIBER OPTIC CONNECTOR, REMOVABLE, GENERAL SPECIFICATION FOR
MIL-PRF-29504/4D	TERMINI, FIBER OPTIC, CONNECTOR, REMOVABLE, ENVIRONMENTAL RESISTING, PIN TERMINUS, SIZE 16, REAR RELEASE, MIL-DTL-38999, SERIES III
MIL-PRF-29504/5D	TERMINI, FIBER OPTIC, CONNECTOR, REMOVABLE, ENVIRONMENTAL RESISTING, SOCKET TERMINUS, SIZE 16, REAR RELEASE, MIL-DTL-38999, SERIES
MIL-DTL-38999K	CONNECTORS, ELECTRICAL, CIRCULAR, MINIATURE, HIGH DENSITY, QUICK DISCONNECT (BAYONET, THREADED, AND BREECH COUPLING), ENVIRONMENTAL RESISTANT, REMOVABLE CRIMP AND HERMETIC SOLDER CONTACTS GENERAL SPECIFICATION FOR

2.7 Aeronautical Radio, Inc. (ARINC) Publications

Available from Aeronautical Radio, Inc., 2551 Riva Road, Annapolis, Maryland 24101-7435, www.arinc.com

ARINC Report 805-1 Fiber Optic Test Procedures

ARINC Report 806 Fiber Optic Installation and Maintenance

2.8 Other Applicable References

Understanding Fiber Optics, Jeff Hecht, ISBN 0-13-956145-5

Fiber Optics Installer and Technician Guide, Bill Woodward, ISBN 0-7821-4390-3

3. HOW TO USE THIS DOCUMENT

This document is intended to be used as a guideline for all persons conducting aerospace fiber optics engineer training. This training document is broken into 16 major categories. Each category contains detailed training competencies. The detailed training competencies describe the level of knowledge each student should have about that particular item.

1. INTRODUCTION TO AEROSPACE FIBER OPTICS

- 1.1 Explain the historical evolution of fiber optic technology
- 1.2 Explain the harsh environments of fiber optic technology in aeronautical and space applications

2. PRINCIPLES OF FIBER OPTIC TRANSMISSION

- 2.1 Describe the basic parts of a fiber optic link
- 2.2 Describe the basic operation of a fiber optic transmitter
- 2.3 Describe the basic operation of a fiber optic receiver
- 2.4 Describe how the decibel is used to compare relative power levels (dB)
- 2.5 Describe how the decibel is used to measure absolute power (dBm)

3. SAFETY AWARENESS

- 3.1 Explain personnel and platform safety issues including foreign object damage (FOD) and equipment damage
- 3.2 Describe the best practices associated with the safe handling of fiber materials and hand tools
- 3.3 Describe how to properly dispose of fiber optic waste
- 3.4 Explain how to properly handle hazardous materials and the purpose of a material safety data sheet (MSDS)
- 3.5 Describe emergency procedures

4. BASIC PRINCIPLES OF LIGHT

- 4.1 Compare wavelength and frequency, and demonstrate how to calculate one when the other is known
- 4.2 Explain light wave and light particle theory

- 4.3 Describe the electromagnetic and light spectrum
- 4.4 Describe refraction
- 4.5 Explain reflection to include angle of incidence, critical angle, and angle of refraction
- 4.6 Explain how the index of refraction is used to describe the speed of light through a transparent material
- 4.7 Describe angle of incidence
- 4.8 Explain Fresnel reflections and how they can impact the performance of a fiber optic communication system
- 4.9 Explain Snell's law

5. OPTICAL FIBER CONSTRUCTION AND THEORY

- 5.1 Describe basic optical fiber manufacturing techniques
- 5.2 Describe the core of an optical fiber
- 5.3 Describe the cladding of an optical fiber
- 5.4 Describe the different types of optical fiber coatings specific to aerospace applications
- 5.5 Describe mode in an optical fiber
- 5.6 Describe the three refractive index profiles commonly found in optical fiber
- 5.7 Explain how an optical fiber is categorized by modes and refractive index profiles

6. OPTICAL FIBER CHARACTERISTICS

- 6.1 Describe modal dispersion and its effects on the bandwidth of an optical fiber
- 6.2 Describe material dispersion and its effects on the bandwidth of an optical fiber
- 6.3 Describe waveguide dispersion and its effects on the bandwidth of an optical fiber
- 6.4 Describe the causes of attenuation in an optical fiber
- 6.5 Describe the numerical aperture of an optical fiber
- 6.6 Describe the cone of acceptance
- 6.7 Describe microbends in an optical fiber
- 6.8 Describe macrobends in an optical fiber
- 6.9 Define tensile strength
- 6.10 Define bend radius limitations

7. FIBER OPTIC SOURCES

- 7.1 List safety classifications of fiber optic lights sources
- 7.2 Describe the basic operation and output pattern of an LED
- 7.3 Describe the basic operation and output pattern of a laser

8. FIBER OPTIC DETECTORS

- 8.1 Describe the basic operation of a photodiode
- 8.2 Describe the performance characteristics of PIN and APD photodiodes
- 8.3 Explain the effects of saturation on detectors

9. AEROSPACE FIBER OPTIC CABLES (UNTERMINATED)

- 9.1 Draw a cross section of a simplex aerospace fiber optic cable and explain the purpose of each segment
 - 9.1.1 Draw and dimension a cross section of a simplex 100/140 um multimode aerospace fiber optic cable
 - 9.1.2 Draw and dimension a cross section of a simplex 5.8/125 um single-mode aerospace fiber optic cable
 - 9.1.3 Explain the purpose of each subcomponent
 - 9.1.4 Identify the materials used in each subcomponent
- 9.2 Explain loose structure
 - 9.2.1 Explain the low temperature advantages of loose structure over tight structure
 - 9.2.2 Explain the pull proof capability of loose structure
 - 9.2.3 Explain the bend radius characteristics
- 9.3 Explain tight structure
 - 9.3.1 Explain the bend radius advantages of tight structure over loose structure
 - 9.3.2 Explain the crushability advantages of tight structure over loose structure
- 9.4 Explain loose buffer tube
- 9.5 Explain tight buffer
- 9.6 Describe tensile strength properties
 - 9.6.1 Describe how to interpret the manufacturer's short term and long term tensile strength specifications
 - 9.6.2 Describe the reduction in tensile strength after termination
 - 9.6.3 Describe the reduction in tensile strength when the cable is bent

- 9.7 Describe common strength members used in aerospace and contrast with telecommunications
 - 9.7.1 Describe the difference between aramid yarn and fiberglass
 - 9.7.2 Describe longitudinal, helical, and braided strength member lay
- 9.8 Describe common jacket materials used in aerospace and contrast with telecommunications
 - 9.8.1 Describe the stiffness differences between PVC and fluoropolymers
 - 9.8.2 Describe the shrinkage properties of fluoropolymers and PVC
 - 9.8.3 Describe the out gassing characteristics of fluoropolymers and PVC
 - 9.8.4 Describe the memory properties of fluoropolymers and PVC
- 9.9 Explain installation and operating bend radius
 - 9.9.1 Describe how to interpret the manufacturers bend radius specifications
 - 9.9.2 Explain the tensile stressed and non-tensile stressed short-term bend radius limitations
 - 9.9.3 Explain the tensile stressed and non-tensile stressed long-term bend radius limitations
- 9.10 Describe simplex, duplex, and multi-fiber cables
 - 9.10.1 Explain the difference between a single multi-fiber cable and a cable assembly/harness made up of simplex fiber optic cables
- 9.11 Describe ribbon cables
 - 9.11.1 Explain the difference between enclosed and non-enclosed strength members
- 9.12 Explain variations in the aerospace industry of cable color codes and markings
 - 9.12.1 Explain that color codes are platform specific
 - 9.12.2 Explain the cable markings and labels are used to distinguish fiber optic cables from copper cables

10. AEROSPACE FIBER OPTIC INTERCONNECTS (UNTERMINATED)

- 10.1 Describe the basic components of a single fiber connector and multi-fiber interconnect
 - 10.1.1 Compare and contrast single fiber connector differences in the ferrule, connector body, spring mechanism, keying, alignment sleeve, ferrule contact and non-contact design between the FC pull-proof, ST, and FSMA-905
 - 10.1.2 Compare and contrast multi-fiber connector differences in the termini, connector body, insert (front and rear release), spring mechanism, keying, alignment sleeve, coupling nut, jack screw, environmental seals, ferrule contact and non-contact design between the MT, ARINC 600, and MIL-DTL-38999
 - 10.1.3 Describe how to interpret the manufacturer's maximum attenuation, mating cycles, back reflection, and environmental specifications

- 10.2 Describe ferrule materials/composition
 - 10.2.1 Describe the differences between ceramic, metallic, and hybrid (jeweled and metallic/ceramic) ferrule materials/composition
 - 10.2.2 Describe internal and external ferrule dimensions
 - 10.2.3 Explain the difference between a chamfer ferrule and a non-chamfered ferrule
- 10.3 Describe how intrinsic factors can affect connector performance
 - 10.3.1 Explain how ferrule imperfections and variations affect connector performance
 - 10.3.2 Explain how alignment sleeve imperfections and variations affect connector performance
- 10.4 Describe how extrinsic factors can affect connector performance
 - 10.4.1 Explain how termini/connector imperfections and variations affect connector performance
 - 10.4.2 Explain how alignment sleeve imperfections and variations affect connector performance
- 10.5 Describe ferrule endfaces and characteristics
 - 10.5.1 Describe the geometry and performance characteristics of a flat endface
 - 10.5.2 Describe the geometry and performance characteristics of a radiused endface
 - 10.5.3 Describe the geometry and performance characteristics of an angled physical contact endface
 - 10.5.4 Ferrule Diameters
 - 10.5.4.1 List the diameters of the ST, FC, and SC ferrule in inches and millimeters
 - 10.5.4.2 List the diameter of the LC ferrule in inches and millimeters
 - 10.5.4.3 List the diameters 29504 style termini
- 10.6 Describe lensed contacts
- 10.7 Describe tunable ferrules in connectors (FC and LC)
- 10.8 Describe termini in multi-fiber connectors (keyed and un-keyed)
- 10.9 Describe alignment sleeves in multi-fiber connectors
 - 10.9.1 Describe the difference between a split and solid alignment sleeve
 - 10.9.2 Describe alignment sleeve retaining mechanisms
 - 10.9.3 Describe alignment sleeve insertion and removal tools
 - 10.9.4 Describe alignment sleeve insertion and removal techniques