



Technical Standard Order

(Proposed)

Subject: AIRCRAFT WIRES

1. PURPOSE. This technical standard order (TSO) is for manufacturers of insulated single conductor electrical wires applying for a TSO authorization or letter of design approval (LODA). In it, we (the Federal Aviation Administration, or FAA) tell you what minimum performance standards (MPS) your aircraft electrical wire must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY.

a. This TSO affects new applications submitted after its effective date.

b. Major design changes to aircraft electrical wires approved under this TSO will require a new authorization. See Title 14 of the Code of Federal Regulations (14 CFR) § 21.611(b).

3. REQUIREMENTS.

a. New insulated single conductor aircraft electrical wires identified and manufactured on or after the effective date of this TSO must meet the MPS in:

- SAE International's Aerospace Standard (AS) 22759, *Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy*, dated July 2001, Sections 2, 3 and 4, the applicable specifications in paragraph 2.1, plus appendix 1 of this TSO; or

- SAE AS81044, *Wire, Electrical, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer or Polyarylene Insulated, Copper or Copper Alloy*, dated July 1998, the applicable specifications in paragraph 2.1, plus appendix 1 of this TSO.

b. **Deviations.** We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your aircraft wires maintain an equivalent level of safety. Apply for a deviation under 14 CFR §21.609 before submitting your data package.

4. MARKING. Mark each aircraft wire permanently and legibly with all the information required in:

- 14 CFR 21.607(d) and
- SAE AS22759, Section 3.6.5, or

- SAE AS81044, Section 3.6.3.

5. APPLICATION DATA REQUIREMENTS. As a TSO manufacturer-applicant, you must give the FAA aircraft certification office (ACO) manager responsible for your facilities a statement of conformance, as specified 14 CFR § 21.605(a)(1) and one copy each of the following technical data to support your design and production approval. (Under 14 CFR § 21.617(a)(2), LODA applicants submit the same data through their civil aviation authority:)

a. Operating instructions and wire limitations in an installation/instructions manual (IM) sufficient to describe the operational capability of the wire. Describe any deviations in detail. If needed, identify the wires by part number, version, revision, and criticality level of software/hardware, classification for use, and environmental categories.

b. Installation procedures and limitations in an IM, sufficient to ensure that the wire, when installed according to the installation procedures, still meets this TSO's requirements. The limitations must identify any unique aspects of the installation. Finally, the limitations must include a note with the following statements:

The conditions and tests required for this TSO approval of this wire are minimum performance standards. Those installing this wire in a specific class or type of aircraft must determine that the aircraft installation conditions are within the TSO standards. The wire may be installed only according to 14 CFR part 43 or the applicable airworthiness requirements.

c. Schematic drawings of the installation procedures.

d. Wiring diagrams of the installation procedures.

e. List of components, by part number, that make up the aircraft wire complying with the standards prescribed under this TSO. Include vendor part number cross-references, when applicable.

f. A component maintenance manual (CMM), covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed aircraft wire. Include recommended inspection intervals and service life. Describe the details of deviations granted, as noted in paragraph **5.a** of this TSO.

g. Material and process specifications list.

h. The quality control system (QCS) description required by 14 CFR §§ 21.143 and 21.605(a)(3), including functional test specifications. The QCS should ensure that you will detect any change to the wire that could adversely affect compliance with the TSO MPS, and reject the item accordingly. (Not required for LODA applicants.)

i. Manufacturer's TSO qualification test report.

j. Nameplate drawing with the information required by paragraph 4 of this TSO.

k. List of all drawings and processes (including revision level) that define the wire's design. For a minor change, follow the directions in 14 CFR § 21.611(a). Show any revisions to the drawing list only on our request.

l. Inspection lot number(s) of qualified wires.

m. Raw material heat (lot) or certification number for each qualification lot(s) of wires.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to us, have the following technical data available for review by the responsible ACO or civil aviation authority:

a. Copies of all standards, /specifications submitted with the manufacturer's application for TSO authorization.

b. Inspection lot number and quantity for each production lot of wires.

c. Raw material heat (lot) or certification number for each production lot of wires.

d. Acceptance test results for each lot of wires.

e. Corrective maintenance procedures (within 6 months after TSO authorization).

7. FURNISHED DATA REQUIREMENTS.

a. If furnishing one or more wires manufactured under this TSO to one entity (such as an operator or repair station), provide one copy of the data in paragraphs 5.a through 5.f of this TSO, and inspection lot number(s) and quantity of wires shipped.

b. Add any other data needed for the proper installation, certification, use, or for continued airworthiness, of aircraft electrical wires.

8. DEFINITION OF AN INSPECTION LOT OF WIRES. An inspection lot must consist of all aircraft wires of the same type covered by one specification sheet, produced under the same conditions, and offered for inspection at one time.

9. HOW TO GET REFERENCED DOCUMENTS.

a. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096. Telephone (724) 776-4970, fax (724) 776-0790. You can also order copies online at: <http://www.sae.org/>

b. Order the military documents identified in SAE AS22759, AS81044, and AS50881B by mail from the Defense Automated Printing Service, Standardization Document Order Desk, Bldg. 4, Section D, 700 Robbins Avenue, Philadelphia PA 19111-5094; or by phone at (215) 697-2179, fax (215) 697-1462. You can also order online at www.dodssp.daps.dla.mil/.

c. Order American Society for Testing and Materials (ASTM) publications identified in SAE AS22759 and AS81044 from ASTM, 1916 Race Street, Philadelphia PA 19103. You can also order them online at: <http://www.astm.org/>

d. Order American National Standards Institute (ANSI) publications identified in SAE AS22759 and AS81044 from ANSI, 11 West 42nd Street, New York, NY 10036. You can also order them online at: www.ansi.org

e. Order European Association of Aerospace Industries (AECMA) document EN3475-503 from AECMA, Gulledele 94-b.5, B-1200 Brussels, Belgium. Telephone: +32 2 775 81 10, Fax: +32 2 775 81 11. You can also order online at www.aecma.org.

f. Order copies of Title 14 CFR part 21, Subpart O, from: the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh, PA 15250-7954. You can order them online at <http://www.access.gpo.gov/> Select "Access" and scroll to "Online Bookstore".

g. You can find a current list of technical standard orders on the FAA internet website Regulatory and Guidance Library at: <http://www.airweb.faa.gov/rgl> You can also find advisory circulars and the TSO Index of Articles at the same site.

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**APPENDIX 1. MINIMUM PERFORMANCE
STANDARD (MPS) FOR AIRCRAFT ELECTRICAL WIRES**

1-1. PURPOSE. Aircraft electrical wires must meet both industry MPS and FAA modifications to those standards.

1-2. REQUIREMENTS. Industry standards are specified in paragraph **3.b** of this TSO. Unless otherwise specified by the test method, test a minimum of three wire specimens for each wire insulation system and each wire size range specified by the industry standards.

a. Performance Tests. In addition to the MPS required in paragraph **3.b.**, aircraft electrical wire must meet performance requirements when tested as described in paragraphs **1-2.b**, **1-2.c**, and **1-2.d** below. Applicable test methods are described in SAE AS4373B, *Test Methods for Insulated Electric Wire*, dated October 2001.

b. Aging, Thermal and Environmental Tests.

(1) Thermal Index.

Requirement: Integrity of the wire must be maintained for 60,000 hours at the maximum rated temperature of the conductor-insulation system. Wire must pass the dielectric withstand voltage requirement following an aging protocol and physical stressing.

Test Method: AS4373B, Section 4.8.4, Method 804, Relative Thermal Life and Temperature Index.

(2) Conductor Strand Blocking.

Requirement: Conductor strands must not adhere to each other at the wire's maximum rated temperature.

Test Method: AS4373B, Section 4.4.4, Method 404, Conductor Strand Blocking. Visually examine conductor strands for adhesion.

(3) Insulation Blocking.

Requirement: Wire insulation adherence must not occur at the wire's maximum rated temperature.

Test Method: AS4373B, Section 4.8.8, Method 808, Blocking. Visually examine insulation for adhesion.

(4) Moisture Sensitivity.

Requirement: Wire must not degrade when exposed to moisture. Wire must meet 2000 hours of exposure and pass a dielectric withstand voltage test.

Test Method: AS4373B, Section 4.6.2, Method 602, Forced Hydrolysis.

(5) Fluid Exposure.

Requirement: Wire must not swell more than 5%, and must pass the bend and dielectric withstand voltage test following exposure to aircraft fluids.

Test Method: AS4373B, Section 4.6.1, Method 601, Fluid Immersion.

(6) Flammability.

Requirement: Wire must be self-extinguishing when tested according to applicable requirements of 14 CFR § 25.869(a)(4) (Amendment 25-72), and Part 25, Appendix F, Part I.

Test Method: 14 CFR Part 25, Appendix F, Part I.!!

(7) Smoke and Fumes.

Requirement: Wire must not generate smoke or fumes that are visually seen at the maximum rated temperature.

Test Method: AS4373B, Section 4.5.7, Method 507, Time/Current to Smoke.

c. Electrical Tests.

(1) Wet Arc Propagation.

Requirement: A minimum of 67 of 75 wires must pass dielectric withstand voltage application following exposure. In any test bundle, fewer than four wires must degrade and no more than three inches of insulation in each wire can be damaged.

Test Method: AS4373B, Section 4.5.9, Method 509, Wet Arc Propagation Resistance.

(2) Dry Arc Propagation.

Requirement: A minimum of 67 of 75 wires must pass dielectric withstand voltage application following exposure. In any test bundle, fewer than four wires must degrade and no more than three inches of insulation in each wire can be damaged.

Test Method: AS4373B, Section 4.5.8, Method 508, Dry Arc Propagation Resistance.

d. Mechanical Tests.**(1) Bend Sensitivity.**

Requirement: Wire must maintain flexibility and not degrade when bent on a circular mandrel with a diameter of ten times the diameter of the wire. Test wire at -65°C and the rated temperatures. Wire must not develop cracks and must pass a dielectric withstand voltage test. The rated temperature, defined in AS4373B, is the maximum temperature that the wire is designed for.

Test Methods: AS4373B, Section 4.7.2, Method 702, Cold Bend, for low temperature; and Method 712, Bend Test, for high temperature.

(2) Dynamic Insulation Cut-through.

Requirement: Average cut-through force at rated temperature for the wire must be 6 pounds or higher.

Test Method: AS4373B, Section 4.7.3, Method 703, Dynamic Cut Through.

(3) Notch Propagation.

Requirement: Wire must not propagate a crack to the conductor. Wire must pass a dielectric withstand voltage test following a minimum of ten bend cycle of the notched area.

Test Method: AS4373B, Section 4.7.6, Method 706, Notch Propagation, using a notch of 50% insulation wall thickness.

(4) Wicking.

Requirement: Wires with multiple layers of insulation, jacket, or over-braid must not wick more than three-quarters of an inch from the exposed end of the insulation or over-braid.

Test Method: AS4373B, Section 4.6.7, Method 607, Wicking.

(5) Insulation Abrasion Resistance.

Requirement: Average scrape abrasion cycles at ambient temperature must be 25 cycles minimum with a 500-gram load. See AS4373B, Section 4.7.1, Abrasion.

Test Method: European Association of Aerospace Industries (AECMA) document EN3475-503, *Aerospace Series - Cables, Electrical, Aircraft Use - Test Methods - Part 503 Scrape Abrasion*, dated January 2002.