



Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C44c

Effective
Date: 08/22/06

Technical Standard Order

Subject: **FUEL FLOWMETERS**

1. **PURPOSE.** This technical standard order (TSO) is for manufacturers of fuel flowmeters 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 fuel flowmeter must first meet for approval and identification with the applicable TSO marking.

2. **APPLICABILITY.** This TSO affects new applications submitted after its effective date.

a. All prior revisions of this TSO are no longer effective. Generally we will not accept applications after the effective date of this TSO. However we may do so up to six months after it, if we know that you were working against the earlier MPS before the new change became effective.

b. Fuel flowmeters approved under previous versions of this TSO may still be manufactured under the provisions of their original approval.

c. Major design changes to fuel flowmeters approved under previous versions of this TSO require a new authorization. See Title 14 of the Code of Federal Regulations (14 CFR) § 21.611(b).

3. **REQUIREMENTS.** New models of fuel flowmeters identified and manufactured on or after the effective date of this TSO must meet the MPS in SAE International's Aerospace Standard (AS) 407C, *Fuel Flowmeters*, dated July 1, 2001, as amended by this TSO.

a. **Functionality.** This TSO's standards apply to fuel flowmeters used on reciprocating engine or turbine-powered civil aircraft.

b. **Failure Condition Classification.** Failure of the function defined in paragraphs 3 and 3.a of this TSO is a *hazardous* failure condition. Develop each fuel flowmeter to at least the design assurance level equal to the failure condition classification of the system on which the flowmeter is installed.

c. **Environmental Qualification.** Test the fuel flowmeter according to SAE AS407C, SAE AS1055D, *Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings, and Similar System Components*, dated June 1997, sections 4 and 5, and RTCA Inc. document RTCA/DO-

160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004, as amended by appendix 1 of this TSO.

d. Software Qualification. If the fuel flowmeter includes a digital computer, develop the software according to RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992, or the most current revision. The software design assurance level should be consistent with the failure condition classification in paragraph **3.b** of this TSO. The software design assurance level should be consistent with the failure condition classification in paragraph **3.b** of this TSO.

e. Electronic Hardware Qualification. If the fuel flowmeter contains a complex custom micro-coded component, develop the component to the guidance in FAA advisory circular (AC) 20-152, *RTCA, Inc. Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware*. The hardware design assurance level should be consistent with the failure condition classification in paragraph **3.b** of this TSO.

f. 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 fuel flowmeter maintains an equivalent level of safety. Apply for a deviation under 14 CFR § 21.609 before submitting your data package.

4. MARKING.

a. Mark each fuel flowmeter with the identification information required in SAE AS407C, except paragraph 3.2.b. Also, mark at least one major component permanently and legibly with all the information in 14 CFR § 21.607(d), except for the following:

(1) 14 CFR § 21.607(d)(2). Use the name, type, and part number. Do not use the optional model number.

(2) 14 CFR § 21.607(d)(3). Use the date of manufacture. Do not use the optional serial number.

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

(1) Each component that is easily removable (without hand tools),

(2) Each interchangeable element, and

(3) Each subassembly of the fuel flowmeter that you determined may be interchangeable.

c. If the component includes a digital computer, then the part number must include hardware and software identification. Or, you can use a separate part number for hardware and software. Either way, you must include a means to show the modification status.

NOTE: Similar software/hardware versions, approved to different software levels, must be differentiated by part number.

d. If applicable, identify deviations granted to the equipment by marking “Deviation. See installation/instruction manual (IM)” after the TSO number. You can abbreviate the marking to “(Dev. See IM.)”.

e. When applicable, identify the equipment as an incomplete system, or state that the article performs additional functions beyond that described in paragraphs 3 and 3.a of this TSO.

f. Optional marking is permitted to allow the use of aircraft specific or operational specific installation limitations, such as: **“FOR USE ON {insert aircraft type or serial number} ONLY,”** or **“FOR USE ON AIRCRAFT USED IN PART {insert number} OPERATIONS ONLY,”** or **“SEE DRAWING NO. XYZ FOR INSTALLATION LIMITATIONS.”**

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 in 14 CFR § 21.605(a)(1) and one copy each of the following technical data to support our 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 equipment limitations in an IM, sufficient to describe the flowmeter’s operational capability. Describe any deviations in detail. If needed, identify equipment 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 fuel flowmeter, when installed according to 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 statement:

The conditions and tests required for TSO approval of this article are minimum performance standards. Those installing this article, on or in a specific type or class of aircraft, must determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation on an aircraft. The article 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 fuel flowmeter complying with the standards in 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 flowmeters. 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 flowmeters 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), to define the fuel flowmeter'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. An environmental qualifications form as described in SAE AS407C, SAE AS1055D, sections 4 and 5, and RTCA/DO-160E.
 - m. If the fuel flowmeter includes a digital computer: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary. We recommend that you submit the PSAC early in the software development process. Early submittal will allow you to quickly resolve issues, such as partitioning and determining software levels.
 - n. If the fuel flowmeter includes a complex custom micro-coded component: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary. We recommend that you submit the PHAC early in the software development process. Early submittal allows us to quickly resolve issues.
- 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. The functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

- b. Equipment calibration procedures.
- c. Corrective maintenance procedures within 12 months after TSO authorization.
- d. Schematic drawings.
- e. Wiring diagrams.
- f. The results of the environmental qualification tests conducted per SAE AS407C.
- g. Material and process specifications.
- h. Results of environmental qualification tests conducted per references in paragraph **3.d** of this TSO.
- i. If the fuel flowmeter includes a digital computer, the appropriate documentation defined in RTCA/DO-178B, including all data supporting the applicable objectives in Annex A, Process Objectives and Outputs by Software Level. For software developed before the availability of RTCA/DO-178B, see Section 12.1.4 to upgrade a baseline for software development.
- j. If the fuel flowmeter includes a complex micro-coded component, the appropriate hardware life-cycle data combined with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-1.

7. FURNISHED DATA REQUIREMENTS. If furnishing one or more articles 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. Add any other data needed for the proper installation, certification, use, or for the continued airworthiness of the fuel flowmeter.

8. HOW TO GET REFERENCED DOCUMENTS.

- a. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone (724) 776-4970, fax (724) 776-0790. You can also order them online at www.sae.org.
- b. Order RTCA documents from RTCA Inc., 1828 L Street NW, Suite 805, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order them online at www.rtca.org.
- c. Order copies of 14 CFR part 21, subpart O, from the Superintendent of Documents, Government Printing Office, P.O. Box 37154, Pittsburgh, PA 15250-7954. Telephone (202) 512-1800, fax (202) 512-2250. You can also order them from the Government Printing Office website at www.access.gpo.gov. Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

d. You can find a current list of technical standard orders on the FAA's Regulatory and Guidance library at www.airweb.faa.gov/rgl. You will also find advisory circulars and the TSO Index of Articles at the same site.

/s/ Susan J. M. Cabler

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APPENDIX 1. MINIMUM PERFORMANCE STANDARD FOR FUEL FLOWMETERS

1. **General Requirements.** The applicable standard is SAE AS407C, *Fuel Flowmeters*, dated July 1, 2001. Paragraphs 3.1, 3.1.1, 3.1.2, 3.2.b, and 4.2.1 of the SAE AS407C do not apply to this TSO. We modified the SAE AS407C as follows (changed text shown in gray):

a. **Temperature.** On Page 2 of SAE AS407C, replace Table 1 with the following table.

TABLE 1

INSTRUMENT LOCATION	<u>A</u>	<u>B</u>
Heated Areas (Temp. Controlled)	-30 to 50 °C	-65 to 70 °C
Unheated Areas (Temp. Controlled)	-55 to 70 °C	-65 to 100 °C
Power Plant Compartment	-55 to 70 °C	-65 to 100 °C
Power Plant Accessory Compartment	-55 to 70 °C	-65 to 100 °C

b. **Altitude.** In the first sentence of paragraph 3.3.4, Altitude, (page 3), replace “40,000 feet standard altitude” with “51,000 feet standard altitude.”

c. **Leak Test.** In the second sentence of paragraph 6.3, Leak Test, (page 6), replace “to an air pressure of 40 psi” with “to an air pressure in accordance with the manufacturer’s recommendations”

2. **Testing Your Fuel Flowmeter.** In addition to the qualification test requirements described in SAE AS407C, perform the following tests:

a. **Thermal Shock Test.** This test applies to any hermetically sealed components. Subject the components to four cycles of exposure to water $85^{\circ} \pm 2^{\circ} \text{C}$ and $5^{\circ} \pm 2^{\circ} \text{C}$. There should be no evidence of moisture damage to coating or enclosure. During each cycle of the test, immerse the component in water at $85^{\circ} \pm 2^{\circ} \text{C}$ for 30 minutes. Within 5 seconds of removal from the bath, immerse the component for 30 minutes in the other bath maintained at $5^{\circ} \pm 2^{\circ} \text{C}$. Repeat this cycle continuously, one cycle following the other until you complete four cycles. After this test, subject the component to the sealing test in paragraph 2b(2) of this appendix. The component must have no leakage resulting from the test.

b. **Sealing Test.** Apply this performance test to any hermetically sealed components. Immerse the component in a suitable liquid such as water. Then reduce the absolute pressure of the air above the liquid to about 1 inch of mercury (Hg). Maintain this absolute pressure for 1 minute, or until the liquid stops giving off air bubbles, whichever is longer. Increase the absolute pressure by 2½ inches Hg. If any bubbles come from the component case, consider it

leakage and reject the component. Do not consider bubbles, resulting from entrapped air in the exterior parts of the case, as leakage. If other test methods provide evidence equal to the immersion test, you can use them to test the integrity of the instrument's seals. If the component includes nonhermetically sealed appurtenances such as a case extension, you can remove these appurtenances before the sealing test.

- c. **Other Tests.** The following table lists where you find other tests and conditions:

For:	Use the test conditions in:
Fire-resistant or fireproof test	SAE AS 1055, Rev. D, , dated June 1997, Sections 4 and 5
Explosion proofness test	RTCA/DO-160E, Section 9
Power input test	RTCA/DO-160E, Section 16
Voltage spike test	RTCA/DO-160E, Section 17
Audio frequency conducted susceptibility test	RTCA/DO-160E, Section 18
Induced signal susceptibility test	RTCA/DO-160E, Section 19
Radio frequency susceptibility test	RTCA/DO-160E, Section 20