



Technical Standard Order

Subject: **FUEL AND OIL QUANTITY INSTRUMENTS**

1. **PURPOSE.** This technical standard order (TSO) is for manufacturers of aircraft fuel and oil quantity instruments 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 and oil quantity instrument 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 to 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 and oil quantity instruments approved under a previous TSO authorization may still be manufactured under the provisions of their original approval.
 - c. Major design changes to fuel and oil quantity instruments 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 and oil quantity instruments identified and manufactured on or after the effective date of this TSO must meet the MPS in SAE International's Aerospace Standard (AS) 405C, *Fuel and Oil Quantity Instruments*, dated July 2001, as amended by appendix 1 of this TSO.
 - a. **Functionality.** This TSO's standards apply to any instrument intended to provide cockpit indication of the quantity of fuel or oil in a tank.
 - b. **Failure Condition Classification.** The failure condition classification will depend on the system on which the fuel and oil quantity instrument is installed. The classification must be determined by the safety assessment conducted as part of the installation approval. Develop each fuel and oil quantity instrument to at least the design assurance level equal to the failure condition classification of the system on which the fuel and oil quantity instrument is installed.

c. **Environmental Qualification.** Test the fuel and oil quantity instrument according to RTCA Inc. document RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004 and SAE International's Aerospace Standard (AS)405C, *Fuel and Oil Quantity Instruments*, dated July 2001, Section 7. The standards for these tests are in appendix 1 of this TSO.

d. **Software Qualification.** If the fuel and oil quantity instrument includes a digital computer, develop the software according to RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 1, 1992.

e. **Electronic Hardware Qualification.** If the fuel and oil quantity instrument includes complex electronic hardware, 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 defined in paragraph 3.b.

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 and oil quantity instrument maintains an equivalent level of safety. Apply for a deviation under 14 CFR § 21.609 before submitting your data package.

4. **MARKING.**

a. 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. Mark at least one major component permanently and legibly with all the information in SAE AS405C, Section 3.2 (except paragraph 3.2.b). Also, mark the component with the following information:

(1) The basic type and accuracy classification, and

(2) The fluids for which the instrument is substantiated

c. 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 and oil quantity instrument that you determined may be interchangeable.

d. If the fuel and oil quantity instrument 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 versions, approved to different software levels, must be differentiated by part number.

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

f. When applicable, identify equipment as an incomplete system or that the article performs functions beyond those described in paragraph 3.a of this TSO.

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 fuel and oil quantity instrument’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 and oil quantity instrument, 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 instrument are minimum performance standards. Those installing this instrument, 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 in an aircraft. The instrument 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 and oil quantity instrument 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 the installed fuel and oil quantity instrument. Instructions should 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 equipment 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 in paragraph 4 of this TSO.
 - k. List of all drawings and processes (including revision level), to define the fuel and oil quantity instrument'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 AS405C for each component of the fuel and oil quantity instrument.
 - m. If the fuel and oil quantity instrument 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.

NOTE: Substantiate the software levels using the safety assessment process in RTCA/DO-178B. If the fuel and oil quantity instrument includes more than one software level, you must partition different software levels.
 - n. If the fuel and oil quantity instrument includes complex electronic hardware: 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 hardware 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. Material and process specifications.

g. Results of the environmental qualification tests conducted per SAE AS405C.

h. If the fuel and oil quantity instrument 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. See RTCA/DO-178B, Section 12.1.4 to upgrade a baseline for software development.

i. If the fuel and oil quantity instrument 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 quantity instruments 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 and oil quantity instrument.

8. HOW TO GET REFERENCE 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.

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APPENDIX 1. MPS FOR FUEL AND OIL QUANTITY INSTRUMENTS

This appendix prescribes the MPS for fuel and oil quantity instruments as modified by the FAA. The applicable standard is SAE AS405C, *Fuel and Oil Quantity Instruments*, dated July 2001. We don't require fuel and oil quantity instruments to meet the requirements in paragraphs 3.1, 3.1.1, 3.1.2, and 3.2.b.

1. ADDITIONS TO SAE AS405C, PARAGRAPH 5.

- **Paragraph 5.7**, Instrument Setup:

- a. Before starting tests, set up the instrument as follows:

- (1) Place the sensor component in a simulated fuel or oil tank, and the indicator and other components in a convenient location, and

- (2) Connect all components by the same means required when the instrument is in service.

- b. If you choose, you can test individual components. When testing components individually, provide proper inputs or outputs for the components under test.

- **Paragraph 5.8**, Accuracy Tolerances. All accuracy tolerances are for the complete system. Before testing components individually, connect the components per the manufacturer's instructions. The complete system must meet the tolerances of figure 1 (see SAE AS8029, *Minimum Performance Standard for Fuel and Oil Quantity Indicating System Components*, dated June 1983):

FIGURE 1. ACCURACY TOLERANCES FOR THE COMPLETE SYSTEM

Class	Accuracy Tolerance
1	+/- 0.75% full scale
2	+/- 2% of full scale
3	+/- 3% of full scale

- **Paragraph 5.9**, Ambient Room Conditions. At ambient room conditions, test the instrument for scale error, hysteresis error, friction error, and position error. The resulting total error must not exceed the values in the applicable listing in figure 1 of this appendix.

**APPENDIX 1. MPS FOR
FUEL AND OIL QUANTITY INSTRUMENTS (continued)**

- **Paragraph 5.10**, Applicable Environmental Conditions. Test the instrument under the applicable environmental conditions. The resulting total error must not exceed the values in the applicable listing in figure 1 of this appendix.

2. MODIFICATIONS TO SAE AS405C, PARAGRAPH 6.

Replace <i>all</i> the wording in:	With:
Paragraph 6.1, Scale Error	Adjust the tank unit and all components before the test. You cannot adjust anything during the test. Immerse the tank unit, and compensators when used, in the test fluid. Calculate the percent of errors by comparing readings taken from the design calibration of the system or component you are testing.
Paragraph 6.2, Friction	Test all components with moving parts for friction error at several points. Test the components by applying the needed inputs to bring the output to a desired test point. Hold the input constant while taking the two output readings. Take the first reading before vibrating the indicator. Take the second reading after vibrating the indicator.
Paragraph 6.4, Position Error	To get a reading near mid-scale, the fluid tank should be about half-full, or have equal electrical input. Hold each component (except the tank unit) in several different positions and record any change in output. Test the instrument for position error at several positions.

3. ADDITIONS TO SAE AS405C, PARAGRAPH 6.

- **Paragraph 6.8**, Hysteresis Error. Test the instrument for hysteresis at several points. Increase the test fluid level, or equal inputs, to each selected test point and hold while taking a reading.

- **Paragraph 6.9**, Speed of Response. Under ambient room conditions, the indicator must

**APPENDIX 1. MPS FOR
FUEL AND OIL QUANTITY INSTRUMENTS (continued)**

register from empty to full or vice versa in less than 30 seconds but more than 5 seconds. When testing at any environmental extremes, the speed of response must not exceed 3 times the time measured at room ambient conditions.

4. ADDITIONS TO SAE AS405C, PARAGRAPH 7. Add the following new paragraphs:

∞ **Paragraph 7.7**, Operational Shocks Tests. Use test requirements in Section 7 of RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 9, 2004.

∞ **Paragraph 7.8**, Explosion Proof Test. Use test requirements in RTCA/DO-160E, Section 9.

∞ **Paragraph 7.9**, Power Input Test. Use test requirements in RTCA/DO-160E, Section 16.

∞ **Paragraph 7.10**, Voltage Spike Test. Use test requirements in RTCA/DO-160E, Section 17.

∞ **Paragraph 7.11**, Audio Frequency Conducted Susceptibility Test. Use test requirements in RTCA/DO-160E, Section 18.

∞ **Paragraph 7.12**, Induced Signal Susceptibility Test. Use test requirements in RTCA/DO-160E, Section 19.

∞ **Paragraph 7.13**, Radio Frequency Susceptibility Test. Use test requirements in RTCA/DO-160E, Section 20.

∞ **Paragraph 7.14**, Emission of Radio Frequency Energy Test. Use test requirements in RTCA/DO-160E, Section 21.

∞ **Paragraph 7.15**, Lightning Induced Transient Susceptibility Test. Use test requirements in RTCA/DO-160E, Section 22.

∞ **Paragraph 7.16**, Lightning Direct Effects Test. Use test requirements in RTCA/DO-160E, Section 23.

∞ **Paragraph 7.17**, Electrostatic Discharge Test. Use test requirements in RTCA/DO-160E, Section 25.

∞ **Paragraph 7.18**, Flammability Test. All materials used must be self-extinguishing when tested in accordance with applicable requirements of 14 CFR § 25.853 (Amendment 25-83), and

**APPENDIX 1. MPS FOR
FUEL AND OIL QUANTITY INSTRUMENTS (continued)**

∞ Part 25, Appendix F, Part I. This requirement doesn't apply to small parts (where the greatest equipment dimension is less than 50 mm; such as knobs, fasteners, seals, grommets and small electrical parts) that don't contribute significantly to fire propagation.