AEROSPACE STANDARD

AS407™ REV. E

Issued 1948-11
Reaffirmed 2008-02
Stabilized 2012-08
Revised 2024-04

Superseding AS407D

(R) Fuel Flow Rate Measurement System

RATIONALE

This standard has been revised to add applicability of fuel flow flowmeters to turbine engines. The scope of the standard was adjusted to include minimum requirements for each flow rate measurement system component, which may consist of a fuel flowmeter, and a fuel flow indicator that processes the flowmeter signal and provides a reading in the cockpit. The document title was changed from Fuel Flowmeters to Fuel Flow Rate Measurement System to address the increased scope of the standard.

The “Type 1 - measure rate of flow of fuel used” and “Type 2 - totalize amount of fuel consumed or remaining” definitions are no longer used since indicators may display both fuel flow parameters and the indicator requirements in this revised standard applies to both types.

1. SCOPE

This SAE Aerospace Standard (AS) defines minimum performance standards (MPS) for fuel flowmeters, fuel flow indicators, and fuel flow transmitters. The fuel flow indicators and transmitters are intended for use in 14 CFR Part 23, 25, 27, and 29 aircraft equipped with reciprocating and turbine engines. Multiple function displays are not within the scope of this SAE Aerospace Standard (refer to AS6296).

1.1 Applicability

This MPS addresses the performance criteria for fuel flowmeters, fuel flow indicators, and fuel flow transmitters for use in reciprocating and turbine powered civil transport aircraft.

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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AS407E/

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS6296 Electronic Flight Instrument System (EFIS) Displays

AS8034 Minimum Performance Standard for Airborne Multipurpose Electronic Displays

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D1655 Specification for Aviation Turbine Fuels

ASTM D910 Standard Specification for Leaded Aviation Gasolines

2.1.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC20-135 Hand Fire Extinguisers for Use in Aircraft

AC33.17-1A Fire Prevention

2.1.4 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA DO-160G Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Definitions

COMMERCIAL FREQUENCY: Frequency of the power supplied at the test facility, nominally 60 Hz in the U.S.

MUST: The word “must” is used to express an essential (mandatory) requirement that is required by a specific regulation.

SHALL: The word “shall” is used to express an essential requirement where a compliance is mandatory.

SHOULD: The word “should” is used to express a recommendation. Deviation from the specificed recommendation shall require justification.

WARNING: The use of the word “warning” in this document could mean a warning, caution, or advisory level alert. A warning is a condition that requires immediate flight-crew awareness and immediate flight-crew response. A caution is a condition that could require immediate flight-crew awareness and subsequent flight-crew response. An advisory is a condition that requires flight-crew awareness and may require subsequent flight-crew response.

3. GENERAL REQUIREMENTS

3.1 Materials and Workmanship

3.1.1 Materials

Materials shall be of a quality that experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments and transmitters. This includes compatibility with fuels, fuel additives, oils, and cleaners. Material quality is verified per the test requirements specified in this aerospace standard.

3.1.2 Workmanship

Workmanship shall be consistent with high-grade aircraft instrument manufacturing practices. Workmanship is verified per the performance and test requirements specified in this aerospace standard.

4. DETAILED REQUIREMENTS

Requirements are specified for indicators and fuel flow transmitters. The system can include a signal conditioner or data concentrator.

NOTE: The overall fuel flow accuracy as a fuel flow measurement system should meet the accuracy of ±3% of full scale flow reading. The accuracy requirement for the electronic indicator is provided in 4.1.4 (±0.5%) and for the transmitter in 4.2.5 (±2.5%). For electromechanical systems, the combination of transmitter and indicator should meet a system accuracy of ±3% (see 4.1.3).

4.1 Indicator Requirements

The indicator may display fuel flow rate, fuel totalizer, or a combination of the fuel flow information. Electromechanical gauges are those that may be affected by viewing parallax or a moving mass. Electronic indicators are presented on an LCD or similar display and are not affected by parallax or pointer mass. The unit of measure shall be provided on the indicator face.

4.1.1 Identification

The instrument shall be legibly and permanently marked with the following:

a. Name of instrument

b. Manufacturer’s part number

c. Manufacturer’s serial number

d. Manufacturer’s CAGE code or name or trademark

e. Electrical power supply range

4.1.2 Viewing Angle

All indicating means displayed (indicia, pointers, symbols, etc.) shall be completely visible from any eye position within the viewing envelope(s) as specified by the equipment manufacturer. Text and symbology shall be readily discernible and should be legible and readable within the specified viewing envelope(s). The viewing envelope requirement includes any specialized bezels/hand grips that may be used for stabilization.

The minimum viewing envelope shall be the frustum of a cone, whose side makes an angle of 30 degrees perpendicular to the indicator face and whose small diameter is the aperture or width of the indication area.

4.1.3 Flow Rate Indication Electromechanical

Indicate the fuel flow rate with a rotating pointer over a fixed graduated dial, linear bar graph, and/or numeric indication. A clockwise pointer motion shall indicate an increasing flow rate. Linear bar graph vertical movement up or horizontal movement to the right shall indicate increasing flow rates. If an electronic numeric indication is not provided, numerals shall distinctly indicate the major graduations to which each applies. Major graduations shall not exceed 10% of full scale. Indicator scale resolution shall not exceed ±3% of full scale reading except as required for electromechanical indicators (see 4.1.5).

Graduations, numerals, and indication features shall be a color in contrast with the background surfaces (see 4.1.6). For rotating pointer indicators, the difference in indicator reading when the indicator is rotated in the direction of the needle sweep, from the normal position to any other position, shall not exceed 2.5% of full scale reading.

The instrument scale error shall be determined at all major graduations. This test shall be conducted by subjecting the instrument first with rates of flow increasing, then with rates of flow decreasing. With the flow rate increasing, the rate shall be brought up to, but shall not exceed, the rate specified to give the desired reading, and with the flow rate decreasing, the rate shall be brought down to, but shall not fall below, the rate specified to obtain the desired reading. The error at each major graduation shall not exceed ±3% of full scale reading, including transmitter error. The difference between the reading on increasing flow rate and the reading on decreasing flow rate at each major graduation shall not exceed ±1% of full scale reading.

4.1.4 Flow Rate Indication Electronic

Indicated fuel flow rate error shall not exceed ±0.5% of full scale. This error should include error from a signal conditioner or data concentrator. Appropriate significant digits and resolution shall be a minimum of 0.5% of full scale. Graduations, numerals, and indication features shall be a color in contrast with the background surfaces (see 4.1.6).

4.1.5 Fuel Totalizer Indication

Indicate fuel totalizer information with an electromechanical and/or electronic rotating pointer over a fixed graduated dial, linear bar graph, and/or numeric indication. The indication shall be the fuel consumed and/or quantity remaining. The operator shall be able to initialize or set the indicator. If a numeric indication is not provided, then sufficient numerals shall be marked to identify positively and quickly all graduations. Numerals shall distinctly indicate the graduations to which each applies. Numeric displays shall indicate increments no larger than every 10 pounds (4.5 kg) or 2 gallons (7.6 L). Units of measure shall be displayed on the indication. Electronic indicator error, including signal processing equipment, shall not exceed ±3% of fuel used following at least 10 gallons of totalized fuel. The totalizer may be verified using a compatible electronic signal generator or a compatible fuel flow transmitter with a continuous nominal fluid flow rate and temperature.

4.1.6 Color

In all cases, the luminance contrast and/or color differences between all symbols, characters, lines, or backgrounds shall be sufficient to preclude confusion or ambiguity as to information content of any displayed information.

NOTE: It is not recommended to place a symbol on a background of equal luminance regardless of color differences. Saturated colors are not recommended to be used for background; saturated colors should be saved for smaller items such as symbols, icons, targets, etc. The use of colors red (warning) and amber/yellow (caution) should not adversely affect flight-crew alerting. Monochrome displays are acceptable.

4.1.7 Flicker and Jitter

The display shall not exhibit an unacceptable level of flicker under the full range of ambient environment up to the maximum ambient illumination level when viewed from any viewing angle defined in 4.1.2 with both foveal and full peripheral vision. There should be no discernible display jitter when viewed within the viewing envelope. In no case shall the display exhibit an unacceptable level of irregular movement, variation, or unsteadiness.

NOTE: Flicker is an undesired, rapid temporal variation in the display luminance of a symbol, group of symbols, or a luminous field. It can cause discomfort for the viewer (such as headaches and irritation).

4.2 Transmitter Requirements

The transmitter measures the rate of fuel flow being delivered to the aircraft power plant. The transmitter shall be designed to operate with aviation gasoline, jet fuel, or other fuel types such as diesel, kerosene, biofuel, etc. The manufacturer shall declare what fuel that the transmitter is designed for in field service.

4.2.1 Identification

Fuel flow transmitter information shall be legibly and permanently marked and shall include:

a. Manufacturer's part number

b. Manufacturer's serial number

c. Manufacturer's CAGE code or name or trademark

Additional information may be legibly and permanently marked on the transmitter when capable, or the additional information shall be provided in a data package with the transmitter:

a. Name of component (fuel flow transmitter)

b. Flow range

c. Maximum operating pressure

d. Maximum pressure drop

e. Electrical power supply range (if applicable)

4.2.2 Leak Test

Each transmitter shall be tested for leaks after all assembly and test operations. The pressure test chamber shall subject the transmitter to a maximum normal operating pressure (as defined by the manufacturer) for a 5-minute period. There shall be no signs of a leak. This requirement shall be demonstrated on each transmitter as part of final acceptance testing.

4.2.3 Proof Pressure

The transmitter shall operate at a proof pressure of 1.5 times maximum operating pressure. Accuracy requirements shall be met before and after exposure to the proof pressure test. This requirement shall be demonstrated by design verification testing.

4.2.4 Burst Pressure

The transmitter shall not leak, rupture, or deform such that it loses its mounting when subjected to a burst pressure of 2.0 times maximum operating pressure. This requirement shall be demonstrated by design verification testing.

4.2.5 Transmitter Accuracy

Fuel flow transmitter accuracy, including signal conversion, shall not exceed ±2.5% of full scale over the flow range defined by the manufacturer. This requirement shall be demonstrated on each transmitter as part of final acceptance testing.

4.2.6 Flow Direction Marking

The direction of flow through the transmitter shall be permanently and legibly marked thereon.

4.2.7 Fuel Characteristics

Unless otherwise specified by the manufacturer, transmitter materials shall be suitable and compatible with the following fuels: Jet A per ASTM D1655 and/or aviation gasoline per ASTM D910.

4.2.8 Safety Provisions

Each transmitter shall continue to provide fuel flow in case of a malfunction in flight either by means of an automatic bypass or non-flow restricting design mechanism. Maximum allowable pressure drop, restricting fuel flow, shall be per 4.2.9.

4.2.9 Pressure Drop

The manufacturer shall specify if the transmitter is qualified for low-pressure and/or high-pressure aircraft fuel system(s). The allowable pressure drops are specified below. The test fluid and pressure drop at the maximum rated flow rate with the transmitter in its most restricted flow position shall be specified by the manufacturer. If it contains a movable element, the element shall be blocked in its most restricted flow position. Pressure drop testing shall be conducted at a fluid temperature of 15 °C.

Low-pressure fuel systems: For aircraft fuel systems with a maximum operating line pressure of 100 psi or less, the maximum allowable pressure drop in the most restricted flow position shall be equal to or less than the differential pressure values in Table 1 and shown graphically in Figure 1.

Table 1 - Low-pressure fuel system pressure drop values

Max Flow Rate (pph)	Max Pressure Drop (psi)	
	AVGAS	JET
0-1000	2.75	3.21
1001-1500	3.00	3.50
1501-2000	3.25	3.79
2001-3000	3.50	4.08

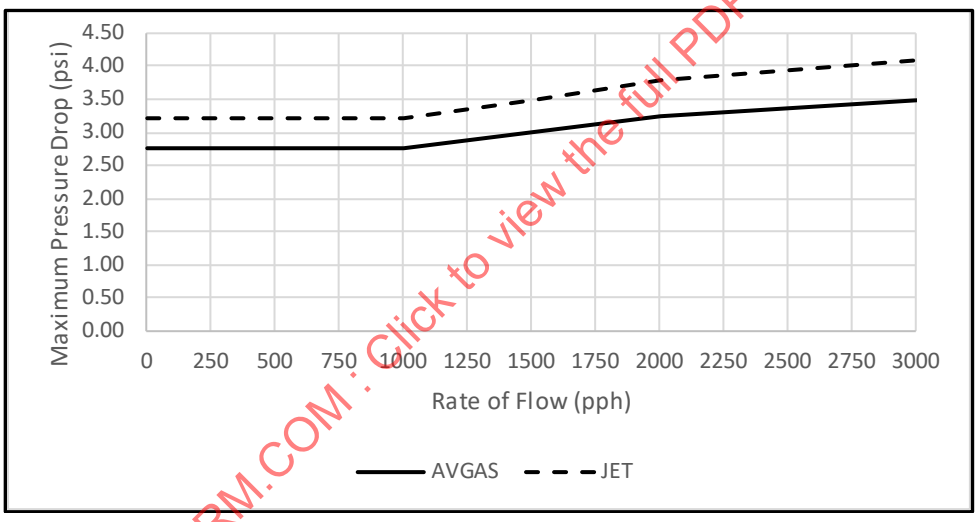

Figure 1 - Low-pressure fuel system pressure drop chart

High-pressure fuel systems: For aircraft fuel systems with a maximum operating line pressure greater than 100 psi, the maximum allowable pressure drop in the most restricted flow position shall not exceed 4% of operating line pressure at all operating flow rates. The manufacturer shall specify the assumed operating line pressure that was used to define the 4% allowance.

5. ENVIRONMENTAL REQUIREMENTS

5.1 General

5.1.1 Test Conditions

Unless otherwise specified, all tests required by this aerospace standard shall be conducted within the ambient test conditions specified in RTCA DO-160G, Paragraph 3.5.

5.1.1.1 Electromechanical Indicator Vibration (to Minimize Friction)

Unless otherwise specified, electromechanical indicators may utilize vibration to minimize internal mechanism friction during performance verification tests. The indicator may be subjected to a vibration of 0.002- to 0.005-inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.

5.2 Indicator Environmental Requirements

After completion of an environmental test, the instrument shall pass the applicable performance requirements in 4.1.3, 4.1.4, or 4.1.5. If the instrument is hermetically sealed, the seal shall pass the test requirement in 5.4.2.

5.2.1 Temperature and Altitude

The instrument shall be subjected to the temperature and altitude test per RTCA DO-160G, Section 4. The category shall be determined by the manufacturer and documented in the installation manual. The instrument shall meet the requirements of Table 4-1 for the appropriate category and the equipment operating portions of the test.

5.2 2 Temperature Variation

The instrument shall be designed and qualified to temperature variation per Section 5 of RTCA DO-160G at the appropriate category for the application. Application temperatures shall apply. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.2.3 Humidity

The instrument shall be designed and qualified to the humidity test per RTCA DO-160G, Section 6, Category A.

5.2.4 Operational Shocks and Crash Safety

The instrument shall be designed and qualified to the shock test per RTCA DO-160G, Section 7, Category B.

5.2.5 Vibration

The instrument shall be designed and qualified to meet the vibration test per RTCA DO-160G, Section 8 at the appropriate category for the application. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.2.6 Magnetic Effect

The instrument shall be designed and qualified to meet the magnetic effect test per RTCA DO-160G, Section 15, Category Z.

5.2.7 Power Input

The instrument shall be designed and qualified to meet the power input test per RTCA DO-160G, Section 16 at the appropriate category for the application for equipment that is connected to the aircraft power bus. The manufacturer shall establish the category, and it shall be documented in the installation manual. This requirement is not applicable to instruments that are not electrically powered.

5.2.8 Voltage Spike

The instrument shall be designed and qualified to meet the voltage spike test per RTCA DO-160G, Section 17, Category B.

5.2.9 Audio Frequency Conducted Susceptibility

The instrument shall be designed and qualified to meet the audio frequency conducted susceptibility voltage spike test per RTCA DO-160G, Section 18. This verification test is applicable if the instrument is connected to aircraft power. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.2.10 Induced Signal Susceptibility

The instrument shall be designed and qualified to meet the induced signal susceptibility test per RTCA DO-160G, Section 19. This verification test is applicable if the instrument is connected to aircraft power. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.2.11 Radio Interference

The instrument shall be designed and qualified to meet the radio interference test per RTCA DO-160G, Section 20, Category S and Section 21, Category B.

NOTE: The instrument should not be the source of interference, under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in electronic equipment installed in the same aircraft as the instrument.

5.2.12 Electrostatic Discharge

The instrument shall be designed and qualified to meet the electrostatic discharge test per RTCA DO-160G, Section 25, Category A.

5.3 Transmitter Environmental Requirements

After completion of an environmental test, the instrument shall pass the performance tests in 4.2.3 and 4.2.5. If the instrument is hermetically sealed, the seal shall be checked per 5.4.2.

5.3.1 Temperature

The instrument shall be designed and qualified to meet the high- and low-temperature test per RTCA DO-160G, Section 4 at the appropriate category for the application. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.3.2 Altitude

The instrument shall be designed and qualified to meet the altitude test per RTCA DO-160G, Section 4 at the appropriate category for the application. The manufacturer shall establish the category, and it shall be documented in the installation manual.

5.3.3 Temperature Variation

The instrument shall be designed and qualified to meet temperature variation test per Section 5 of RTCA DO-160G at the appropriate category for the application. Application temperatures shall be designated by the manufacturer, and they shall be documented in the installation manual.

The instrument shall be designed and qualified to meet the high- and low-temperature test per RTCA-DO-160G, Section 4 at the appropriate category for the application. Application temperatures shall be designated by the manufacturer, and they shall be documented in the installation manual.

5.3.4 Humidity

The instrument shall be designed and qualified to meet the humidity test per RTCA DO-160G, Section 6, Category B.