SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP433

REV. A

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Superseding ARP433

Liquid Oxygen Quantity Instruments

FOREWORD

Changes in this Revision are format/editorial only.

1. SCOPE:

This Aeronautical Recommended Practice covers Liquid Oxygen Quantity Indicators for use with associated Liquid Oxygen converters.

1.1 Purpose:

To recommend requirements for electrical Liquid Oxygen Quantity Instruments for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in Paragraph 3.3.

2. REFERENCES:

NACA Report 1235

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

3.1.1 Materials: Materials should be of a quality which experience and/or tests have demonstrated to be suitable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship should be consistent with high-grade aircraft instrument manufacturing practice.

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3.2 Identification:

The following information should be legibly and permanently marked on the instrument or attached thereto:

a. Name of instrument - Liquid Oxygen Quantity Instrument
b. SAE Aeronautical Recommended Practice ARP433A
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trademark
f. Range
g. Rating

3.3 Environmental Conditions:

The following conditions have been established as design requirements only. Tests should be conducted as specified in Sections 5, 6, and 7.

3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument should function over a range of ambient temperature from -55 °C to 70 °C. It should not be adversely affected by exposure to temperatures of -65 °C to 80 °C.

3.3.2 Humidity: The instrument should function and not be adversely affected when exposed to any relative humidity in the range of 0 to 95% at any temperature up to 70 °C.

3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instrument should function and should not be adversely affected when subjected to vibrations of the following characteristics:

TABLE 1

Type of Mounting	Cycles per Second	Maximum Double Amplitude (Inches)	Maximum Acceleration
Fuselage Forward of Spar Area	5 to 500	.036	2 G
Panel or Rack (with shockmounts)	5 to 500	0.020	2 G

3.3.4 Altitude: The instrument should function and should not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 to 50,000 feet standard altitude, per NACA Report 1235 except as limited by application of Paragraph 3.3.1. The instrument should not be adversely affected when subjected to a pressure of 50 inches Hg absolute.

3.4 Fire Hazard:

The electrical circuit should be so designed that the potentials should not create a fire hazard in the aircraft. The design of the circuit should be such that the current in the leads to the converter sensing element should in no case exceed 0.2 amperes.

3.5 Radio Interference:

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

3.6 Magnetic Effect:

The magnetic effect of the indicator should not adversely affect the operation of other instruments installed in the same aircraft.

3.7 Converter Capacitance:

The instrument assembly should be designed for operation from the following input capacitances:

a. Capacitance for various size empty converters is in accordance with the linear relationship shown in Table 2.

TABLE 2

Converter Capacitor (liters)	Capacitance of Empty Converter (uuf)
5	63.5
10	123.5
25	303.5

b. Capacitance for converters containing liquid oxygen should be calculated as follows:

$C = C_e + 5.796V$
C = Total capacitance (uuf)
C_e = Capacitance of empty converter (uuf)
V = Volume of liquid oxygen in converter (liters)

4. DETAIL REQUIREMENTS:

4.1 Rating:

4.1.1 Electrical: The instrument should be designed to operate on 115±10 percent variation in AC voltage, and 400±5 percent variation in frequency.

4.2 Indication:

The quantity instrument should be of the null balancing three wire capacitance bridge type.

4.2.1 Visibility: The indicating means and all significant markings should be readable from any point within the frustum of a cone whose side makes an angle of not less than 30 degrees with the perpendicular to the dial, and whose small diameter is the aperture of the instrument case. The distance between the dial and the cover glass should be a practical minimum and should not exceed 0.250 of an inch.

4.2.2 Indicator Case: The case should conform to Air Force-Navy Aeronautical Standard or a Military Standard such as: AND10412, MS33549, etc. The case should be hermetically sealed.

4.2.3 Filling Medium: The case should be filled with an inert gas, at least 10 percent helium, if at least 98 percent purity, free of dust particles, and sufficiently dry so that fogging of the dial glass does not occur during the low temperature tests of this ARP.

4.2.4 Dial:

4.2.4.1 Finish: Unless otherwise specified by the user, matte white material should be applied to all major graduations, numerals, and indicating means. Non-functional surfaces should be durable dull black.

4.2.4.2 Scale Length: The dial scale length shall be 180 angular degrees, minimum.

4.2.4.3 Graduations: The intervals employed should be determined by the associated converter in order to have a scale with sufficient graduations and numerals for each reading without overcrowding.

4.2.4.4 Numerals: Sufficient numerals should be marked to positively identify all graduations.

4.2.4.5 Instrument Name: The words "Liquid Oxygen" and "Liters" should appear on the dial.

4.2.5 Low Level Indications: A preset switch may be incorporated in the indicator to actuate an external warning light.

4.2.6 Power Indication: A means should be provided to permit checking operation of the indicator such as connections to an external test switch.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless otherwise specified, all tests required by this ARP should be made at atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25 °C. When tests are conducted with the atmospheric pressure or the temperature differing materially from thee values, allowance should be made for the variation from the specified conditions.

5.2 Applied Voltages:

Unless otherwise specified, all tests should be conducted at the power rating recommended by the manufacturer.

5.3 Master Test Instrument:

Unless otherwise specified, a master test instrument in accordance with MIL-T-8579 should be used to simulate input signals to the instrument. Tolerances of the master test instrument should be added to the specified tolerances for the given test.

5.4 Position:

Unless otherwise specified, all tests should be conducted with the instrument in its normal operating position.

5.5 Weighing Equipment:

The accuracy of the weighing equipment to be used during the complete instrument error test should be ±0.02 pounds or ±.2% of "full" converter weight whichever is greater.

5.6 Vibration Equipment:

Vibration equipment should be used which will provide frequencies and amplitudes consistent with the requirements of Paragraph 3.3.3 with the following characteristics:

5.6.1 Linear Motion Vibration: Vibration equipment should be such as to allow vibration to be applied along each of three mutually perpendicular axes of the test instrument.

5.6.2 Circular Motion Vibration: Vibration equipment should be such that a point on the instrument case will describe a circle in a plane inclined 45 degrees to the horizontal plane, the diameter of which is equal to the double amplitude specified.

6. INDIVIDUAL PERFORMANCE REQUIREMETNS:

All instruments should be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this ARP including the following requirements where applicable.

6.1 Indicator Scale Error - Room Temperature:

The instrument should be connected to a master test instrument. The test instrument should be set to capacitance values corresponding to empty and full converter. The instrument adjustment should be set so that it reads empty and full. Once set, the adjustments should not be altered for the remainder of the tests. The test instrument should be varied such that the instrument indicates at each major graduation and the capacitance input to the gage should be measured. Capacitance readings should be taken at each of these points and should not deviate from the capacitance values calculated from the formula in Paragraph 3.7 by more than 1.25 percent of full scale added capacitance. These capacitance readings should be used as a reference in determining subsequent scale errors.

6.2 Sealing Test:

Hermetically sealed components should be tested for leaks by means of a mass spectrometer type of helium leak detector (or equivalent). Where a nitrogen-helium mixture is utilized as the filling medium, the detected leak rate should not exceed 0.01 micron cubic foot per hour at a pressure differential of 1 atmosphere. Where 100% helium is utilized as the filling medium, the leak rate should not exceed 0.1 micron cubic foot per hour.

6.3 Dielectric:

Ungrounded instruments or grounded instruments prior to connection of internal ground wire, should be tested by either the method of inspection of Paragraph 6.3.1 or 6.3.2.

6.3.1 Insulation Resistance: The insulation resistance measured at 500 volts DC (200 volts for hermetically sealed, inert gas filled instruments) between all electrical circuits connected together and the metallic case shall not be less than 20 megohms.

6.3.2 Dielectric Strength: The insulation should withstand without evidence of damage the application of a sinusoidal voltage at a commercial frequency between all electrical circuits connected together and the metallic case, for a period of five seconds. The RMS value of the sinusoidal voltage applied shall be either five (5) times the maximum instrument operating voltage, or 500 volts (200 volts for hermetically sealed, inert gas filled instruments), whichever is lower.

6.3.2.1 Instruments having a permanent internal ground connection should be tested as follows:

The insulation should withstand without evidence of damage the application of a sinusoidal voltage at a commercial frequency between each electric circuit and the metallic case for a period of five (5) seconds. The RMS value of the sinusoidal voltage applied should be 1.25 times the maximum circuit operating voltage obtainable between two test points.

6.4 Speed of Response:

The instrument should be designed so that the indicating means will traverse full scale in not more than 15 seconds to provide a means of indicating when the liquid oxygen system is filled.

7. QUALIFICATION TESTS:

As many instruments as may be deemed necessary to demonstrate that all instruments will comply with the requirements of this section should be tested in accordance with the instrument manufacturer's recommendations. Tests specified in Section 6 plus the following constitute the requirements of this section as applicable.

7.1 Complete Instrument Scale Error:

The complete instrument should be electrically connected with the probe installed in the converter for which it is intended. The test should be conducted in the following manner:

a. Adjust the "Empty" and "Full" adjustments in accordance with the instrument manufacturer's instructions.
b. Fill the converter with nominal liquid oxygen to the design full value as determined by weight.
c. With liquid oxygen at atmospheric pressure, remove in increments which will cause the instrument to read at each major division below the initial reading.
d. Record the readings and weight of liquid oxygen remaining for each reading.
e. The readings obtained should not deviate respectively from the actual quantities remaining by more than2 percent of indication plus 4 percent of full scale indication at any of the major dial divisions.

7.2 Temperature Tests:

7.2.1 High Temperature: The instrument should be connected and adjusted as in 6.1. The instrument should be subjected to a temperature of plus 70 ±2 °C for a period of at least 4 hours.

The master test instrument should be kept at room temperature. At the end of the four hour period, while the instrument under test is still at the high temperature capacitance, readings should be determined for each major graduation by means of the test instrument. The readings should not differ from the reference values obtained in Paragraph 6.1 by more than 1.75 percent of full scale added capacitance.

7.2.2 Low Temperature: The tests of 7.2.1 should be repeated except the temperature should be -55 ±2 °C. The instrument scale error test should be performed after the system has been energized for 5 minutes and while still at this temperature, there should be no fogging of the cover glass.

7.2.3 Temperature Exposure Tests:

7.2.3.1 High Temperature Exposure: The tests specified in Paragraph 7.2.1 should be repeated except the temperature should be maintained for at least 24 hours.

7.2.3.2 Low Temperature Exposure: Repeat tests specified in Paragraph 7.2.2 except gage should be kept at a temperature of -65 ±2 °C for a period of 18 hours, after which the temperature should be raised to -55 ± 2 °C and kept for a period of 6 hours. During the last 2 hours of the 6 hour period, the pressure should be reduced to 0.82 inch of mercury absolute, or less.

7.3 Vibration:

7.3.1 Resonance: The instrument, while operating, should be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Paragraph 3.3.3.

The instrument should then be subjected to a vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.3.3 at the resonant frequency for a period of one hour in each axis. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failures. The test period should not be less than one-half hour at any resonant mode.