Society of Automotive Engineers, Inc.
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# AERONAUTICAL STANDARD AS 411

## MANIFOLD PRESSURE INDICATING INSTRUMENTS

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Revised

1. PURPOSE: To specify minimum requirements for manifold pressure indicating instruments for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. SCOPE: This specification covers instruments intended for use in airplanes to indicate engine manifold absolute pressure.

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

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

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

3.2 Identification: The following information shall be legibly and permanently marked on the units or attached thereto:

(a) Name of instrument
(b) SAE Specification AS 411
(c) Range (Transmitters Only)
(d) Rating (Nominal electric, pressure, vacuum etc.)
(e) Manufacturer's Part No.
(f) Manufacturer's Serial No. or date of manufacture
(g) Manufacturer's name and/or trade mark

3.3 Environmental Conditions: The following conditions have been established as design requirements only. Tests shall be conducted as specified in Sections 5, 6, 7.

3.3.1 Temperature: When installed in accordance with the manufacturer's instructions, the units shall function through the temperature ranges as listed in Column A below and shall not be adversely affected by exposure to the temperature ranges shown in Column B.

| Instrument Location | A | B |
|---|---|---|
| Power Plant Accessory Compartment | -30 to 100C | -65 to 100C |
| Heated Areas (Temp. Controlled) | -30 to 50C | -65 to 70C |
| Unheated Areas (Temp. Uncontrolled) | -55 to 70C | -65 to 70C |

3.3.2 Humidity: The units shall function and not be adversely affected when exposed to any relative humidity in the range from 0 to 95 % at approximately 32C.

3.3.3 Altitude: The instrument shall function and not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 feet to 40,000 feet standard altitude except as limited by application of Section 3.3.1.

3.3.4 Vibration: When installed in accordance with the instrument manufacturer's instructions, the units shall function and shall not be adversely affected when subjected to the following vibrations:

| Type of Instrument Mounting | Cycles Per Min.* | Amplitude | Max. Acceleration |
|---|---|---|---|
| Shock Mounted Panel Units | 500-3000 | 0.005 in. | 0.8 g |
| Unshock Mounted Panel Units | 500-3000 | 0.010 in. | 1.3 g |
| Structurally Mounted Units | 500-3000 | 0.030 in. | 3.8 g |
| Engine Compartment Mounted Units | 500-3000 | 0.20 in. | 25 g |

*Note - It is understood that the units shall withstand vibration at higher frequencies, but the acceleration values need not exceed those shown above.

(When specified by the purchaser for use in rotary wing aircraft, the frequency range shall be 150 to 3000 cycles per minute.)

3.3.5 Pressure Extremes: The units shall not be adversely affected by exposures to pressures of 2 inches of mercury absolute and 110% of maximum scale value.

3.4 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feed back, in radio sets installed in the same aircraft as the instruments.

4. DETAIL REQUIREMENTS:

4.1 Indicating Method: The instrument shall indicate by means of a pointer moving over a fixed dial. Clockwise pointer motion shall indicate increasing pressure.

4.2 Dial Markings:

4.2.1 Graduations: Markings shall be provided at intervals not exceeding one inch of mercury with major increment markings at 5 inch intervals.

4.2.2 Finish: Unless otherwise specified luminescent material (self-activating) shall be applied to the pointer (s), major graduations and numerals.

4.2.3 Numerals: Sufficient numerals shall be marked to positively and quickly identify all graduations. Numerals shall distinctly indicate the graduations to which each applies.

4.2.4 Instrument Name: The words "Manifold Pressure" shall be marked on the dial and may be in the same finish as the numerals.

4.3 Visibility: Pointer (s) and dial markings shall be visible from any point within the frustrum of a cone, the side of which makes an angle of 30 degrees with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed 1/8 inch for the single indicator and 3/16 inch for the dual indicator.

4.4 Power Variations: All units shall properly function with ±15% variation in DC voltage and/or ±10% variation in AC voltage and frequency provided the AC voltage and frequency vary in the same direction.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this specification shall be made at an atmospheric pressure of approximately 29.92 inches of mercury and at a temperature of approximately 22C. When tests are made with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified condition.

5.2 Vibration (to minimize friction): Unless otherwise specified, all tests for performance may be made with the instrument subjected to a vibration of 0.002 to 0.005 inch amplitude at a frequency of 1500 to 2000 cycles per minute. The term amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.

5.3 Vibration Stand: A vibration stand shall be used which will vibrate at any desired frequency between 500 and 3000 cycles per minute and shall subject the instrument to vibration such that a point on the instrument case will describe, in a plane inclined 45 degrees to the horizontal, a circle, the diameter of which is equal to the amplitude specified herein.

5.4 Power: Unless otherwise specified, all tests for performance shall be conducted at the power rating recommended by the manufacturer.

5.5 Test Position: Unless otherwise specified, the instrument shall be mounted and tested in its normal operating position.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this specification including the following requirements where applicable.

6.1 Scale Error: The instrument shall be tested for scale errors and the errors shall not exceed two percent of the full scale in degrees. When the pressure is varied uniformly, the movement of the pointer (s) shall be uniform and free from effects of backlash.

6.2 Dielectric Test: The instrument shall be subjected to whichever one of the following dielectric tests is most applicable:

6.2.1 Ungrounded instruments, or grounded instruments prior to connection of internal ground wire, shall be tested by either method (a) or (b) described below:

(a) Insulation resistance: The insulation resistance measured at 500 volts d-c between all electrical circuits connected together and the metallic case shall not be less than 20 megohms.

(b) Dielectric strength: The insulation shall 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 5 seconds. The RMS value of the sinusoidal voltage applied shall be either five (5) times the maximum instrument operating voltage, or 500 volts, whichever is the greater.

6.2.2 Instruments operated with a permanent internal ground connection shall be tested as follows:

The insulation shall 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 5 seconds. The RMS value of the sinusoidal voltage applied shall be 1.25 times the maximum circuit operating voltage obtainable between two test points.

6.3 Position Error: The change in pointer indication with change in instrument position from the normal position shall not exceed 1% of full range.

6.4 Leak: With pressure applied to cause a full scale deflection of the pointer, the change in pointer position in one minute shall not change by more than 1% of full scale value.

7. QUALIFICATION TESTS: As many instruments as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations.

7.1 Low Temperature: The instrument shall be exposed to a temperature of -30C for 3 hours. The change in indication at -30C from the reading obtained at room temperature shall not exceed 1½ percent of full scale.

7.2 High Temperature: The instrument shall be exposed to a temperature of +50C for 3 hours. The change in indication at +50C from the reading obtained at room temperature shall not exceed 1 percent of full scale.

7.3 Extreme Temperature Exposure: The instrument shall, after alternate exposures to ambient temperatures of -65C and 70C for periods of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of Section 6.1. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.

7.4 Damping: A pressure sufficient to produce the scale deflection of the pointer mark specified in the following table shall be applied. When this pressure is suddenly released, the time for the pointer to move to the test point specified in the following table shall be 2 ±1.0 seconds.

| Instrument Range | Pointer Deflection Mark | Test Point |
|---|---|---|
| 10 - 50 inches of mercury | 50 | 32 |
| 10 - 75 inches of mercury | 50 | 32 |
| 10 - 100 inches of mercury | 75 | 35 |

7.5 Low Pressure: With the instrument subject to an ambient pressure equivalent to 15000 feet, a scale error test shall be conducted. The difference between the readings of the Scale Error Test of Section 6.1 and this test shall not exceed 1% of full range.