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Superseding AS408B

**Pressure Instruments - Fuel, Oil and Hydraulic
(Reciprocating Engine Powered Aircraft)**

FOREWORD

Changes in this Revision are format/editorial only.

1. SCOPE:

This Aeronautical Standard covers two basic types of fuel, oil and hydraulic pressure instruments as follows:

Type I - Direct Indicating

Type II - Remote Indicating

This Aerospace Standard does not apply to engine mounted torque meter systems.

1.1 Purpose:

This Aerospace Standard establishes the essential minimum safe performance standards for fuel, oil and hydraulic pressure instruments primarily for use with reciprocating engine powered transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. REFERENCES:

NACA Report 1235

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

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

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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 instrument or attached thereto:

- a. Name of instrument
- b. SAE AS408C
- 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 (Electrical, vacuum, etc.)
- h. Explosion category

3.3 Environmental Conditions:

The following conditions have been established as minimum design requirements. Tests shall 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 shall function over the range of ambient temperature shown in Column A below and shall not be adversely affected by exposure to the range of temperature shown in Column B below:

TABLE 1

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Power Plant Compartment	-30 to +100 °C	-65 to +100 °C
Heated Areas (Temperature Controlled)	-30 to +70 °C	-65 to +70 °C
Unheated Areas (Temperature Controlled)	-55 to +70 °C	-65 to +70 °C
Power Plant Accessory Compartment	-30 to +100 °C	-65 to +100 °C

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- 3.3.2 Altitude: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected following exposure to a pressure and temperature range equivalent to -1000 to 40,000 feet standard altitude, per NACA Report 1235, except as limited by the application of Paragraph 3.3.1. The instrument shall not be adversely affected when subjected to an ambient pressure of 50 inches of mercury absolute.
- 3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

TABLE 2

<u>Instrument Location in Airframe</u>	<u>Cycles per Second</u>	<u>Maximum Double Amplitude (Inches)</u>	<u>Maximum Acceleration</u>
Power Plant Mounted	5-150	0.100	20 g
Wings and Empennage	5-500	0.036	10 g
Fuselage	5-500	0.036	5 g
Panel or Rack (Vibration Isolated)	5-50	0.020	1.5 g

- 3.3.4 Humidity: The instruments shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately +70 °C.
- 3.4 Explosion Category:

The instrument component, when intended for installation either in uninhabited areas of non-pressurized aircraft or in non-pressurized areas of pressurized aircraft, shall not cause an explosion when operated in an explosive atmosphere. The component shall meet the requirements applicable to the explosion category below. Specifically, any instrument component which can be an ignition source and is intended for installation in an area in which combustible fluid or vapor may result from abnormal conditions, e.g., fuel line leakage, shall meet the requirements of Category I. If the intended location is an area where combustible fluid or vapor can occur during normal operation, e.g., fuel tank, the instrument component shall meet the requirements of Category II listed below:

TABLE 3

<u>Category</u>	<u>Definition</u>	<u>Requirement</u>
I	Explosion proofed: Case not designed to preclude flame or explosion propagation	Paragraph 7.11.1
II	Explosion proofed: Case designed to preclude flame or explosion propagation	Paragraph 7.11.2
III	Hermetically sealed	Paragraph 6.6
IV	Instrument not capable of causing an explosion	Shall not be capable of producing a capacitive or inductive spark of more than 0.2 millijoules of energy or a contact spark of more than 4.0 millijoules of energy.

3.5 Fire Hazard:

The instruments shall be so designed to safeguard against hazards to the aircraft in the event of malfunction or failure, and the maximum operating temperature of surfaces of any instrument component, whether functioning correctly or malfunctioning, contacted by combustible fuel or vapor shall not exceed +200 °C due to self-heating.

3.6 Radio Interference:

The instruments shall not be the source of objectionable 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 instruments.

3.7 Magnetic Effect:

The magnetic effect of the instruments shall not adversely affect the performance of other instruments installed in the same aircraft.

3.8 Suction or Overpressure:

Pressure or suction instruments, as applicable, shall not be adversely affected when subjected to suction or overpressure as specified in the following table:

TABLE 4

<u>Maximum Indicated Pressure - PSI</u>	<u>Overpressure</u> <u>Percent of Maximum Indicated</u> <u>Pressure</u>		<u>Suction</u> <u>Percent of Maximum Suction</u>
	<u>Oil & Hydraulic</u>	<u>Fuel</u>	<u>Fuel Vent</u>
0 to 200	200	120	135
201 to 1000	150		
1001 to 2000	133		
2001 up	125		

3.9 De-Compression:

When installed in accordance with the instrument manufacturer's instructions the instrument shall function and not be adversely affected following exposure to a pressure decrease from 22 to 2 inches of mercury in 2 seconds.

4. DETAIL REQUIREMENTS:

4.1 Indicating Means:

The pressure instrument shall indicate by means of a visual display such as pointer(s) moving over a fixed dial, digital counter, etc.

- 4.1.1 Finish: Unless otherwise specified by the user, matte white material shall be applied to all graduations, numerals, pointers and indication means.

Non-functional surfaces and markings shall be durable dull black.

- 4.1.2 Graduations: The graduations shall be arranged to provide the maximum of readability consistent with the accuracy of the instrument.

- 4.1.3 Numerals: The display shall include sufficient numerals to permit quick and positive identification of each graduation. Numerals shall distinctly indicate the graduation to which each applies.

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- 4.1.4 Instrument Title: The instrument title when used shall be of the same approximate size but no larger than the numerals. The title may be of the same finish as the numerals. The units of measure (PSI x 1000 or PSI as applicable) shall appear on the dial in lettering noticeably smaller than either the numerals or title.
- 4.1.5 Visibility: The indicating means and all markings shall be visible from any point within the frustrum of a cone, the side of which makes an angle of at least 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.
- 4.2 Pressure Bosses:
- Where a vent boss is used in the instrument, it shall be identified with lettering "V" and the pressure boss shall be identified with lettering "P". Pressure bosses shall be provided with wrench flats.
- 4.3 Cover Glass:
- The cover glass of the instrument shall be clear, flat, colorless, and free from flaws which would affect the readability of the instrument.
- 4.4 Operation:
- The transmitter shall be capable of operating in either the horizontal or vertical position.
- 4.5 Overpressure Stop:
- An overpressure stop shall be provided and shall be designed to restrain the prime mover. The stop shall allow the pointer of direct indicating instruments to travel beyond full scale to a point approximately mid-way between the last and first graduations. For remote systems, the transmitter overpressure stops shall allow a minimum overtravel of 5% of fullscale and the indicator mechanical stops shall provide a minimum overtravel of 3% of full scale.
- 4.6 Noncorrosive Sealing:
- The instrument mechanism shall be sealed from the pressure compartment by a metal diaphragm or bellows to prevent corrosive or explosive vapors from coming in contact with the mechanism.
- 4.7 Case Pressure Release:
- The instrument shall be provided with a metal blowout device which will relieve case pressure prior to any disintegration of the instrument case or cover glass.

4.8 Power Variation:

The instrument shall properly function with plus or minus 15 percent variation in DC voltage and/or plus or minus 10 percent variation in AC voltage and plus or minus 5 percent variation in frequency.

4.9 Hermetic Sealing:

When hermetically sealed, the case shall be filled with a dry inert gas free of dust particles. The gas shall be sufficiently dry so that fogging of the instrument cover glass does not occur during the fogging test of this Aeronautical Standard.

4.10 Synchro Requirements:

The synchro requirements shall be in accordance with the conditions specified in ARP461.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless otherwise specified herein, all tests required by this Aeronautical Standard shall be made at an atmospheric pressure of approximately 29.92 inches of mercury, an ambient temperature of approximately plus 25 °C and a relative humidity of not greater than 85%. When tests are conducted with the atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variation from the specified conditions.

5.2 Vibration to Minimize Friction:

Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 25 to 33 cycles per second. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

5.3 Vibration Equipment:

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

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

Circular Motion Vibration: Vibration equipment shall 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.

5.4 Power Conditions:

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

5.5 Position:

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

5.6 Test Medium:

The medium used for applying pressure during the tests shall be the medium with which the instrument is intended to be used or its equivalent.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

All instruments shall be subjected to tests by the instrument manufacturer to demonstrate specific compliance with this Aeronautical Standard including the following requirements where applicable:

6.1 Dielectric:

Each instrument shall be tested by the method of inspection listed in Paragraphs 6.1.1 and 6.1.2.

6.1.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made for circuits where the potential will appear across elements such as windings, resistors, capacitors, etc., since this measurement is intended only to determine adequacy of insulation.

6.1.2 Overpotential Tests: The instruments shall not be damaged by the application of a test potential between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with a RMS value of five times the maximum circuit voltage, or per Paragraphs 6.1.2.1 or 6.1.2.2 whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds and then reduced at a uniform rate to zero.

Since these tests are intended to insure proper electrical isolation of the circuit components in questions, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

6.1.2.1 Hermetically sealed instruments shall be tested at 200 volts, RMS.

6.1.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

6.2 Scale Error at Room Temperature:

The direct reading and transmitter instruments shall be tested for scale errors. The test shall be made by subjecting the instrument to the pressure required to produce the test points first with the pressure increasing, then with the pressures decreasing. With the pressures increasing, the pressure shall be brought up to, but shall not exceed the pressure specified to give the desired reading; and with the pressure decreasing, the pressure shall be brought down to, but shall not fall below the pressure specified to give the desired reading. The scale errors at room temperature of direct reading instruments shall not exceed $\pm 2\%$ of the full scale value and transmitters shall not exceed $\pm 2.0\%$ of the full scale value. The scale errors of remote indicators shall be determined by applying the specified electrical inputs. The scale errors at room temperature shall not exceed $\pm 0.75\%$ of the full scale value.

6.3 Friction Error:

The instrument shall be tested for friction error at each test point. The pressure shall be so increased as to bring the pointer of the direct reading instrument or test instrument (for test of transmitters) approximately to the desired reading and then held constant while two readings are taken, the first before the direct reading instrument or transmitter is tapped and the second after the instrument is tapped. The difference between any such readings is the friction error and shall not exceed 1% of the full scale value. The friction error of remote indicators shall be determined in a similar manner by applying suitable electrical inputs. The friction error shall not exceed 1% of the full scale value.

6.4 Position Error:

With sufficient pressure applied to obtain a reading of approximately mid-scale, the direct reading instrument or transmitter shall be held in each of several different positions. The change in the reading of a direct reading instrument or test instrument (for test of transmitters), with change in position from the normal test position shall not exceed 1% of the full scale value. The position error of remote indicators shall be determined in a similar manner by applying suitable electrical inputs. The position error shall not exceed 0.5% of the full scale value.

6.5 Leakage (Pressure Element):

With pressure applied to produce a full scale reading, the connection tubing shall then be sealed at a point within 2 inches of the pressure connection. During a period of 5 minutes, there shall be no change in reading.

6.6 Sealing:

Hermetically sealed instruments shall be tested for leaks by means of a mass spectrometer type of helium leak detector or equivalent. The leak rate shall not exceed 76 micron cubic foot per hour at a pressure differential of one atmosphere.

6.7 Differential Pressure Error:

This test is applicable to differential pressure instruments only. The applicable pressure shall be applied to the vent boss. Pressures shall be so applied to the pressure boss that the pressure differential between the pressure and vent bosses is equal to the required test pressure. The scale errors shall not exceed the tolerances specified in Paragraph 6.2.

7. QUALIFICATION TESTS:

As many instruments or components deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with his recommendation.

7.1 Temperature Characteristics:

7.1.1 Low Temperature Operation: The instrument shall be subjected to the applicable low ambient temperature listed in Column A of Paragraph 3.3.1 for a period of five hours without operating. The instrument shall be subjected to at that temperature, a scale error test and the scale errors of direct reading instruments shall not exceed $\pm 3.5\%$ of the full scale value and transmitters shall not exceed $\pm 3.0\%$ of the full scale value. The scale errors of remote indicators shall not exceed $\pm 1.0\%$ of the full scale value.

7.1.2 High Temperature Operation: The instrument shall be subjected to the applicable high ambient temperature listed in Column A of Paragraph 3.3.1 for a period of five hours without operating. (Electrical equipment shall be energized). The instrument shall be subjected to, at that temperature, a scale error test and the scale errors of direct reading instruments shall not exceed $\pm 3.5\%$ of the full scale value and transmitters shall not exceed $\pm 3.0\%$ of the full scale value. The scale errors of remote indicators shall not exceed $\pm 1.75\%$ of the full scale value.

7.1.3 Extreme Temperature Exposure: The instrument shall be exposed to the applicable low and high temperatures listed in Column B of Paragraph 3.3.1 for a period of 24 hours at each extreme temperature, without operating. After a delay of three hours at room temperature, the instrument shall meet the applicable individual performance tests (Section 6, except 6.1) at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.

7.1.4 Altitude: The instrument shall be subjected to the ambient temperature and pressure listed in Paragraph 3.3.2 for a period of three hours while operating. The instrument shall meet the requirements of Paragraphs 7.1.1 and 7.1.2 while at these conditions.

The instrument shall be exposed alternately to 50 inches Hg absolute and three inches Hg absolute, nonoperating. The instrument shall then meet the applicable individual performance tests (Section 6 except 6.1) at atmospheric pressure following this test.

7.2 Vibration:

- 7.2.1 Resonance: The instrument while operating shall 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 shall then be subjected to 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 along each axis. If 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 failure. The test period shall not be less than one-half at any resonant made. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours along each axis in accordance with the vibration requirements schedule (Paragraph 3.3.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.
- 7.2.2 Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in Paragraph 3.3.3 in 15 minute cycles for a period of one hour along each axis at an applied double amplitude specified in Paragraph 3.3.3, or an acceleration specified in Paragraph 3.3.3, whichever is the limiting value or a total of three hours for circular motion vibration whichever is applicable. Pointer variation and oscillation shall not exceed 1.5% of the full scale value for direct reading instruments and $\pm 1.5\%$ for pointer oscillation and $\pm 1.0\%$ for pointer variation of the full scale value for remote indicators. After the completion of this vibration test, no damage shall be evident and the instrument shall meet the applicable individual performance tests. (Section 6).

7.3 Humidity:

The instrument, unless hermetically sealed, shall be mounted in a chamber maintained at a temperature of 70 plus or minus 2 °C and a relative humidity of 95 plus or minus 5% for a period of six hours. After this period, the heat shall be shut off and the instrument allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% at the temperature decreases to not more than 38 °C. This complete cycle shall be conducted:

- a. Five times for components located in uncontrolled temperature areas.
- b. One time for components in controlled temperature areas.

Immediately after recycling, there shall be no evidence of damage or corrosion, which affects performance. Following this test, the instrument shall meet the requirements of Section 6 (other than Paragraph 6.1).

7.4 Magnetic Effect:

The magnetic effect of the instrument shall be determined in terms of the deflection of a free magnet, approximately 1 1/2 inches long, in a magnetic field with a horizontal intensity of 0.18 ± 0.01 gauss when the indicator is held in various positions on an east-west line with its nearest port 12 inches from the center of the magnet. With the instrument operating, the maximum deflection of the free magnetic shall not exceed 5 degrees from any indicating or reference position.

7.5 Thermal Shock:

This test is applicable only to hermetically sealed components. The components shall be subjected to eight cycles of exposure to the applicable high and low temperatures listed in Column B of Paragraph 3.3.1 without evidence of damage to the enclosure. Each cycle of the test shall consist of subjecting the component to the high temperature for a period of 30 minutes and then within 5 seconds of removal, the component shall be subjected to the low temperature for a period of 30 minutes. This cycle shall be repeated continuously one cycle following the other, until eight cycles have been completed. Following this test, the component shall be subjected to and meet the requirements of the Sealing Test specified in Paragraph 6.6.

7.6 Seasoning:

The pressure operated instrument shall be subjected to 10,000 applications of a pressure from 0 to 80 ± 5 percent of full scale value and return to zero at a rate of 30 ± 10 opm. The applied pressure with respect to time shall approximate a sine wave shape. Not less than one hour following this test, the instrument shall be subjected to and meet the requirements of the Scale Error and Friction Tests specified in Paragraphs 6.2 and 6.3 respectively.

7.7 Overpressure:

The pressure operated instrument shall be subjected to the applicable overpressure specified in Paragraph 3.8 for a period of 10 minutes. Not less than one hour following the application of the specified pressure, the instrument shall be subjected to and meet the requirements of the Scale Error Test specified in Paragraph 6.2.

7.8 Case Pressure Release:

The pressure blowout device shall be tested either under simulated increasing case pressure or by actual injection of pressure into the instrument case. The blowout device shall operate prior to any case disintegration or cover glass failure.

7.9 Damping:

A pressure sufficient to produce full scale deflection of the instrument shall be applied. When the pressure is suddenly released, the time for the instrument to traverse the interval from full scale to 10% of full scale shall be noted and shall be within 1.0 to 3.0 seconds.

7.10 Dielectric Test:

After completion of all the qualification tests, the instrument shall meet the dielectric test of Paragraph 6.1.

7.11 Explosion Proof:

The instrument component shall be subjected to whatever requirements are applicable for the specific category listed in Paragraph 3.4. The following requirements cover only two categories.

- 7.11.1 Category I:** The instrument component shall be subjected while in the test chamber to an ambient temperature in the range of 20 °C to 50 °C. The test shall be conducted while the component is operating, and if applicable, it shall be connected electrically to related system components located externally to the test chamber. It shall be possible to operate the electrical and/or the mechanical controls, and to apply electrical and/or mechanical loads, as appropriate to the component. All making and breaking electrical contacts shall be operated at least 10 times while the component is being tested.

The test chamber pressure shall be reduced to a pressure approximately 10,000 feet above the altitude pressure test point at which the test is to be conducted to compensate for increase in pressure when fuel is introduced. Tests shall be conducted at pressure altitudes in feet at approximately sea level, 10,000, 20,000, 30,000 and 40,000 feet. The introduction of the explosive mixture into the test chamber shall be made at each test altitude, and the amount of fuel used shall be appropriate for the test chamber, the test altitude pressure, and the prevailing atmospheric conditions. The test shall be conducted utilizing an explosive mixture in the lean sector of the explosive range, and capable of producing an instantaneous explosion when ignited by a spark plug. The fuel used for conducting the tests shall be aviation grade 100/130 gasoline or commercial butane.

The above tests shall be repeated utilizing explosive mixtures in the intermediate and rich sectors respectively of the explosive range and also at approximately sea level and at 40,000 feet pressure altitude with the instrument component at the lowest applicable ambient temperature listed in Column A of Paragraph 3.3.1.

Operation of the instrument component during the above conditions without an explosion resulting in the test chamber shall be considered as evidence that the instrument component fulfills the requirements of this explosion category.

7.11.2 Category II: The instrument component shall be installed in the test chamber, and both the case of the instrument component and the test chamber shall be subjected to an explosive mixture circulated in a positive manner. The instrument component need not be operating during this test. Upon energizing the ignition means located within the case, an explosion shall take place within the case but not within the test chamber external to the case in order for the case design characteristics to be considered as fulfilling the requirements of this explosion category.

This test shall be repeated at least five times using any pressure altitude between sea level and 5,000 feet. It shall be repeated utilizing explosive mixtures in the "intermediate" and "rich" sectors respectively of the explosive range. Any burned gases shall be cleared from the test chamber after completing each test.

7.12 Fogging (Hermetically Sealed Instruments Only):

The instrument, while operating, shall be exposed to a 70 °C ambient for a minimum of 30 minutes. While at this temperature, the external face of the cover glass shall be reduced to a temperature of 20 °C or less. No moisture or other material shall be deposited on the internal face of the cover glass as a result of this test.

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