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AERONAUTICAL RECOMMENDED PRACTICE

ARP 427

PRESSURE RATIO INSTRUMENTS

Issued 2/15/58
Revised

1. PURPOSE:

- 1.1 To recommend requirements for electrical Pressure Ratio Indicating Instruments for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in Para. 3.3.
- 1.2 This recommended practice is to be considered as being currently applicable and necessarily subject to revision from time to time due to rapid development in the aircraft industry.

2. SCOPE: This Aeronautical Recommended Practice covers two types of two unit Pressure Ratio Instruments each of which consist of a Transducer and an Indicator. The Transducer computes the ratio of two pressures and converts this ratio to a synchro electrical signal which is transmitted to the Indicator.

Type I - All material in this document applies to this classification only.

Type II - Additional material for this classification will be added to superseding issues as the state of the art permits.

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 and dependable for use in aircraft instruments.
- 3.1.2 Workmanship: Workmanship should be consistent with high-grade aircraft instrument manufacturing practice.

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

- a. Name of instrument - Pressure Ratio Transducer, or Indicator
- b. SAE Aeronautical Recommended Practice ARP 427
- 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.

Section 7C of the SAE Technical Board rules provides that: "All technical reports including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no obligation to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against infringement of patents."

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3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, both transducer and indicator should function over a range of ambient temperatures from -55C to 70C. The indicator should not be adversely affected by exposure to temperatures of from -65C to 80C. The transducer should not be adversely affected by exposure to temperatures of from -65C to 120C.

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

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 it is subjected to vibrations of the following characteristics.

<u>Instrument Location in Airframe</u>	<u>Cycles per Sec.</u>	<u>Maximum Double Amplitude (Inches)</u>	<u>Maximum Acceleration</u>
Fuselage Forward-of spar area	5-500	.036	2g
Panel or Rack (with shock mounts)	5-500	.02	2g

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 Para. 3.3.1. The indicator should not be adversely affected when subjected to a pressure of 50 in. Hg absolute.

3.4 Explosive Atmosphere: All instruments located in the uninhabited areas of non-pressurized aircraft or in non-pressurized areas of pressurized aircraft should not cause an explosion when operated in an explosive mixture.

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 the radio equipment installed in the same aircraft as the instrument.

3.6 Magnetic Effect: The magnetic effect of the instrument should not adversely affect the operation of other instruments installed in the same aircraft.

4. DETAILED REQUIREMENTS:

4.1 Rating:

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- 4.1.1 Pressure: The engine inlet pressure (PT_2) limits are 7.0 to 60.0 inches of mercury absolute. The engine exhaust pressure (PT_7) limits are 8.4 to 180.0 inches of mercury absolute.
- 4.1.2 Electrical: The instrument should be designed to operate on 115 plus or minus 10% volts a-c, 400 plus or minus 5% cycles per second power.
- 4.2 Mounting: The mounting rack, if used, should be such that it will satisfy the conditions necessary for shock and vibration tests.
- 4.3 Indicating Range: The indicating range should be graduated from 1.2 to 3.4.
- 4.4 Filling Medium: When hermetically sealed, the case should be filled with an inert gas at least 10 percent helium, of at least 98 percent purity, free of dust particles, and sufficiently dry so that fogging of the dial glass (indicator) does not occur during the low temperature tests of this ARP.
- 4.5 Finish: Unless otherwise specified by the user, matte white material should be applied to all major graduations, numerals and pointer. Non-functional surfaces should be durable dull black.
- 4.6 Visibility: The indicating means and all significant dial markings should be readable from any point within the frustrum of a cone whose sides make 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.
5. TEST CONDITIONS:
- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this ARP should be made at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25 deg C, and at a relative humidity of not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature differing materially from these values, allowance should be made for the variation from the specified conditions.
- 5.2 Power Conditions: Unless otherwise specified, the instrument should be tested with an applied voltage of 115V plus or minus 2 percent, AC single phase, 400 cps plus or minus 2 percent.

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- 5.3 Transmitting and Indicating Standards:** Each synchro transmitter in the transducer and each synchro receiver in the indicator should be connected to an indicating standard and a transmitting standard, respectively, when readings must be taken except as otherwise specified. The indicating standard should be completely calibrated, and should have a maximum error of plus or minus 0.50 circular degrees when tested against a primary transmitting master. The primary transmitting master should have a maximum error of plus or minus 0.10 circular degrees. The tolerances of the standards may be added to those indicated for the applicable tests.
- 5.4 Position:** Unless otherwise specified, all tests should be conducted with the instrument in its normal operating position.
- 5.5 Vibration Equipment:** Vibration equipment should be used which will provide frequencies and amplitudes consistent with the requirements of Para. 3.3.3 with the following characteristics:
- 5.5.1 Linear Motion Vibration:** Vibrating equipment should be such as to allow vibration to be applied along each of three mutually perpendicular axes of the test instrument.
- 5.5.2 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 REQUIREMENTS:** 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 Scale Error:** With the transducer connected under the conditions of Para. 5.1 and 5.2 pressures should be applied to the engine exhaust pressure and engine inlet pressure connections per Table I. The engine inlet pressure is to be stabilized. The engine exhaust pressures should be brought up to, but should not exceed the value given; a reading taken; the transducer tapped or gently vibrated, and another reading taken. The procedure should be repeated for decreasing engine exhaust pressures. Each reading taken after tapping should not differ from the theoretical reading by more than the tolerances given in Table IIa.
- The indicator scale errors should not exceed the tolerances given in Table IIb.
- 6.2 Friction Error:** The difference between readings taken before and after tapping in Para. 6.1 should not be more than the values given in Tables IIa and IIb.

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- 6.3 Position Error: The difference in indicator readings between tests in the normal position and those in any other position should not exceed that shown in Table IIb.
- 6.4 Power Variation Test: When the power supply is varied between the limits indicated in Para. 4.1.2, the instrument (system) should not indicate a pressure ratio change exceeding .005.
- 6.5 Leakage: The engine inlet pressure connection should be pressurized to 42 inches of mercury absolute. The pressure tube should then be "pinched" or otherwise sealed off upstream of the manometer. The pressure should not decrease by more than .15 inches of mercury during the next five (5) minute period. The engine exhaust pressure connection should be open to atmosphere during this test.

The above test should be repeated with a pressure of 96 inches of mercury absolute applied to the engine exhaust pressure connections and a pressure of 35 inches of mercury absolute applied to the engine inlet pressure connection. The engine exhaust pressure should not decrease more than .25 inches of mercury during the five (5) minutes. The volume of the entrapped air in the manometer well and connecting piping should not exceed 45 cubic inches.

- 6.6 Dielectric: Ungrounded instruments or grounded instruments prior to connection of internal ground wire, should be tested by either the method of inspection of Para. 6.6.1 or 6.6.2.
- 6.6.1 Insulation Resistance: The insulation resistance measured at 500 volts D.C. (200 volts for hermetically sealed, inert gas filled instruments) between all electrical circuits connected together and the metallic case should not be less than 20 megohms.
- 6.6.2 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 should 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.
- 6.6.2.1 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.

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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 manufacturer's recommendations.

7.1 Room Temperatures:

- 7.1.1 Response Rate: The transducer should be connected to an indicating standard. Pressure should be applied to the engine inlet pressure connection per Table III and stabilized at each test point. Pressure should then be applied to the engine exhaust pressure connection for the smaller number listed in Table III corresponding to the engine inlet pressure used. When the pressures are stabilized the pressures should be blocked in the transducer. The power should remain "on" during this test. A set up similar to Figure I should be used. The quick acting valve should be closed and the pressure should then be raised to and stabilized at the higher pressure given in Table III corresponding to the engine inlet pressure used. The quick acting valve should be opened within 5 minutes after the pressures are stabilized. The response time during each step tested should not be greater than the times specified in Table III. The indicator should be considered stabilized when the total motion does not exceed 0.02 inches. The indicating means should begin to move within 0.25 seconds of the change in pressure in the transducer. The indicator should stabilize within 1.5 seconds of the time the indicating means first shows the final reading.

- 7.1.2 Sensitivity and Deadband: The engine inlet pressure and the engine exhaust pressure should be adjusted and stabilized to the pressures indicated in Table IV. While holding the engine inlet pressure constant, the engine exhaust pressure should be increased until a change of indication is first detected. The engine exhaust pressure should then be decreased slowly until a change of indication is detected. The decrease of pressure necessary to cause the change of indication should not be greater than those values specified in Table IV. The procedures should be repeated by varying the engine inlet pressure and holding the engine exhaust pressure constant.

- 7.2 Humidity: The instrument, unless hermetically sealed, should 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 should 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% as the temperature decreases to not more than 38 C. This complete cycle should be conducted.

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

Immediately after recyoling; there should be no evidence of damage or corrosion, which affects performance. Following this test the instruments should meet the requirements of Para. 6.1 and 6.2.

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7.3 Low Temperature Tests:

- 7.3.1 Low Temperature High Altitude Tests (Operating):** Both the transducer and indicator should be placed within a test chamber and the internal absolute pressure reduced to a pressure equivalent to an altitude of 50,000 ft. above sea level. Simultaneously the chamber should be cooled to and be maintained at a temperature of -55 C for a period of three hours. The instruments should then meet the requirements of Para. 6.1 and 6.2.
- 7.3.2 Low Temperature (Exposure):** The chamber in Para. 7.3.1 should be returned to ambient pressure then further cooled to -65 C and maintained for three hours to assure stabilization. Thereafter allow instrument to return to a stabilized room temperature condition. The instrument should then meet the requirements of Para. 6.1 and 6.2.

7.4 High Temperature Tests:

- 7.4.1 Operating:** Both indicator and transducer should be placed in a test chamber and the internal temperature of the chamber raised to 70 C with an internal humidity of not more than 5%. The temperature should be maintained for a period of three hours. The instrument should then meet the requirements of Para. 6.1 and 6.2.
- 7.4.2 Exposure:**
- 7.4.2.1 Indicator:** With the indicator only left in the test chamber the internal temperature of the chamber should be raised to 80 C and maintained for a period of three hours. Thereafter allow the indicator to return to stabilized room temperature conditions. The instrument should then meet the requirements of Para. 6.1 and 6.2.
- 7.4.2.2 Transducer:** Repeat the procedure of Para. 7.4.2.1 with only the transducer in the chamber and the temperature raised to 120 C. Maintain for three hours for complete stabilization. Thereafter allow the transducer to return to stabilized room temperature conditions. The instrument should meet the requirements of Para. 6.1 and 6.2.

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7.5 Vibration:

Resonance - The instrument should be subjected to a resonant frequency survey of the appropriate range specified in Para. 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 Para. 3.3.3.

The instrument should then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Para. 3.3.3 at the resonant frequency for a period of one hour in each axis or with circular motion vibration, whichever is applicable. 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 should be considered most likely to produce failure. The test period should not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument should be vibrated for two hours in accordance with the vibration requirements schedule (Para. 3.3.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

Cycling - The instrument, while operating, should be tested with the frequency cycled between limits specified in Para. 3.3.3 in 15-minute cycles for a period of one hour in each axis at an applied double amplitude or an acceleration specified in Para. 3.3.3, whichever is the limiting value, or a total of three hours for circular motion vibration, whichever is applicable. While being vibrated the indicator reading should not vary more than that indicated in Table IIb.

The instrument should be tested to determine that it is functioning properly during vibration.

On completion of the above test, the component should meet the requirements of Para. 6.1 and 6.2.

- 7.6 Explosion Proof:** All instruments which are not hermetically sealed and which fall into the category defined in Para. 3.4 should be operated in an explosive atmosphere in such a manner that all normal operations occur. All making and breaking electrical contacts should be actuated a minimum of 10 times. Normal operation of the instrument should not ignite the explosive atmosphere. The test should be conducted at pressures simulating altitudes of sea level and 40,000 feet. The temperature of the explosive atmosphere should be between 20 C and 50 C. At the conclusion of each test it should be demonstrated that the ambient mixture was explosive by intentionally igniting it with an electric spark. Aviation gasoline or commercial butane should be used to generate the explosive mixture.

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- 7.7 **Sealing:** The instrument, if hermetically sealed, should be immersed in water and the absolute air pressure above the water reduced to one inch of Hg until bubbles substantially cease to be given off by the water. The absolute pressure is then increased to 2-1/2 inches of mercury. Any bubbles coming from within the instrument should be considered as leakage. A helium leak detector or other means of test, equal or superior in sensitivity to the immersion test method described above, may be used.
- 7.8 **Magnetic Effect: (Indicator only):** The magnetic effect of the instrument should 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 (plus or minus .01) gauss when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center line of the magnet. With the instrument operating the maximum deflection of the free magnetic should not exceed 5 degrees from any indicating or reference position.

TABLE 1

Engine Inlet Pressure (in of HG) Absolute PT ₂	PRESSURE RATIO						
	1.20	1.50	1.70	2.30	2.70	3.00	3.40
7.5		11.25		17.25		22.50	
15.0	18.00	22.50				45.00	51.00
25.0			42.50	57.50	67.50		85.00
42.0	50.4					126.0	
60	72.0					180	

ENGINE EXHAUST PRESSURES
(In of HG ABSOLUTE PT₇)