



# AEROSPACE INFORMATION REPORT

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.

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## AIR 818A

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### SUBSONIC AIRCRAFT INSTRUMENT STANDARDS: WORDING, TERMINOLOGY, PHRASEOLOGY, ENVIRONMENT AND DESIGN STANDARDS FOR

This information report is intended to provide the sponsors of minimum performance instrument standards with standard wording and with minimum environmental and design requirements for use in the preparation of their documents.

The individual sponsor shall use only those parts of this report that apply to his particular document.

The individual sponsor shall expand the standard wording, especially sections 6, 7, and 8, as required, for his particular document.

The paragraphs of this report shall be used verbatim wherever possible.

Unless otherwise directed by the Committee, cross-referenced documents shall be called out by specific revision letter, e. g. ". . . shall be in accordance with AS XXXA." In addition, non-SAE document callouts shall include the document title. However, every effort shall be made to keep cross referencing to an absolute minimum.

Title

(Reciprocating Engine Powered Aircraft)

or

Title

(Turbine Powered Subsonic Aircraft)

1. PURPOSE - This standard establishes the industry standards for \_\_\_\_\_ instruments primarily for use with reciprocating engine powered (or turbine powered subsonic, as applicable) transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.4 et seq.

2. SCOPE - This standard covers \_\_\_\_\_  
or

SCOPE - This standard covers \_\_\_\_\_ basic types of \_\_\_\_\_ (no capitals)  
instruments as follows:

Type I \_\_\_\_\_

Type II \_\_\_\_\_

Note: Each type number to be followed by a brief description.  
As many types as required may be used.

E Technical Board rules provide 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 agreement to adhere to any SAE standards 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 liability for infringement of patents."

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 instrument or nameplate attached thereto:

- a. Name of instrument
- b. SAE AS \_\_\_\_\_ (show number and revision letter)
- c. Manufacturer's part number
- d. Manufacturer's serial number or date of manufacture
- e. Manufacturer's name and/or trademark
- f. Range (if applicable)
- g. Rating (electrical, vacuum, etc., if applicable)
- h. Explosion category (if applicable)
- i. Aircraft identification (if applicable)

3.3 Compatibility of Components - If components are individually acceptable, but require matching for proper operation, they shall be identified in a manner that will assure proper matching.

3.4 Environmental Conditions - The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5, 6, 7, and 8 to insure compliance with this standard.

3.4.1 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 following exposure to the range of temperature shown in column B below:

(Reciprocating Engine Powered Aircraft)

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Power plant compartment	0 to 100 C	-65 to +100 C
Heated areas (temperature controlled)	0 to 50 C	-65 to +70 C
Unheated areas (temperature uncontrolled)	-55 to + 70 C	-65 to +70 C

(Turbine Powered Subsonic Aircraft)

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Power plant accessory compartment	0 to 150 C	-65 to +150 C
Pressurized areas (temperature controlled)	0 to 70 C	-65 to +70 C
Non-pressurized or external areas	-55 to +70 C	-65 to +70 C

3.4.2 Altitude (Reciprocating Engine Powered Aircraft)

When installed in accordance with the instrument manufacturer's instructions, the instrument shall function and shall not be adversely affected following exposure to a pressure and temperature range equivalent to -1000 to +40,000 ft standard altitude, per NACA Report 1235, except as limited by the application of paragraph 3.4.1. The instrument shall not be adversely affected when subjected to ambient pressures of 50 and of 3 in. Hg abs.

Altitude (Turbine Powered Subsonic Aircraft)

When installed in accordance with the instrument manufacturer's instructions, the instrument shall function from sea level up to the altitudes and temperatures listed below: Altitude pressure values are per NACA Report 1235: The instrument shall not be adversely affected following exposure to extremes in ambient pressure of 50 and 2 in. Hg abs, respectively.

<u>Instrument Location</u>	<u>Altitude (Ft)</u>	<u>Temperature (C)</u>
Power plant accessory compartment	50,000	80
Pressurized areas	15,000	50
Non-pressurized areas	50,000	40
External areas	50,000	-2

3.4.3 Vibration (Reciprocating Engine Powered Aircraft)

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

<u>Instrument Location in Airframe</u>	<u>Cycles Per Second</u>	<u>Maximum Double Amplitude (In. )</u>	<u>Maximum Acceleration (g)</u>
Power plant mounted	5 - 150	0.100	20
Wings and empennage	5 - 500	0.036	10
Fuselage	5 - 500	0.036	5
Panel or rack (vibration isolated)	5 - 50	0.020	1.5

Vibration (Turbine Powered Subsonic Aircraft)

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

<u>Instrument Location</u>	<u>Frequency (cps)</u>	<u>Maximum Double Amplitude (In. )</u>	<u>(Peak) Maximum Acceleration (g)</u>
Nacelles and mounts	5 - 350	0.030	5
	350 - 1000	0.0008	10
Wings, empennage and wheel wells	5 - 1000	0.036	10
Fuselage			
Forward of spar area	5 - 1000	0.020	2
Center of spar area	5 - 1000	0.020	3
Aft of spar area	5 - 340	0.020	6
	340 - 1000	0.001	8
Vibration isolated rack	5 - 55	0.020	----
	55 - 1000	----	.75
Flight deck area	5 - 1000	0.020	.25

3.4.4 Humidity - The instrument shall function and shall not be adversely affected following exposure to any relative humidity in the range from 0 to 95% at a temperature of approximately 70 C.

3.5 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:

<u>Category</u>	<u>Definition</u>	<u>Requirement</u>
I	Explosion proofed; case not designed to preclude flame or explosion propagation	Paragraph 8. 3. 1
II	Explosion proofed; case designed to preclude flame or explosion propagation	Paragraph 8. 3. 2
III	Hermetically sealed	Paragraph 7. 2
IV	Instrument not capable of causing an explosion	Shall not be capable of producing a spark of more than 1.0 millijoule of energy and shall not have a short circuit current of more than 100 milliamperes

3.6 Fire Hazard - The instrument shall be so designed as 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 contacted by combustible fuel or vapor shall not exceed 200 C due to self heating.

All materials shall be non-combustible and shall not liberate gases or fumes which will result in such corrosion as to cause malfunction of equipment or discoloration of dials or indicia, nor shall toxic gases or fumes that are detrimental to performance of the aircraft or health of personnel be liberated under the operating conditions specified herein.

3.7 Radio Interference - The instruments shall not be a source of objectionable interference under operating conditions at any frequencies used on the aircraft, either by radiation, conduction, or feedback in any electronic equipment installed in the same aircraft as the instruments, in accordance with specification MIL-I-6181, latest revision.

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

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 in. Hg in 2 sec.

3.10 Interchangeability - Instruments and components which are identified in accordance with paragraph 3.2 shall be directly and completely interchangeable.

3.11 Definitions - Definitions shall be in accordance with AS 425, "Flight Control Compartment Nomenclature and Abbreviations," and as noted in the glossary of terms defined in Section 9.

#### 4. DETAIL REQUIREMENTS

##### 4.1 Instrument Markings

4.1.1 Finish - Unless otherwise specified by the user, matte white material shall be applied to all graduations, numerals and indication means. Non-functional surfaces and markings shall be durable dull black.

- 4.1.2 Graduation - The graduations shall be arranged to provide the maximum degree 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 clearly and distinctly indicate the graduation to which each applies.
- 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," "Degrees C," "In. Hg Abs," as applicable) shall appear on the dial in lettering noticeably smaller than either the numerals or the title. All letters and numerals shall conform to military standard drawing MS 33558.
- 4.1.5 Visibility - The indicating means (indicia, pointers, counters, etc.) shall be completely visible from all points within a space defined by a surface generated by lines making angles of at least 30 deg with a perpendicular to the display surface and diverging from the perimeter of the instrument window aperture. The distance between the dial and the cover glass shall be a practical minimum.
- 4.2 Function Indicating Means - The function shall be indicated by means of one or more pointers, dials, tapes, drums or any compatible combination thereof. Unless otherwise specified, relative motion of the index with respect to the scale (either the index or the scale may be the moving element) shall be clockwise, up or to the right for increasing function except as noted in paragraph 4.2.1.
- 4.2.1 Relative Motion Counters - Relative motion of counters with respect to the window shall be downward for increasing value.
- 4.3 Internal Lighting - Red internal lighting shall be in accordance with ARP 582, "Lighting, Integral, for Aircraft Instruments; Criteria for Design." White internal lighting shall be in accordance with ARP 798, "Design Criteria for White Incandescent Lighted Aerospace Instruments."
- 4.4 Power Variation - The instrument shall properly function with  $\pm 15\%$  variation in d-c voltage and/or  $\pm 10\%$  variation in a-c voltage and  $\pm 5\%$  variation in frequency, or hydraulic pressure limits of  $\pm 30\%$  of rated value.
- 4.5 Power Failure and Malfunction Monitoring
  - 4.5.1 Power Failure Indication - Means shall be incorporated in the instrument to indicate when adequate electrical power (voltage and/or current) is not being made available to all phases required for proper operation of the instrument. Such indicating means shall indicate electrical power failure in a positive manner.
  - 4.5.2 Fail-Safe Provisions - No single failure or malfunction of the instrument shall introduce unsafe transients to associated interconnected instruments.
  - 4.5.3 Malfunction Indication - Means shall be incorporated in the instrument to permit electrical and/or mechanical malfunctions, other than power failure, to be monitored by some appropriate means (e. g. , comparison monitoring). Such monitoring means shall indicate malfunctions in a positive manner.

- 4.6 Hermetic Sealing - When hermetically sealed, the case shall be filled with an inert gas, free of dust particles, and sufficiently dry so that fogging of the indicator glass does not occur during the low temperature and fogging tests of this standard.
- 4.7 Synchro Requirements - The synchro requirements shall be in accordance with the characteristics specified in ARP 461B, "Synchros."
- 4.8 Gyro Caging - If a gyro caging means is provided, it shall not be capable of locking the gyro in a caged position. Any malfunction which causes the gyro to remain caged shall be indicated in a positive manner on the face of the instrument affected.
- 4.9 Altitude and Differential Pressures - Altitude pressure values shall be in accordance with those specified in NACA Report 1235, "Standard Atmosphere - Tables and Data for Altitudes to 65,800 Feet".

Differential pressure values shall be per NASA Technical Note D-822, "Tables of Airspeed, Altitude, and MACH Number Based on Latest International Values for Atmospheric Properties."

## 5. TEST CONDITIONS

- 5.1 Atmospheric Conditions - Unless otherwise specified herein, all tests required by this standard shall be made at an atmospheric pressure of approximately 29.92 in. Hg, an ambient temperature of approximately 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

- 5.2.1 Vibration to Minimize Friction (Reciprocating Engine Powered Aircraft) - Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 in. double amplitude at a frequency of 25 to 33 cps. The term "double amplitude" as used herein, indicates the total displacement from positive maximum to negative maximum.
- 5.2.2 Vibration to Minimize Friction (Turbine Powered Subsonic Aircraft) - Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a maximum vibration of 0.001 in. double amplitude at a frequency of 10 to 60 cps. The term "double amplitude," as used herein, indicates the total displacement from positive maximum to negative maximum.

Note: If vibration above the limits specified above is required during normal operation in order to meet the accuracy requirements specified herein, it shall be the responsibility of the equipment manufacturer either to provide such vibration internally or to notify the user that such vibration is required.

- 5.3 Power Conditions - Unless otherwise specified herein, all tests shall be conducted at the power rating recommended by the manufacturer.
- 5.4 Position - Unless otherwise specified herein, all tests shall be conducted with the instrument in its normal operating position.

6. INSTRUMENTATION FOR PERFORMANCE CHECKS

6.1 Vibration Equipment

- 6.1.1 Vibration Equipment (Reciprocating Engine Powered Aircraft) - Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of paragraph 3.4.3, 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 deg to the horizontal plane, the diameter of which is equal to the double amplitude specified in paragraph 3.4.3.

- 6.1.2 Vibration Equipment (Turbine Powered Subsonic Aircraft) - Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument at frequencies and amplitudes consistent with the requirements of paragraph 3.4.3.
- 6.2 Test Synchros - Synchro transmitters used to provide test input functions to the instrument shall be in accordance with the requirements specified in ARP 461B, "Synchros."
- 6.3 Test Potentiometers - Potentiometers used to provide test input functions to the instrument shall be precision potentiometers with an impedance of \_\_\_\_\_ ohms + \_\_\_\_\_%, a resolution of 0.01%, and a linearity of at least 0.005%.
- 6.4 Other Instrumentation - All other instrumentation used in the tests in this standard should have an accuracy of at least ten times better than the tolerances specified for the instrument under test.

7. INDIVIDUAL PERFORMANCE REQUIREMENTS - All instruments shall be subjected to tests by the instrument manufacturer to demonstrate specific compliance with this standard, including the following requirements where applicable.

- 7.1 Dielectric - Each instrument shall be tested by the method of inspection listed in paragraphs 7.1.1 and 7.1.2.

- 7.1.1 Insulation Resistance - The insulation resistance measured at 200 v d-c for 5 sec between all electrical circuits and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to 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.
- 7.1.2 Overpotential Tests - The instruments shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with an rms value of five times the maximum circuit voltage, or per paragraph 7.1.2.1 or 7.1.2.2, 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 question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

- 7.1.2.1 Hermetically sealed instruments shall be tested at five times the maximum circuit voltage up to a maximum test voltage of 200 v rms.
- 7.1.2.2 Circuits that operate at potentials below 15 v are not to be subjected to overpotential tests.
- 7.2 Sealing - Hermetically sealed components shall be tested for leaks by means of a mass spectrometer type of helium leak detector or equivalent. The leak rate shall not exceed 0.0434 mu cu ft/hr\*/cu in. of filling gas at a pressure differential of one (1) atmosphere.

\*A "micron cubic foot per hour leak rate" is defined as that gas leakage which would change the pressure of one cubic foot of volume by the amount of one micron (one millionth of a meter of mercury) in one hour at a pressure differential of one atmosphere.

8. 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 recommendations.

8.1 Temperature Characteristics

- 8.1.1 Low Temperature Operation - The instrument shall be subjected to the applicable low ambient temperature listed in column A of paragraph 3.4.1 for a period of 3 hr without operating. The instrument shall meet, at that temperature, the applicable individual performance tests. (Section 7, except 7.1.)
- 8.1.2 High Temperature Operation - The instrument shall be subjected to the applicable high ambient temperature listed in column A of paragraph 3.4.1 for a period of 3 hr without operating (electrical equipment shall be energized). The instrument shall meet, at that temperature, the applicable individual performance tests. (Section 7, except 7.1.)
- 8.1.3 Extreme Temperature Exposure - The instrument shall be exposed to the applicable low and high temperatures listed in column B of paragraph 3.4.1 for a period of 24 hr at each extreme temperature, without operating. After a delay of 3 hr at room temperature, the instrument shall meet the applicable individual performance tests (Section 7, except 7.1) at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.
- 8.1.4 Altitude - The instrument shall be subjected to the applicable ambient temperature and pressure listed in paragraph 3.4.2 for a period of 3 hr while operating. The instrument shall then meet, at the conditions specified, the applicable individual performance tests. (Section 7, except 7.1.)

The instrument shall be exposed alternately to 50 in. Hg abs and 3 in. Hg abs, non-operating. The instrument shall meet the applicable individual performance tests (Section 7, except 7.1) at atmospheric pressure following this test. The time required to change from one pressure extreme to the other shall not exceed 4 minutes.

- 8.2 Vibration - After the completion of the following vibration tests, no damage shall be evident and the instrument shall meet the applicable individual performance tests. (Section 7, except 7.1.)
- 8.2.1 Resonance - The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in paragraph 3.4.3 in order to determine if there exist 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 3.4.3.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in paragraph 3.4.3 at the resonant frequency for a period of 1 hr 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 1/2 hr at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for 2 hr along each axis in accordance with the vibration requirements schedule (paragraph 3.4.3) at the maximum double amplitude and frequency to provide the maximum acceleration.

- 8.2.2 Cycling - The instrument, while operating, shall be tested with the frequency cycled between the limits specified in paragraph 3.4.3 in 15-minute cycles for a period of 1 hr along each axis at an appropriate applied double amplitude specified in paragraph 3.4.3, or an appropriate acceleration specified in paragraph 3.4.3, whichever is the limiting value, or a total of 3 hr for circular motion vibration, whichever is applicable.

During this test the instrument shall meet the individual accuracy performance requirements as specified in the applicable AS (the need for, and the type of performance checks shall be determined by the individual AS requirements).

- 8.3 Explosion Proof - The instrument shall be subjected to whatever requirements are applicable for the specific category listed in paragraph 3.5. The following requirements cover only two categories.

- 8.3.1 Category I - The instrument component shall be subjected, while in the test chamber, to an ambient temperature in the range of 20 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 ten times while the component is being tested.

The test chamber pressure shall be reduced to a pressure approximately 10,000 ft 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, 40,000 and 50,000 ft for turbine aircraft application only. 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 ft pressure altitude with the instrument component at the lowest applicable ambient temperature listed in column A of paragraph 3.4.1.

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.