

Remote Servoed Air Data Instruments for Subsonic Aircraft

FOREWORD

This document has been declared "NONCURRENT". It is recommended, therefore, that this document not be specified for new designs. "NONCURRENT" refers to those documents which have previously been widely referenced and may continue to be required on some existing designs. "NONCURRENT" documents are available from SAE upon request.

1. PURPOSE:

This standard establishes essential minimum safe performance requirements for remote air data instruments for use with turbine powered subsonic transport type aircraft (exclusive of rotary wing aircraft), the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.4 et seq.

2. SCOPE:

This standard provides minimum performance criteria for air data instruments intended to provide cockpit indication of:

- a. Indicated airspeed (V_i)
- b. Computer airspeed (V_c)
- c. True airspeed (V_t)
- d. Equivalent airspeed (V_e)
- e. Mach number (M)
- f. Altitude (H)
- g. Vertical speed (H_{pr})
- h. Maximum operating limit speed (V_{mo})
- i. True angle of attack (α_t)
- j. Free air temperature (T_{fat})
- k. Total temperature (T_t)

These functions shall be derived from a central air data computer (AS 417) and through system wiring applied to the respective indicator.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2008 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

SAE AS791

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials should 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 should 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. AS 791
- 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)

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, and 7 to insure compliance with this standard.

3.4.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instruments 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 ambient temperature shown in column B below:

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Pressurized areas	0 to 70 C	-65 to +70 C
Nonpressurized or external areas	-55 to +70 C	-65 to +70 C

SAE AS791

- 3.4.2 Altitude: When installed in accordance with the instrument manufacturer's instructions, these instruments shall function from sea level up to the altitudes and temperatures listed below. Altitude pressure values are per NACA Report 1235. These instruments 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</u>	<u>Temperature</u>
Pressurized areas	15,000 ft	50 C
Nonpressurized or external areas	60,000 ft	40 C

- 3.4.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, these instruments shall function and shall not be adversely affected when subject to vibration of the following characteristics:

<u>Instrument Location</u>	<u>Frequency (CPS)</u>	<u>Maximum Double Amplitude (In.)</u>	<u>Maximum Acceleration (g)</u>
Fuselage			
Foreward 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	-----	0.75
Flight Deck Area	5 - 1000	0.020	0.25

- 3.4.4 Humidity: These instruments 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 components, when intended for installation either in uninhabited areas of nonpressurized aircraft or in nonpressurized areas of pressurized aircraft, shall not cause an explosion when operated in an explosive atmosphere. The instruments shall meet the requirements of the applicable explosion category listed 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 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	See para. 8.4.1
II	Explosion proofed: case designed to preclude flame or explosion propagation	See para. 8.4.2
III	Hermetically sealed	See para. 7.1
IV	Instrument not capable of causing an explosion	Should 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 instruments shall be so designed as to safeguard against hazards to the aircraft in the event of a 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.

SAE AS791

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 or feedback in electronic equipment installed in the same aircraft as the instruments, as per MIL-I-6181 (latest revision).

3.8 Magnetic Effect:

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

3.9 Decompression:

When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and not be adversely affected following exposure to a pressure decrease from 22 to 2.0 in. Hg in 2 sec.

4. DETAIL REQUIREMENTS:

4.1 Display Markings:

4.1.1 Range of Presentation: The indicators shall present the following information derived from signal inputs in the form of electrical signals from a central air data computer (AS 417).

- a. Indicator or computed airspeed - range: 50 to 500 knots
- b. True airspeed - range: 100 to 650 knots
- c. Mach Number - range: 0.3 to 1.0
- d. Altitude - range: -1000 to +60,000 ft
- e. Vertical speed - range: 0 to $\pm 20,000$ fpm
- f. Maximum operating limit speed - range: defined by airframe company
- g. True angle-of-attack - range: -10 to +25 deg
- h. Free air temperature - range: -100 to +50 C
- i. Equivalent airspeed - range: 50 to 650 knots
- j. Total temperature - range: -70 to +150 C

4.1.1.1 Indicating Method: Each of the functions listed in paragraph 2 shall be presented by means of one or more pointers, dials, tapes, drums, counters, or any compatible combination thereof. Unless otherwise specified, relative motion of the index with respect to the scale (either the index or scale may be the moving element) shall be clockwise, up, or to the right for increasing value, except as noted in paragraph 4.1.1.1.1.

SAE AS791

- 4.1.1.1.1 Relative Motion-Counters: Relative motion of counters with respect to the window shall be downward for increasing value.
- 4.1.2 Finish: Unless otherwise specified by the user, matte white material should be utilized for all graduations, numerals, and indicating means. Nonfunctional surfaces and markings shall be durable dull black.
- 4.1.3 Graduations: The graduations shall be arranged to provide the maximum degree of readability consistent with the accuracy requirements of the instrument.
- 4.1.4 Numerals: Each instrument 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.
- 4.1.5 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 ("Ft x 1000", "Degrees C", "In Hg. ABS", as applicable) shall appear on the face of the instrument in lettering noticeably smaller than either the numerals or the title. All letters and numerals shall conform to military standard drawing MS 33558.
- 4.1.6 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 Internal Lighting:
- Internal lighting shall be in accordance with ARP 582, Lighting, Integral, for Aircraft Instruments; Criteria for Design. White lighting shall be in accordance with ARP 798, Design Criteria for White Incandescent Lighted Aerospace Instruments.
- 4.3 Power Variation:
- The instrument shall properly function with $\pm 15\%$ variation in dc voltage and/or $\pm 10\%$ variation in ac voltage and $\pm 5\%$ variation in frequency.
- 4.4 Power Failure and Malfunction Monitoring:
- 4.4.1 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.

SAE AS791

4.4.2 Fail Safe Provisions: No single failure or malfunction of the instrument shall introduce unsafe transients to associated interconnected instruments.

4.4.3 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 (i.e., comparison monitoring, etc.). Such monitoring means shall indicate malfunctions in a positive manner.

4.5 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.

4.6 Synchro Requirements:

The synchro requirements shall be in accordance with the characteristics specified in ARP 461B, Synchros.

4.7 Barometric Setting System:

The altimeter should be provided with a barometric or zero setting adjustment which will permit the altimeter to be set throughout the range of at least 28.1 to 31.0 in. Hg (952 to 1049 millibars). A safety feature shall be provided which will prevent incorrect reading of the pressure scale when the zero setting mechanism exceeds its barometric pressure limits.

The barometric setting should appear on a four digit counter on the face of the instrument.

4.8 Vibration to Minimize Friction:

If vibration is required to minimize friction to meet the accuracy requirements specified herein, it shall be the responsibility of the equipment manufacturer to provide notice to assure that this condition is met while the equipment is in normal operation.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless otherwise specified, 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, allowances should be made for the variation from the specified condition.

5.2 Vibration to Minimize Friction:

Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to maximum vibration of 0.001 in. double amplitude at a frequency of 10 to 60 cps. The term "double amplitude", as used herein, indicated the total displacement from positive maximum to negative maximum.

If vibration above the limits specified above is required to minimize friction 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:

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.

SAE AS791

6.3 Test Potentiometers:

Potentiometers used to provide test input functions to the instrument shall be precision potentiometers with an impedance of 10,000 ohms $\pm$ 5%, a resolution of 0.01%, and a linearity of at least 0.005%.

6.4 Electrical Zero and Rotation Reference:

The indicator synchros (where applicable) shall be so oriented electrically that each function will be servoed to the indication listed in Table I when a standard test transmitter is set at electrical zero and connected to the indicator in accordance with ARP 461B.

Table I. Electrical Zero Test

Function	Indicator Reading with Transmitter(s) Set at Zero Degrees	
	Round Dial Ind.	Vert. Scale Ind.
Indicated and/or computed airspeed	100 knots	100 knots
True airspeed	200 knots	200 knots
Equivalent airspeed	100 knots	100 knots
Mach number	0.3 mach	0.3 mach
Maximum Operating limit speed	*	*
Altitude	0.0 ft	0.0 ft
Vertical speed	0.0 ft	0.0 ft
True angle-of-attack	0.0 deg	0.0 deg
Free air temperature	0.0 C	0.0 C
Total temperature	0.0 C	0.0 C

* Transmitter electrical zero to correspond to that of Mach or computed airspeed depending upon to which indicator the user plans to apply the maximum allowable limit speed pointer.