

Submitted for recognition as an American National Standard

Minimum Performance Standard for Mach Meters

FOREWORD

Changes in the revision are format/editorial only.

1. SCOPE:

This AS covers subsonic and supersonic Mach meter instruments which, when connected to sources of static (Ps), and total (Pt), or impact (Pt-Ps), pressure provide indication of Mach number. These instruments are known as Type A. This AS also covers servo-operated repeater or digital display instruments which indicate Mach number when connected to the appropriate electrical output of a Mach transducer of Air Data Computer. These instruments are known as Type B.

1.1 Purpose:

This Aerospace Standard (AS) specifies the minimum safe performance standards for Mach Meter instruments primarily intended for use in aircraft under standard and environmental conditions.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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2.1 FAR Publications:

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

Federal Aviation Regulation 25.1359

2.2 RTCA Publications:

Available from RTCA Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036.

RTCA Document No. DO 160 Environmental Conditions and Test Procedures for Airborne
Electronic/Electrical Equipment and Instruments

2.3 NASA Publications:

NASA Technical Note D-822

2.4 Other Publications:

U.S. Standard Atmosphere 1962

3. GENERAL STANDARDS:

3.1 Operation of Controls:

The design of the instrument must be such that any controls intended for use during flight cannot be operated in any possible position, combinations or sequences that would result in a condition detrimental to the continued performance of the instrument.

3.2 Accessibility of Controls:

Controls which are not normally adjusted in flight must not be readily accessible to flight personnel.

3.3 Malfunction Indication:

Means must be provided to indicate failures and/or the existence of the following conditions:

3.3.1 Loss of such electrical power as is necessary for the functioning of the instrument.

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3.3.2 If the equipment is a remote indicator, means must be incorporated to detect internal malfunction or loss of "information valid" signal from remote Mach number computing source, in addition to the requirement in 3.3.1. Failure warning signals and flag alarms must not degrade the accuracy of associated equipment. The indicating means shall indicate the failure or malfunction in a positive and conspicuous manner, that is effective for any operational lighting condition likely, when a malfunction may occur.

3.4 Self-Test Capability:

If the equipment contains integral arrangements to permit pre-flight and/or in-flight self-test checks on the operation of the equipment in combination with other aircraft subsystems, a means shall be provided to deactivate any subsystem which might be adversely affected during the self-test cycle. In flight, self-test activating controls must provide a means to warn the pilot of this mode of operation.

3.5 Compatibility of Components:

If components are individually acceptable but require matching for proper operation, they shall be identified on the equipment nameplate in a manner that will ensure proper matching.

3.6 Interchangeability:

Mach Meters and their components identified with a manufacturer's part and/or model number must be directly and completely interchangeable with all Mach Meters and their components identified with that part and/or model number.

With reference to type "B" instruments which have a separate sensor and indicator, replacing either device will not degrade the system tolerances beyond those specified in Figures 1 and 2.

3.7 Input Connections - Type A Instruments Only:

The input connections shall be such that it will not be possible to interchange the pitot and static pressure lines to the instrument. The connections must be marked as follows:

"P" - Pitot pressure connection

"S" - Static pressure connection

3.8 Presentation:

The presentation shall be such that it will not associate more than one Mach number with any indication.

3.9 Limitation of Indicator Movement:

Indications beyond the normal range of the instrument shall not be displayed in a manner interpretable as an on-scale reading, or as an off-scale reading in the wrong direction.

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3.10 Indicating Means:

The Mach number must be indicated by means of one or more pointers, dials, tapes, drums, digital displays or other devices. Relative motion of the index with respect to the scale, when moving elements are employed, (either the index or the scale may be moving element) shall be clockwise, down or to the right for increasing Mach number.

The indicating means shall be effective for any operational lighting condition that may occur.

3.11 Dial Markings:

3.11.1 Indicating Graduations: Indicators comprising a dial must be provided with Mach number graduations at intervals not to exceed 0.01 with major graduations every 0.05 and with numerical markings at intervals not greater than 0.1. When digital indication is employed, the resolution shall be better than or equal to 0.01 Mach.

When the display is of the instantaneous change-over type, such as light emitting diodes, a resolution equal to 0.001 Mach shall be provided.

3.11.2 Visibility: Mach number indications must be visible from any point within the frustrum of a cone the side of which makes an angle of at least 30° with the perpendicular to the dial and the small diameter of which is the viewing aperture of the indicator.

3.11.3 Integral Lighting: When integral lighting is provided, it must, under normal cockpit lighting conditions, make all indicia within the required visibility of 3.11.2 easily readable. No direct light shall radiate from the instrument within an angle of 45° either side of the vertical center line of the instrument face in the horizontal plane and above 30° to the longitudinal axis in the vertical plane.

3.11.4 Reflectance Cover Glass: The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 10% of the incident light. This reflectance applies over the visible light spectrum from 450 nanometers to 600 nanometers, and over an incident solid angle of 60° perpendicular to the viewing plane.

3.12 Fire Resistance:

Except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, or produce a significant amount of toxic fumes, all materials used must be self-extinguishing when tested in accordance with the requirements of Federal Aviation Regulation 25.1359 (d) and appendix F, thereto, with the exception that materials tested may be configured in accordance with para. (b) of appendix F or may be configured as used.

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4. MINIMUM PERFORMANCE STANDARDS UNDER STANDARD CONDITIONS:

4.1 The test conditions applicable to a determination of the performance of Mach meters are set forth in Appendix A of this AS. All instruments shall be tested in accordance with the manufacturer's recommendations. The manufacturer shall conduct sufficient tests to prove compliance with this AS.

4.2 Scale Error:

Scale error is defined as the difference between the correct Mach number corresponding to given values of impact or total and static pressure and the value displayed by the Mach meters. With reference to Type "B" Mach meters, the scale error permitted between the nominal values applied to the input and the display, shall not exceed 0.002 Mach. The scale error of the combination of transducer/or Mach computer and the indicating instrument shall not exceed the values in Figures 1 or 2 as appropriate.

4.3 Friction:

The difference between two readings taken under constant pressure conditions, one with the instrument, or transducer and instrument not subjected to any vibration, and the other with tapping applied to remove all friction, shall not exceed .01 Mach.

4.4 Balance Error:

The difference between the readings obtained in the normal operating position, and in any other position shall not exceed 0.01 Mach for Type A instruments and 0.001 Mach for Type B instruments.

4.5 Case Leak (Type A Instruments only):

With the pitot and static lines connected together and the common line connected to a vacuum system, evacuate the system to a level of 400 mbar abs (11.8 inches Hg abs). With the system evacuated to this level and sealed, the rise in pressure, after allowing 1 minute for stabilization shall not exceed 1 mb/minute (0.03 inch Hg/minute). The total volume of the sealed system, including the instrument, shall not exceed 1 liter (61 inches³).

4.6 Dynamic Pressure Capsule Leak (Type A Instruments only):

When differential pressure equal to the maximum dynamic pressure for which the instrument is rated is applied to the dynamic pressure input and then shut off at the instrument connections, the Mach indication shall not decrease at a rate exceeding 0.001 Mach per minute.

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4.7 Over Pressure and Under Pressure (Type A Instrument only):

4.7.1 Over Pressure: The instrument shall be subjected to a static pressure equivalent to an altitude of 5000 ft (1524 m) in excess of the maximum declared altitude, and a dynamic pressure corresponding to 0:1 Mach above the maximum declared Mach indication for a period of 1 minute. After subjection, the instrument must be undamaged and must comply with the requirements of 4.1 through 4.3 of this AS.

4.7.2 Under Pressure: With the static connection open to atmosphere, a pressure of 16 mbar (0.472 in Hg) below ambient atmospheric pressure shall be applied to the pitot connection for a period of 1 minute. After subjection, the instrument must comply with the requirements of 4.1 through 4.3 of this AS.

4.8 Static Pressure Error Correction:

It shall be permissible to calibrate the Mach meter such that the static pressure errors for a particular aircraft, are minimized. The manufacturer's data for the aircraft concerned, approved by FAA, or the Certifying Authority of the State of manufacture of the aircraft, shall be the only data used for such calibration.

The instrument nameplate must be clearly marked with the aircraft type to which such calibration applies.

5. MINIMUM PERFORMANCE STANDARD UNDER ENVIRONMENTAL CONDITIONS (QUALIFICATION TEST UNITS ONLY):

Unless otherwise specified herein, the measurement procedures applicable to a determination of the performance of Mach meters under environmental conditions, shall be as set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. DO 160, entitled "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments," dated 28th February 75. Performance tests (4.1 through 4.7 of this AS) which must be made after subjection to test environments may be made after exposure to several environmental conditions. The order of tests must be in accordance with 3.2, page 4, of DO 160. The test procedures specified or references are satisfactory for use in determining the performance of Mach meters under normal and extreme environmental conditions. Alternate approved test procedures that provide equivalent results may be used.

5.1 Temperature - Altitude:

5.1.1 Low Temperature: The instrument shall be subjected to the tests of DO 160, paragraph 4.4.1, and meet the requirements of 4.1 through 4.3 of this AS, excepting that the applicable tolerances shall be 50% larger than indicated in Figures 1 or 2.

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5.1.2 High Temperature: The instrument shall be subjected to the test of DO 160, paragraphs 4.5.1 and 4.5.2, and meet the requirements of 4.1 through 4.3 of this AS, excepting that the applicable tolerances shall be 50% larger than indicated in Figures 1 or 2. Following the appropriate High, not operating Temperature and High Short-time Operating Temperature, DO 160, paragraph 4.5.1, tests and after stabilizing the instrument at standard conditions, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.1.3 Altitude: The instrument shall be subjected to the tests of DO 160, paragraph 4.6.1, at the appropriate altitude and must meet the requirements of 4.1 through 4.3 of this AS.

5.1.4 Decompression and Overpressure Tests: The instrument shall be subjected to the test of DO 160, paragraph 4.6.2 (decompression) and 4.6.3 (overpressure). These tests shall be conducted by applying the test pressures externally to the instrument case, the pitot and static connection being vented outside the test chamber. Following these tests, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.2 Humidity:

The instrument shall be subjected to the appropriate tests of DO 160, paragraph 6, and must meet the requirements of 4.1 through 4.7 of this AS following this test.

5.3 Shock:

The instrument shall be subjected to the test of DO 160, paragraph 7.1, and must meet the requirements of 4.1 through 4.7 of this AS following this test.

The instrument shall be subjected to the test of DO 160, paragraph 7.2. Following this test, the instrument shall have remained in its mounting and no parts of the instrument or its mounting base shall become detached and free of the shock test equipment. Paragraph 4 of this AS does not apply following this test.

5.4 Vibration:

The instrument shall be subjected to the appropriate test in accordance with DO 160, paragraph 8, and must meet the requirements of 4.1 of this AS, excepting that the tolerances permitted shall be 50% larger than those specified in Figures 1 or 2 as appropriate.

After subjection to this test, the instrument shall meet the requirements of 4.1 through 4.7 of this AS.

5.5 Power Input (All Type B instruments, and Type B where applicable):

5.5.1 Electrical Input Variation:

5.5.1.1 During the test at 110% of design voltage (para. 16.3.1B1, DO 160), the instrument must meet the requirements of 4.1 through 4.3 of this AS.

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5.5.1.2 During the test at 90% of design voltage (para. 16.3.1B2, DO 160), the instrument must meet the requirements of 4.1 through 4.3 of this AS.

5.5.1.3 When the instrument is subjected to the test stated in paragraph 16.3.3.1B2 of DO 160, it must operate electrically and mechanically and a degradation of performance is permissible.

5.5.1.4 When the instrument is subjected to the test stated in paragraph 16.3.3.2B, DO 160, it must meet the requirements of 4.1 through 4.3 of this AS.

5.6 Conducted Voltage Transients (All Type B instruments and Type A where applicable):

5.6.1 Intermittent Transients: Following the tests of paragraph 17.4.1, DO 160, the instrument shall meet the requirements of 4.1 through 4.3 of this AS.

5.6.2 Repetitive Transients: When the instrument is subjected to the test of paragraph 17.4.2, DO 160, it shall meet the requirements of 4.1 through 4.3 of this AS.

5.6.3 Interconnecting Wiring Induced Transients: When the instrument is subjected to the test of paragraph 19.5.2, DO 160, it shall meet the requirements of 4.1 through 4.3 of this AS.

5.7 Conducted Audio Frequency Susceptibility (All Type B instruments and Type A, where applicable):

When the instrument is subjected to the tests of paragraph 18, DO 160, it shall meet the requirements of 4.1 through 4.3 of this AS.

5.8 Audio Frequency Magnetic Field Susceptibility (All Type B Instruments and Type A where applicable):

When the instrument is subjected to the applicable test of paragraph 19, DO 160, it shall meet the requirements of 4.1 through 4.3 of this AS.

5.9 Radio Frequency Susceptibility (All Type B Instruments and Type A, where applicable):

When the instrument is subjected to the test of paragraph 20, DO 160, it shall meet the requirements of 4.1 through 4.3 of this AS.

5.10 Emission of Radio Frequency Energy:

The instrument shall be tested in accordance with the radio frequency interference paragraph 21 of DO 160, Appendix A, for the category to which the instrument is designed.

5.11 Magnetic Effect:

The instrument shall be subjected to the applicable test of DO 160, paragraph 15, and the category declared.

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5.12 Explosion:

Instruments which are to be marked Explosion Category E must be tested in accordance with paragraph 9.2 of DO 160.

5.13 Waterproofness:

Instruments which are to be marked Waterproofness Category W must be tested in accordance with paragraph 10.0 of DO 160. Following this test, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.14 Hydraulic Fluid:

Instruments which are to be marked Hydraulic Fluid Category H must be tested in accordance with paragraph 11.0 of DO 160. Following this test, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.15 Sand and Dust:

Instruments which are to be marked Sand and Dust Category D must be tested in accordance with paragraph 12.0 of DO 160. Following this test, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.16 Fungus Resistance:

Instruments which are to be marked Fungus Resistance Category F must be tested in accordance with paragraph 13.0 of DO 160. Following this test, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

5.17 Salt Spray:

Instruments which are to be marked Salt Spray Category S must be tested in accordance with paragraph 14.0 of DO 160. Following this test, the instrument must meet the requirements of 4.1 through 4.7 of this AS.

PREPARED BY SAE COMMITTEE A-4, AIRCRAFT INSTRUMENTS

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APPENDIX A

TEST CONDITIONS

The following conditions of tests are applicable to the instrument tests specified herein:

1. Atmospheric Conditions: Unless otherwise specified, all tests required by this standard must be conducted at an atmospheric pressure of approximately 1013.25 mbar, (101.325 kPa) 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 shall be made for the variation from the specified conditions, where applicable.

2. Vibration to Minimize Friction: Unless otherwise specified, all tests required by this Standard may be conducted with the instrument subjected to a vibration of 0.01 inch (0.25 mm) double amplitude at a frequency of 10 to 60 Hertz, provided the equipment is mounted in its normal position. The term "Double Amplitude" as used herein indicates the total displacement from positive maximum to negative maximum.
3. Power Conditions: Unless otherwise specified, all tests must be conducted at the power rating recommended by the manufacturer.
4. Calibration:
 - 4.1 Static air pressure values used for calibration shall be to the geopotential altitude tables of the U.S. Standard Atmosphere 1962.
 - 4.2 Impact or Pitot pressure values used for calibration and Mach number values in terms of the ratio of impact to static pressure, shall be in accordance with the relevant tables of NASA TN D-822.
 - 4.3 Mach Number values intermediate to those published in the tables cited in 4.2 may be calculated if required from the following formulae:

$$\text{(Subsonic)} \quad \frac{q_c}{P_s} = [(1 + 0.2M^2)^{7/2} - 1] \quad M < 1$$

$$\text{(Supersonic)} \quad \frac{q_c}{P_s} = [166.92158M^{-7} (7M^2 - 1)^{-5/2} - 1] \quad M > 1$$

where:

q_c = apparent impact of Pitot pressure
 P_s = free Stream Static pressure
 M = Mach number

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- 4.4 Pressure Standards: Pressure standards used for calibration shall be accurate, under standard conditions, i.e. (mercury density = $13,595 \text{ g/cm}^3$ at 0°C , $g = 9.80665 \text{ m.SEC}^{-2}$) to within 0.2 mbar (0.005 inch Hg) for altitudes up to 50,000 ft (15,240 m) and 0.1 mbar (0.0025 inch Hg) for altitudes between 50,000 ft and 70,000 ft (15,240 m and 21,336 m).

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ADDENDUM 1

1. APPLICABLE DOCUMENTS:

- a. U.S. Standard Atmosphere 1962
- b. NASA Technical Note D-822, "Tables of Airspeed, Altitude and Mach Number based on Latest International Values for Atmospheric Properties and Physical Constants", By Sadie P. Livingston and William Gracey, Langley Research Center, Langley Field, VA, NASA Washington, August 1961.
- c. RTCA Document DO 160 by Radio Technical Commission for Aeronautics, Suite 655, 1717 H Street, N.W., Washington, DC 20006.

2. IDENTIFICATION:

The following information shall be legibly and permanently marked on the instrument or name plate attached thereto:

- a. Manufacturer's part number
- b. Range in Mach number
- c. Maximum airspeed (Type A instruments only)
- d. Maximum altitude (Type A instruments only)
- e. Electrical rating (where applicable)
- f. Aircraft identification (if applicable, see 4.8 and 3.5)
- g. Environment categories (see code in Appendix A of RTCA DO 160)

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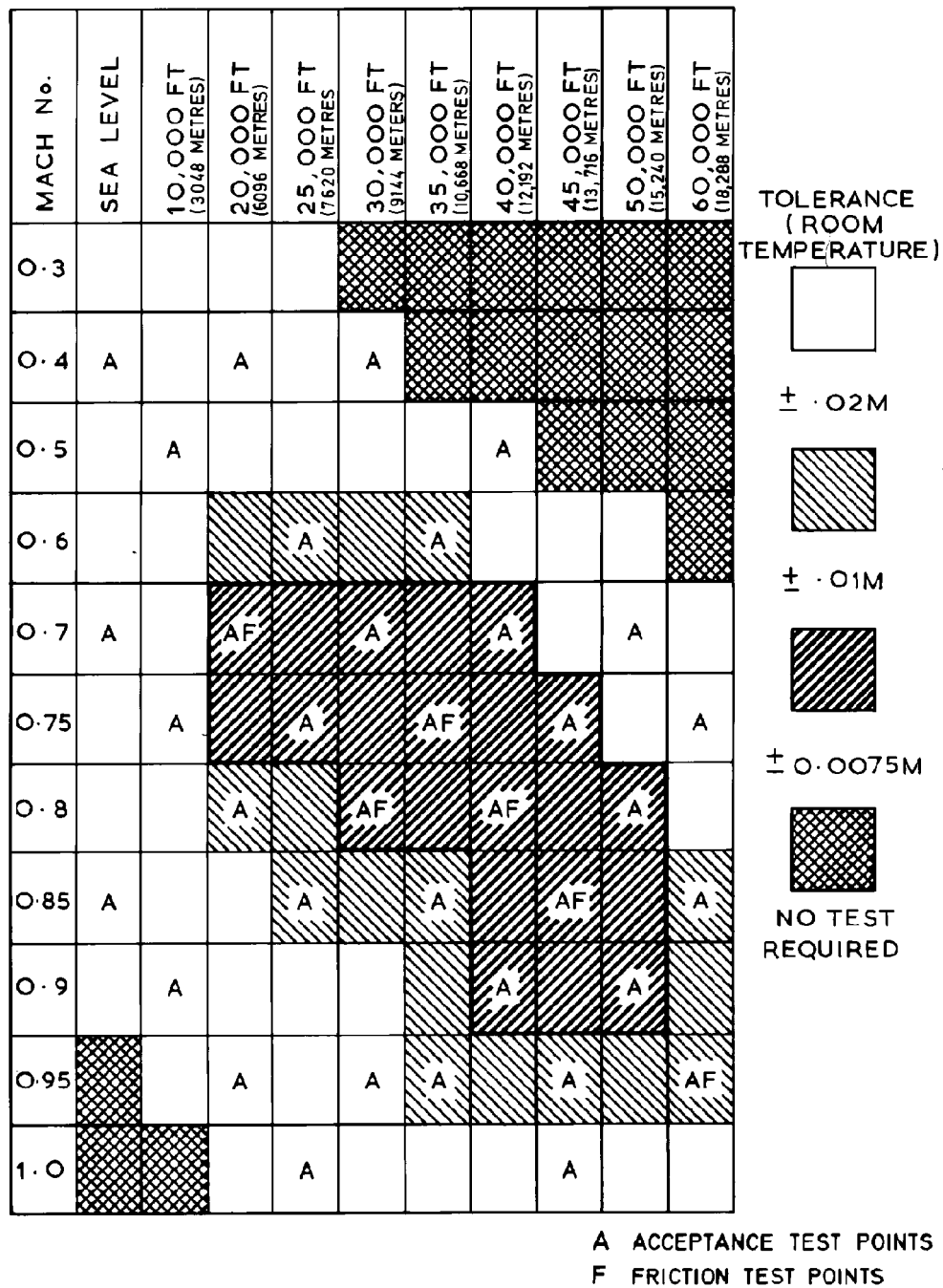


FIGURE 1 - Subsonic

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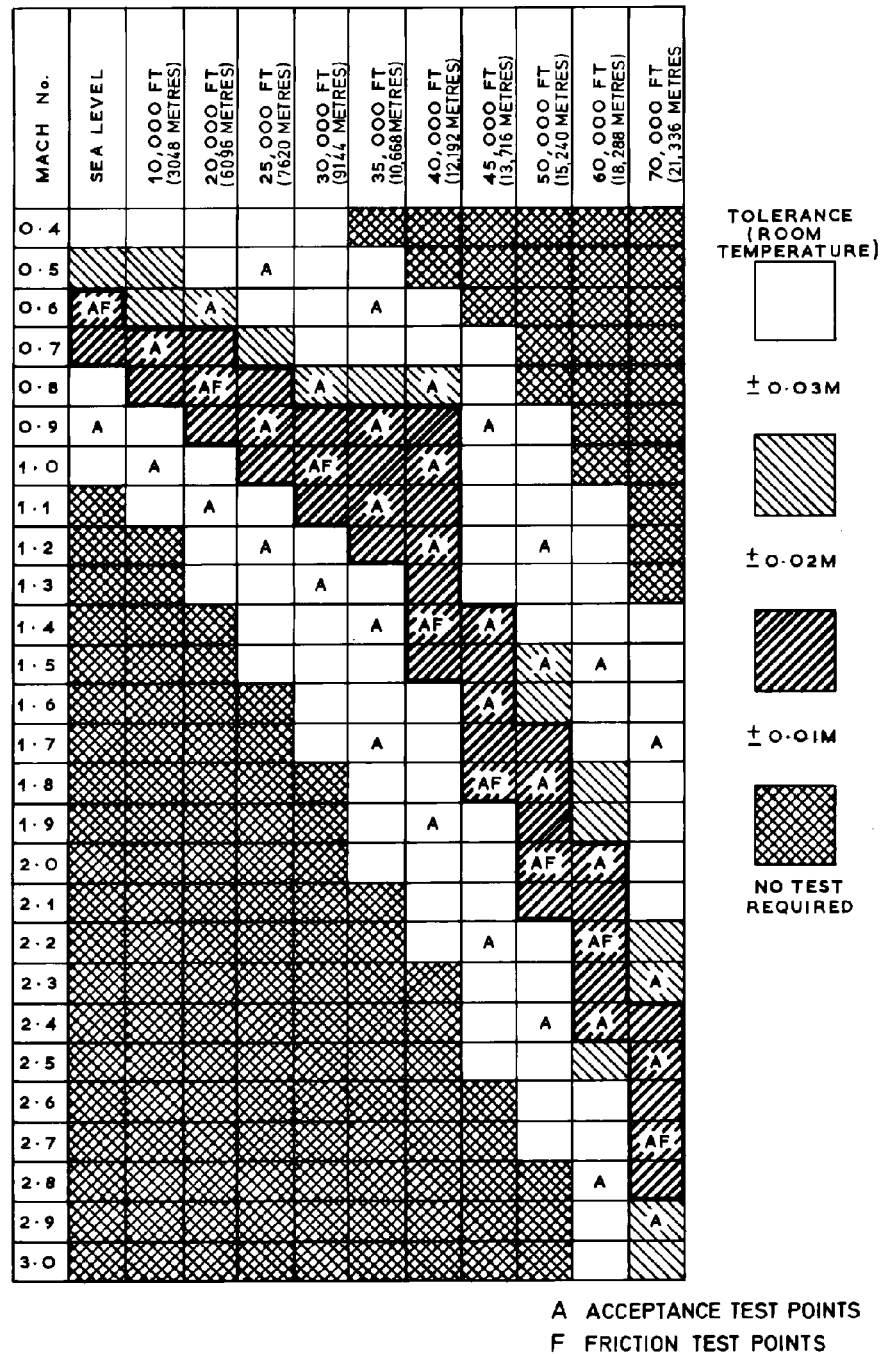


FIGURE 2 - Supersonic