BRITISH STANDARD AEROSPACE SERIES

BS 2G 182: 1975

*(Superseding BS G 182)*

## Specification for

# Pressure-driven machmeters for aircraft

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# Foreword

This revision of BS G 182:1963 has been prepared to cover the requirements of pressure-driven machmeters having closely controlled performance over specified parts of the range.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 4, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been approved by the Aerospace Industry Standards Committee, was published under the authority of the Executive Board on 31 October 1975



The following BSI references relate to the work on this standard:
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## 1 Scope

This British Standard specifies the general design requirements and test procedures for machmeters of the following types.

**1.1 Type A.** Machmeter indicating a Mach scale range of at least 0.5 M up to a maximum scale reading of 1.0 M and of altitude range up to 50 000 ft, with maximum accuracy from 20 000 ft to 40 000 ft, unless otherwise required by the individual specification.

**1.2 Type B.** Machmeter indicating a range extending above 1.0 M and of altitude range up to 60 000 ft with maximum accuracy in the region between the altitude limits 20 000 ft and 40 000 ft and in the indicated range of 0.7 M to 0.9 M.

## 2 References

This standard makes reference to the following British Standards.

BS 185, *Glossary of aeronautical and astronautical terms.*

BS 3G 100, *General requirements for equipment for use in aircraft.*

BS 2G 101, *General requirements for aircraft indicators.*

BS G 199, *Tables relating pressure to altitudes, airspeeds and Mach numbers for use in aeronautical instrument design and calibration.*

The latest issues of these standards shall be used.

## 3 Definitions

For the purposes of this British Standard the definitions given in BS 185 and the following shall apply.

**3.1**
**machmeter**

an instrument used in an aircraft to give an indication of Mach number as derived from pitot and static pressures in accordance with the relationship defined in BS G 199

**3.2**
**machmeter scale range**

the difference between the lowest calibrated Mach number and highest calibrated Mach number

## 4 General construction

**4.1** The design and construction of the indicator shall comply with the relevant requirements of BS 3G 100 and BS 2G 101.

**4.2** The preferred cases are the type 3 and type 6 cases shown in BS 2G 101.

## 5 Particular requirements

### 5.1 Construction

**5.1.1** The indicator shall contain a differential pressure-measuring mechanism driving the indication through a suitable linkage and a static pressure-measuring mechanism which modifies the magnification of the output of the differential pressure-measuring mechanism according to the static pressure.

**5.1.2** The indicator dial shall be marked in whole numbers and decimals of Mach number except that the zero shall not be used before the decimal point for subsonic speeds. The marking shall conform with the requirements of BS 2G 101.

**5.1.3** With no differential pressure applied, the pointer shall rest at least 10° off scale. The calibration characteristics shall be nominally linear over the circular scale, the largest and smallest interval for 0.1 M being within 20 % of the mean.

NOTE Specific requirements for alternative presentation, i.e. counters or tape, will be defined in the individual specification.

**5.1.4** When a lubber or cursor is used to indicate an aircraft limitation it shall not be capable of adjustment in flight.

**5.1.5** The indicator shall be capable of withstanding a reverse pressure (i.e. $S > P$) of 10 mbar[1)] without the calibration being affected.

**5.1.6** The instrument case shall be airtight in accordance with BS 2G 101.

**5.1.7** A warning label stating the limiting differential pressures shall be securely fixed near to the pressure connections.

**5.1.8** The pitot and static connections shall conform to the requirements of BS 2G 101 and shall be indelibly marked *P* and *S* respectively.

[1)] 1 mbar = $10^2$ N/m$^2$ = 0.1 kPa.

### 5.2 Calibration

**5.2.1** The calibration of the indicator over the declared range shall be in accordance with the following as appropriate.

**5.2.1.1** *Type A*. The indicator shall be calibrated at the points indicated in Table 1 and shall be within the tolerances stated. In addition the indicator shall be calibrated at every altitude level within the range of Table 1 at the extremeties of its scale range. Production tests, which will normally include at least half of these test points, shall be specified in the individual specification.

**5.2.1.2** *Type B*. Indicators indicating from 0.5 M to 1.5 M shall be calibrated in accordance with Table 1 to the tolerances specified.

Indicators indicating from $\geqslant$ 0.5 M to $\leqslant$ 1.5 M shall be calibrated in accordance with Table 1 as appropriate but additional points shall be tested so that, during the type and production testing, each altitude level of 10 000 ft up to and including 50 000 ft is tested at least twice, one pressure setting being used within each interval equivalent to 50 knot indicated airspeed between 150 knot and 700 knot indicated airspeed.

Indicators indicating from < 0.5 M or > 1.5 M shall be calibrated using points selected in accordance with the principles outlined in the foregoing paragraph, each increment of 0.1 M being included in the schedule.

For indicators with a scale range (see **3.2**) > 1.0 M the tolerance ± 0.0075 M may be relaxed to ± 0.75 % scale range.

Additionally, for indicators with a scale range > 1.4 M the tolerance ± 0.02 M may be relaxed to ± 1.4 % scale range.

The individual specification shall detail the appropriate tolerance if calibration points are required below the equivalent of 150 knot indicated airspeed.

The individual specification may require a special calibration tolerance at one particular Mach number to approach parity with, for example, independent speed warning devices.

**5.2.2** The relationship between altitude and dynamic pressure to which the instruments are calibrated shall be in accordance with BS G 199.

NOTE Where the individual specification requires the calibration of the instrument to deviate from **5.2.2** to provide some degree of static pressure error compensation, the equivalent tolerances specified in **5.2.1** shall be maintained.

## 6 Declarations

In addition to the declarations required by BS 3G 100-1, the manufacturer shall declare:

a) the limiting Mach number range;

b) the limiting altitude;

c) the limiting *P-S* pressure;

d) if static pressure error compensation is incorporated, the name and type of aircraft for which the compensation is designed.

## 7 Tests

### 7.1 General

**7.1.1** Tests shall be made to prove compliance with all the requirements of this British Standard. It is not intended or recommended that complete tests shall be made on every indicator supplied.

Three kinds of tests, therefore, are specified as follows:

a) type tests, to be made on representative samples to prove the design;

b) production routine tests, to be made on all indicators manufactured in accordance with this standard;

c) production quality tests, to be made on samples as specified in the individual specification.

**7.1.2** For the guidance of users, minimum tests recommended to verify the serviceability of indicators manufactured in compliance with this British Standard are indicated in Appendix A.

NOTE To obtain the best measurement of calibration errors, it is recommended that the static pressure should be set accurately and the pitot pressure adjusted to provide the precise information.
The differential pressure *P-S* is measured and compared with the required pressure taken from the appropriate columns of $q_c$ in Table 3 of BS G 199.
The tolerance may be converted by linearly interpolating with respect to Mach number the figures of $q_c$ from the appropriate column for each calibration point.

### 7.2 Type tests

**7.2.1** *Ranging accuracy test*. The indicator shall be tested over the declared range at a temperature of 20 ± 5 °C with increasing and decreasing pitot pressures. Unless otherwise specified, vibration not exceeding 0.2 *g* shall be applied to the indicator during the test to minimise friction.

NOTE 1 Vibration of this order is attainable with a total amplitude of 0.04 mm at a frequency of 50 Hz.
NOTE 2 On a number of modern aircraft, the temperature behind the instrument panel will be above the + 20 °C temperature at which tests are made in accordance with this specification and normal performance may be required in such circumstances at + 40 °C. Where required, this will be stated in the individual specification and the performance of the indicator at such temperature has to be declared.

The errors of indicated Mach number shall not be greater than those specified in **5.2.1**.

**7.2.2** *Friction test*. At three widely spaced increments on the scale range at any altitude between 25 000 ft and 30 000 ft, the static and pitot pressures shall be adjusted approximately to the desired reading and then held constant, the indicator being carefully isolated from vibration. Two readings shall then be taken for each operation, the first whilst the indicator remains undisturbed and the second after the indicator has been tapped until the pointer no longer moves.

The following tests shall be carried out at each of the three indications:

a) increase P, hold: increase S, hold: read: tap: read.

b) increase P, hold: decrease S, hold: read: tap: read.

c) decrease P, hold: increase S, hold: read: tap: read.

d) decrease P, hold: decrease S, hold: read: tap: read.

The difference between any pair of readings shall not exceed 0.005 M or 0.5 % of scale range, whichever is greater.

The test may be combined with normal ranging and calibration and tests a) to d) may be carried out in any sequence.

**7.2.3** *Position test*. At two widely spaced points on the scale range and at two widely spaced increments on the altitude range (neither exceeding 40 000 ft) (total: four test points), the change in reading when the indicator is turned through 90° in any direction from the declared installed position shall not exceed 0.01 M or the normal calibration tolerance, whichever is the greater, from the reading in the normal position.

**7.2.4** *Temperature-pressure tests*. These tests shall be conducted in accordance with the requirements of BS 3G 100-2.3.2 appropriate to the classification and grading declared in the individual indicator specification. Unless otherwise stated, additional tolerances shall not be greater than the normal tolerance or 0.01 M, whichever is less, for temperatures of – 20 °C and + 50 °C.

**7.2.5** *Overload test*. The indicator shall not be deranged by subjection to the overload pressures specified in the individual specification for five minutes. Readings taken immediately afterwards, with decreasing pitot pressures and with a static pressure corresponding to an altitude of 30 000 ft, shall be such that the errors do not exceed the ranging errors specified in **5.2.1**.

**7.2.6** ***Leakage test***

**7.2.6.1** With the pitot connection blanked off and the static connection open to atmosphere, the indicator shall comply with the requirements of BS 2G 101, **3.10**.

**7.2.6.2** The maximum pressure shall be applied to the pitot connection and then slowly reduced until a precise indication is achieved. The air shall then be shut off. The indication shall not change for a period of one minute, during which time the temperature shall remain constant.

**7.2.7** *Fouling test*. Any lubber or cursor shall be checked at all positions within its range to verify that no fouling takes place that can affect the indication.

**7.2.8** *Vibration tests*. Vibration tests shall be conducted in accordance with the requirements of BS 3G 100-2.3.1, in particular **3.4** or **B.4.2**. The accuracy of the indication shall comply with **5.2.1**, and the magnitude of the oscillation of the indication shall be within the overall tolerance, unless otherwise stated in the individual specification.

**7.2.9** *Acceleration tests*. Acceleration tests shall be conducted in accordance with the general requirements of BS 3G 100-2.3.6 and the particular requirements of the individual specification which shall define the acceleration levels and the indicator tolerances for this test, which shall in no case exceed 0.01 M/*g* for altitudes at or below 40 000 ft.

**7.2.10** *Additional environmental tests*. The indicator shall be subjected to additional environmental tests specified in BS 3G 100-2, as required by the individual specification. The required functioning tests shall be the ranging accuracy test at three points spaced equally over the indicated range, each at three equally spaced altitudes up to 40 000 ft to the tolerances stated in **5.2** and **7.2.4** as appropriate.

### 7.3 Production routine tests

**7.3.1** *Ranging accuracy, friction, position, overload, leakage and lubber mark tests.* Each indicator shall satisfactorily fulfil the requirements of the tests specified in **7.2.1**, **7.2.2**, **7.2.3**, **7.2.5**, **7.2.6**, and **7.2.7**, except that the ranging and accuracy tests shall be at the points and to the tolerances specified in **5.2.1**.

### 7.4 Production quality tests

**7.4.1** Sample indicators, selected and tested in accordance with the individual specification, shall satisfactorily fulfil the requirements of the tests specified in **7.2.8** (resonance search only) and **7.4.2**.

**7.4.2** At temperatures of – 20 °C and + 50 °C the errors in indicated Mach number shall not exceed 1.5 times the tolerances specified in **7.2.1**.

After subjection to temperatures of – 62 °C and + 85 °C, the indicator shall not be deranged nor shall the calibration errors be outside normal tolerances, and the indicator shall satisfy the requirements of the pressure test specified in **7.2.5**.

**Table 1 — Calibration points and tolerances**

| Mach | Sea level | 10 000 ft | 20 000 ft | 25 000 ft | 30 000 ft | 35 000 ft | 40 000 ft | 45 000 ft | 50 000 ft | *60 000 ft |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | | | TT | | TT-P | | | No test required | | |
| 0.6 | | TT-P | | | | | | | | |
| 0.7 | | | | TT-P | | | | | | |
| 0.75 | | | | | | | TT-P | | | |
| 0.8 | TT-P | | TT-P | | | | | | | |
| 0.85 | | | | | TT | | TT | | TT-P | |
| 0.9 | | TT | | TT | | TT-P | | | | |
| 0.95 | | | | | | | | TT-P | | |
| 1.0 | *TT-P | | TT-P | | | | | | | TT* |
| 1.05 | | | | | | | TT-P | | | |
| 1.1 | | TT-P | | | TT-P | | | | | |
| 1.2 | | | TT-P | | | | | | TT | |
| 1.3 | No test required | | | | TT-P | | | | | TT-P* |
| 1.4 | Overloaded exceeded | | | | | | TT-P | | | |
| 1.5 | | | | | TT-P | | | | TT-P | |

Tolerance ± 0.0075 M

Tolerance ± 0.020 M

*May be specifically excluded by the individual instrument specification.

TT represents type test
P represents production test

## Appendix A Serviceability tests

The minimum tests recommended to verify the serviceability of instruments manufactured in compliance with this British Standard are as follows.

**A.1 Ranging accuracy test (7.2.1)**

At those Mach numbers recommended for production tests in **5.2.1** at the following altitudes:

0 ft, 20 000 ft, 30 000 ft, 40 000 ft, 50 000 ft.

The indicated Mach number should be within the appropriate tolerances shown in Table 1.

**A.2 Fouling test (7.2.7)**

**A.3 Leakage test (7.2.6)**

**A.4 Friction test (7.2.2)**

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