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Specification for

Indicating tachometer and speedometer systems for industrial, railway and marine use

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The Instrument Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Internal Combustion Engine Manufacturers' Association
London Transport Executive
Ministry of Defence, (Navy)
Society of Motor Manufacturers and Traders Limited

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Foreword

This standard makes reference to the following British Standards:

BS 229, *Flameproof enclosure of electrical apparatus.*

BS 1259, *Intrinsically safe electrical apparatus for use in explosive atmospheres.*

BS 1597, *Radio-interference suppression on marine installations.*

BS 1991, *Letter symbols, signs and abbreviations — Part 3: Fluid mechanics.*

BS 2011, *Methods for the environmental testing of electronic components and electronic equipment — Part 2: Tests — Part 2Da: Damp heat, cyclic — Part 2 Ka: Salt mist.*

BS 3693, *Recommendations for the design of scales and indexes.*

BS 3807, *Method for the type testing of enclosures for electrical apparatus for use in onerus dust conditions.*

CP 1006, *General aspects of radio interference suppression.*

This British Standard has been prepared under the authority of the Instrument Industry Standards Committee.

This second edition of the standard which originally dealt with indicating tachometers for general industrial use has been revised in order to cater for tachometer and speedometer systems for industrial, railway and marine applications.

This standard is not intended to cover digital tachometers, nor does it cover aircraft applications or speedometers for road vehicles. Speedometers for road vehicles are covered in BS 3190.

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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, 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.

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1 General

1.1 Scope

This British Standard specifies requirements for indicating tachometer and speedometer systems with or without revolution counters for industrial, railway and marine application.

NOTE The titles of the British Standards referred to in this standard are listed on page ii

1.2 Accuracy classes

The three classes of accuracy specified in this standard are as follows:

Class index 0.75. System having a nominal accuracy of ± 0.75 % of maximum scale value (see **3.3.3**).

Class index 1.5. System designed for general purposes, having a nominal accuracy of ± 1.5 % of maximum scale value (see **3.3.3**).

Class index 3.0. System designed for general purposes, having a nominal accuracy of ± 3 % of maximum scale value (see **3.3.3**).

All the requirements of this standard apply to Class 0.75, Class 1.5 and Class 3.0 instruments, except where a distinction between these three classes is made.

1.3 Definitions

For the purposes of this British Standard, the following definitions apply:

1.3.1
tachometer system

a means of measuring the rate of revolution of a rotating body. It may also, but not necessarily, detect the direction of rotation

1.3.2
speedometer system

a device for the measurement of distance travelled per unit time

1.3.3
mechanical tachometer

a tachometer in which the linkage between the rotating body and the measuring device is wholly mechanical

1.3.4
electrical/electronic tachometer

a tachometer in which the means of detection, transmission and measurement are partly electrical

1.3.5
magnetic tachometer

a mechanical or electrical tachometer in which the indicating component includes a driving link effected by interaction between a relatively rotating magnetic system and an induction cup or disc

1.3.6
electrical/electronic tachometer transmitter

a device which provides electrical signals from which the rate of revolution can be measured

1.3.7
electrical/electronic tachometer indicator

a device which accepts signals from the electrical tachometer transmitter with or without intermediate conversion and indicates visually the rate of revolution

1.3.8
index

the pointer or other means by which the measured quantity is indicated relative to the scale

1.3.9
scale

the array of marks together with any associated figuring from which the indicated quantity may be read

1.3.10
accuracy

the accuracy of a measuring instrument or of an accessory is defined by the limits of intrinsic error and the limits of variations due to influence quantities

1.3.11
accuracy class

a class of measuring instruments or accessories, the accuracy of all of which can be designated by the same number, if they comply with all the clauses of this standard

1.3.12
class index

the number which designates the accuracy class

NOTE 1 The class index is applicable to the variation as well as to the intrinsic error.
NOTE 2 Multi-range instruments may have more than one class index.

1.3.13
maximum scale value

the greatest value of the measured quantity which the scale is graduated to indicate

NOTE 1 In multi-range instruments this definition is to be read as applying to the particular range which the instrument is set up to measure.
NOTE 2 In centre-zero or offset zero type instruments the maximum scale value is to be taken as the sum of the two end scale values.

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1.3.14
minimum scale value

the smallest value of the measured quantity which the scale is graduated to indicate

NOTE In multi-range instruments this definition is to be read as applying to the particular range which the instrument is set up to measure.

1.3.15
scale range

the number of units indicated on the scale between the two scale-end marks, with the exception that in suppressed zero instruments, the scale range is from the minimum to the maximum scale value

1.3.16
effective range

that portion of the scale over which the instrument complies with the specified limits of error

1.3.17
revolution counter

a device which counts and displays revolutions (or derived units) without respect to time. It may or may not be an integral part of the indicator

2 Design and construction

2.1 General

The construction shall be mechanically sound, and such as to assure permanence in all mechanical, electrical, electronic or magnetic adjustments when used in accordance with the manufacturer's recommendations.

Mechanical and magnetic types shall be self-contained except for drive details.

Electrical tachometers shall consist essentially of two separate units, namely the transmitter and the indicator.

Electronic types shall consist essentially of three units, viz. the transmitter, electronic conversion unit and indicator.

Any of these units may be combined. Electrical or electronic units shall be connected together by electrical cables, either with or without a separate source of electric supply. Where required, protection against reversal of polarity of a d.c. auxiliary supply shall be provided.

Where revolution counters are incorporated in the indicator, it is recommended that the figures should be outside the swept area of the index.

2.2 Drives and electrical connections

The coupling shall not alter the mean angular velocity condition of drive.

The choice of drive and method of attachment together with any electrical connections shall be the subject of agreement between the purchaser and the manufacturer.

Where instruments are mechanically coupled, the drives shall be capable of accommodating a reasonable amount of angular, parallel or end float displacement between the prime mover and the instrument system so that the accuracy requirements of the tachometer system are maintained.

Suitable forms of mechanical drive include flexible couplings, spring couplings, pin and slot couplings, dog couplings, flexible cable drive, chain and sprocket, toothed belt.

The magnetic or electronic pulse type of tachometer system may be driven as above or it may be directly applied at the point of sensing.

2.2.1 Sealing of drive. It is the responsibility of the user and the manufacturer jointly to prevent the transfer of lubricant to the drive where this is detrimental to satisfactory operation. Due account should also be taken of any relevant environmental conditions.

2.3 Environment

2.3.1 The indicator, transmitter and ancillary apparatus shall be contained in suitable enclosures to afford adequate protection and to ensure permanence of the accuracy of the indications.

2.3.2 Vibration resistance. The tachometry system shall be designed to withstand without damage the vibration test specified in **3.4.8**, except that the indicator, if not normally subjected to vibration in service, may be excluded by agreement between the purchaser and the manufacturer.

2.3.3 Shock resistance. The tachometry system shall be designed to withstand the shock test specified in **3.4.9**.

2.3.4 Variation in indication due to mounting on ferrous supports. Unless otherwise agreed, the variation in indication of a tachometer (or of the receiver for a tachometer transmitter), when mounted on a ferrous support not less than 3 mm thick, shall not differ from that obtained free in air by more than the figure quoted in **3.4.6**.

2.3.4.1 *Variation in output of a generator/transmitter due to mounting, on ferrous supports.* Unless otherwise agreed, the variation in output of a tachometer generator or transmitter, when mounted on a ferrous support not less than 6 mm thick, shall not differ from that obtained free in air by more than the figure quoted in **3.4.6**.

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2.3.5 Effect of transients (spikes and surges) in electronic systems. In general transients will be found to occur and both manufacturer and user should consult each other regarding suppression/immunity.

2.3.5.1 Where commutation or switching is liable to cause radio interference, care shall be taken to minimize such interference, as recommended in CP 1006 and BS 1597.

2.3.6 Intrinsic safety. An intrinsically safe system shall satisfy the requirements of BS 1259.

2.3.7 Flameproofing. A flameproof enclosure shall satisfy the requirements of BS 229.

2.3.8 Weatherproofing. A weatherproof enclosure shall be so constructed or protected that exposure to the weather or splashings of water will not impair the operation of the instrument (for a test, see **3.4.10**).

2.3.9 Watertightness. A watertight enclosure shall satisfy the watertightness tests specified in **3.4.11**.

2.3.10 Dustproofing. A dustproof enclosure shall satisfy the requirements of BS 3807.

2.3.11 Saltspray. A saltspray-proof system shall satisfy the requirements of BS 2011-2Ka.

2.3.12 Tropical use. A tachometer system required for use in particularly severe tropical conditions e.g. high relative humidity, extremes of temperature, shall meet the requirements of BS 2011-2Da or such other appropriate Part of BS 2011 as might be agreed between the purchaser and the manufacturer.

2.4 Dial diameters

The recommended nominal visible dial diameters are 75, 100, 150, 200 and 300 mm.

2.5 Scale ranges, scales and indexes

Scale ranges, scales and indexes should be in accordance with BS 3693.

2.6 Direction of deflection

Unless otherwise specified by the purchaser, the following requirements apply:

1) The direction of deflection of the index of a tachometer for an increasing quantity shall be clockwise for a substantially circular scale of more than 180 degrees, deflection from left to right for a substantially horizontal scale, and upwards for a substantially vertical scale.

2) In other cases the direction of deflection shall be as far as possible upwards for an increasing quantity.

3) In a centre or offset zero indicators deflection to the right or clockwise shall be "forward", and deflection to the left or anticlockwise shall be "reverse".

2.7 Zero adjustment

Tachometer indicators may be fitted with a suitable device for adjusting the pointer to zero or other setting mark. Where such a device is fitted, there shall be no risk of damage to the working parts of the tachometer.

In instruments with a mechanically suppressed zero an external adjuster shall not be fitted unless provision is made to prevent accidental operation and to discourage unauthorized operation.

2.8 Normal position of use and mounting

Unless otherwise specified, the normal position of use for an indicating tachometer (or the receiver for a tachometer transmitter), shall be with the dial vertical.

3 Performance requirements and tests

3.1 Reference conditions

Unless otherwise specified tests shall be carried out at a temperature of 20 ± 3 °C, an air pressure between 800 mbar[1)] and 1060 mbar, a relative humidity of between 45 % and 80 % and a magnetic field not significantly different from that of the Earth, and with non-ferrous mounting surfaces.

In the case of electronic tachometers tests shall be carried out at any value within the user's declared supply voltage and frequency.

3.2 Effective range

The upper limit of the effective range shall be the maximum scale value of the indicator unless otherwise agreed between the purchaser and the manufacturer.

[1)] 1 bar = 10^5 N/m^2.

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The lower limit of the effective range, unless otherwise marked, shall be as follows:

1) The lower limit of effective range of a tachometer system shall be one-fifth of the scale range for a mechanical tachometer system and one-tenth of the scale range for a magnetic or electrical or electronic tachometer, except that in the case of a suppressed-zero tachometer the lowest limit shall be the minimum scale value.

2) In centre or offset zero magnetic and electrical tachometers the effective range shall extend down to zero speed in both directions. In the case of mechanical tachometers which have a rotation-direction indicator, the effective range shall be down to one-fifth of full scale, in both directions.

3.3 Routine test requirements

3.3.1 General. Routine tests are intended to check the manufacture of a tachometry system and shall be applied to every tachometry system or part thereof as applicable.

3.3.2 Insulation of electrical/electronic tachometers

3.3.2.1 *Insulation resistance.* The insulation resistance shall be measured by applying 500 V d.c. for 15 seconds between all terminals coupled together and the case of an electrical/electronic indicator and between the windings and case or core of an electrical transmitter. The insulation resistance shall be not less than 10 MΩ.

3.3.2.2 *High voltage test* (applied to electronic tachometers using an external supply). The insulation between all terminals coupled together and earthed, shall withstand
for 1 minute, 2 000 V r.m.s. 50 Hz applied in such a manner as to avoid any over voltage being produced. During this test, the maximum leakage current shall be measured, and must not exceed 0.005 A.

Tachometer systems where the voltage does not exceed 50 V a.c. r.m.s. or d.c. are exempt from this test.

3.3.3 Accuracy. The accuracy of the tachometry system when tested at a temperature of 20 ± 3 °C as described below, after a warming up period of not less than 30 minutes, shall be ± 0.75 % of the maximum scale value for Class 0.75, ± 1.5 % of maximum scale value for Class 1.5 and ± 3 % of maximum scale value for Class 3.0.

NOTE In the case of centre or offset zero type instruments the maximum scale value shall be taken to be the sum of the two end scale values.

Where ancillary calibrated devices such as wheel diameter adjustment boxes are fitted, any error introduced by these devices should be considered separately and added on to the errors permitted above. The additional error permitted varies according to the category of the basic system. Therefore, at ambient temperature, Class 0.75 systems should be allowed a further ± 0.5 % of full scale deflection, Class 1.5 systems a further ± 1 % of full scale deflection, and Class 3.0 systems a further ± 1.5 % of full scale deflection.

Speed indicating systems are sometimes supplied suitable for operation with either one or two indicating instruments, and the system contains a fixed resistor to simulate the load of the second indicator, where this is not connected. In these cases no additional allowance for the error introduced by this device is necessary.

Each tachometry system shall be tested by arranging for it to be operated by a variable speed drive capable of constant angular velocity at any chosen setting. The indicator shall have the dial in the normal position of use (see **2.8**).

The accuracy shall be measured at a minimum of five settings which give approximately equidistant points over the effective range including full scale with speeds increasing to full scale and decreasing to lower limit of scale range.

In the case of Class Index 1.5 and 3.0 tachometer systems of identical manufacture, the transmitters and indicators shall be chosen at random from the consignment to form complete systems, all of which shall be tested.

The requirement of interchangeability of items making up a tachometry system does not apply to Class Index 0.75.

The error of the revolution counter (if fitted) shall be agreed between the purchaser and the manufacturer and, in any case, shall not be greater than the requirements for the system.

For recommended methods of testing, see Appendix A.

Addition or removal of an indicator may be detrimental to the accuracy of the equipment. In all cases, the purchaser should consult the manufacturer. Where the transmitter and indicator are separated by 45 m or more, the lead resistance may introduce inaccuracy. In such cases the purchaser should consult the manufacturer.

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3.3.4 Balance. The variation in the reading at zero given by an indicating instrument due to changes in attitude from that at which it was calibrated, i.e. from the vertical plane to the horizontal (see **2.8**), shall not exceed 0.5 % of maximum scale value for Class 1.5 and Class 3.0 tachometers and 0.25 % of maximum scale value for Class 0.75 tachometers.

3.4 Type test requirements

3.4.1 General. Type tests are intended to prove the design and performance of a tachometry system in accordance with the requirements of this British Standard. They are normally done once only for each new design or for a modification to an existing design or by special arrangement between the manufacturer and the user.

Where appropriate, an exemption of any part of the system from any of these tests may be agreed between the manufacturer and the user.

3.4.1.1 *Mounting.* When carrying out tests described in **3.4.8** and **3.4.9**, the system shall be mounted on a vibratory table through the normal points of attachment (including anti-vibration mountings if normally fitted in service).

3.4.2 Effect of temperature on accuracy. Tachometry systems shall be capable of operation within an accuracy of a percentage of maximum scale value throughout the temperature ranges, as follows:

Temperature range °C[a]		**+ 17 to + 23**	**– 10 to + 17 and + 23 to + 55**	**– 40 to – 10 and + 55 to + 85**
Accuracy % of maximum scale value	Class 0.75	0.75	1.5	Accuracy to be agreed with user
	Class 1.5	1.5	3	
	Class 3.0	3	5	

[a] By agreement between the manufacturer and the user, other ranges may be specified.

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The tachometry system shall be placed in a test chamber and the temperature reduced to the appropriate low temperature given above; the tachometry system shall then be allowed to reach this temperature before testing. The system shall be operated at this temperature and the accuracy of indication noted at five approximately equidistant points over the whole of the effective range.

The temperature shall then be raised to the appropriate high temperature given above and the tachometry system shall be allowed to reach this temperature before testing; the accuracy shall again be determined at five approximately equidistant points over the effective range.

This test shall be followed immediately after cooling down by the test described in **3.3.3**.

3.4.3 Index oscillation. When tested as follows, the index oscillation, peak-to-peak, shall be within 1 % of the maximum scale value for Class 1.5 and Class 3.0 tachometers and 0.5 % for Class 0.75 tachometers.

The tachometry system shall be arranged so that it is driven at a steady speed which can be varied over the effective range. The system shall be tested for oscillation at five approximately equidistant points, of which the lowest shall be not less than 10 % of maximum scale value, over the effective range.

3.4.4 Index stability. When tested as follows, the additional variation in indication of a tachometry system shall not exceed 0.25 % of the maximum scale value for Class 1.5 and Class 3.0 tachometers and 0.15 % for Class 0.75 tachometers.

The tachometry system shall be arranged so that when first put into operation an indication of approximately 75 % of the full scale reading is obtained. The system shall then be left running for 30 minutes. At the end of this period the speed measured at the start of this test shall be restored and the difference between the indications shall be within the tolerance specified in the preceding paragraph. In the case of electronic tachometers the first reading shall be made after a settling time agreed with the manufacturer has elapsed and the second reading after a further period of 30 minutes has elapsed.

3.4.5 Variation in indication due to external magnetic field. When tested as follows, the variation in indication of a tachometer system due to an external a.c. and d.c. magnetic field strength of 0.5 mT units in the most unfavourable direction shall not exceed 0.5 % of maximum scale value for Class 0.75 tachometers, and 1 % for Class 1.5 and Class 3.0 tachometers.

The a.c. field shall be 50 Hz unless otherwise stated.

The tachometer system shall be placed at the centre of a field of 0.5 mT[2)].

The field shall be capable of being applied in any direction relative to the tachometry system. The tachometry system shall be driven from a known steady drive so that the tachometer indicator reads approximately 75 % of maximum scale value. The difference between readings with and without the disturbing field shall not exceed the value specified in this clause.

3.4.6 Variation in indication due to ferrous supports. When tested at maximum scale value and in accordance with the requirements of **2.3.4** and **2.3.4.1**, the variation in indication of a tachometer system shall not exceed 0.25 % of maximum scale value for Class 0.75 tachometer systems and 0.5 % for Class 1.5 and Class 3.0 tachometer systems.

3.4.7 Damping test. The amount of overswing shall not exceed 5 % of steady reading and the reading shall be to the class limits of accuracy in not more than 4 seconds from reconnection when tested as follows.

The indicator shall be adjusted to zero. The tachometry system shall then be operated at 75 % of the full scale reading. The indicator or input source shall then be mechanically or electrically disconnected and reconnected after the index has returned to zero. The amount of overswing on reconnection shall not exceed the figure stated in the preceding paragraph.

3.4.8 Vibration test. The indicator shall be checked for freedom of movement over the scale range. The tachometry system shall then be mounted on a vibration table capable of a sinusoidal vibration.

A resonance search shall be carried out over the normal range of frequency and amplitude shown in Figure 1, and successively in each of three perpendicular planes, during which time the indicator shall remain deflected to approximately half scale. If resonance is observed an endurance test shall be carried out for 2 hours at the resonance frequency, and at the corresponding amplitude shown in Figure 1. If no resonance is observed this test shall be made at 25 Hz at an amplitude of 0.5 mm.

A similar test may be carried out over the extended range shown in Figure 1 if agreed between the purchaser and the manufacturer.

[2)] 400 ampere turns will produce a field of approximately 0.5 mT at or near the centre of a plane circular coil 1 m in diameter.

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During the endurance test the indicator is to be deflected to approximately half scale. During this time the indicator shall read accurately to within twice the class index.

At the end of this test period the indicator shall be checked again for freedom of movement and the system shall be retested in accordance with **3.3.3**.

Any variation from the requirements of this test shall be subject to agreement between the manufacturer and the user.

3.4.9 Shock test. The system shall be subjected to an impact of 300 m/s^2 (30*g*) in each of three mutually perpendicular planes. In no case shall errors exceed twice the class index when tested in accordance with **3.3.3**.

Any variation from the requirements of this test shall be subject to agreement between the manufacturer and the user.

3.4.10 Weatherproofness test. The weatherproofed parts of the tachometry system shall be placed in a simulated installed position in a chamber at a temperature of 40 ± 5 °C for a period of 30 minutes, after which they shall be subjected to a fine airborne spray of ordinary tap water for 15 minutes. The temperature shall then be allowed to recover to 20 ± 5 °C after which the water shall be found not to have penetrated the system. The system shall operate correctly throughout this test.

3.4.11 Watertightness test. The waterproofed parts of the tachometry system shall be placed in a simulated installed position and immersed for 1 hour under water at a pressure of 0.13 bar (1.5 m head of water) at 20 ± 3 °C, after which they shall be examined to see that there has been no penetration of water.

3.4.12 Polarity of supply. Where reversed polarity protection is fitted, the effectiveness of this shall be tested over a period of not less than 1 minute within the specified voltage range. After this test the system shall be connected correctly and the accuracy shall comply with the requirements of **3.3.3**.

4 Test certificates and marking

4.1 Test certificates

When specified by the purchaser, the manufacturer shall provide test certificates giving the test results on the tachometer system supplied.

4.2 Identification marking

The following particulars shall be clearly and indelibly marked on the appropriate parts of the tachometer system:

1) Manufacturer's or supplier's identification or trade mark.

2) The number of this British Standard, and class index e.g. BS 3403/0.75.

3) Manufacturer's or supplier's designation (type symbol or code, etc.).

4) Designation of the interrelated parts of the system and/or electronic conversion unit with which they are to be used, where necessary.

5) Drive rev/min corresponding to maximum scale value (or such other value as may be marked).

6) Any other information deemed necessary by the manufacturer e.g. suitability for use in ferrous conditions, direction of rotation of input drive, etc.

7) Symbols used on dials shall be in accordance with BS 1991-3.

4.3 Marking of terminals

When the correct operation of the equipment depends upon specific connections, the terminals on both indicator and transmitter shall be marked appropriately.

4.4 Installation instructions

Installation instructions shall be provided in a suitable form e.g. tie-on label or self-adhesive label. These instructions shall include the method of interconnection, type of wire and weight of wire, maximum resistance and whether the wire is screened. The maximum safe transmitter speed shall be stated.

Details of any special precautions necessary shall also be stated.

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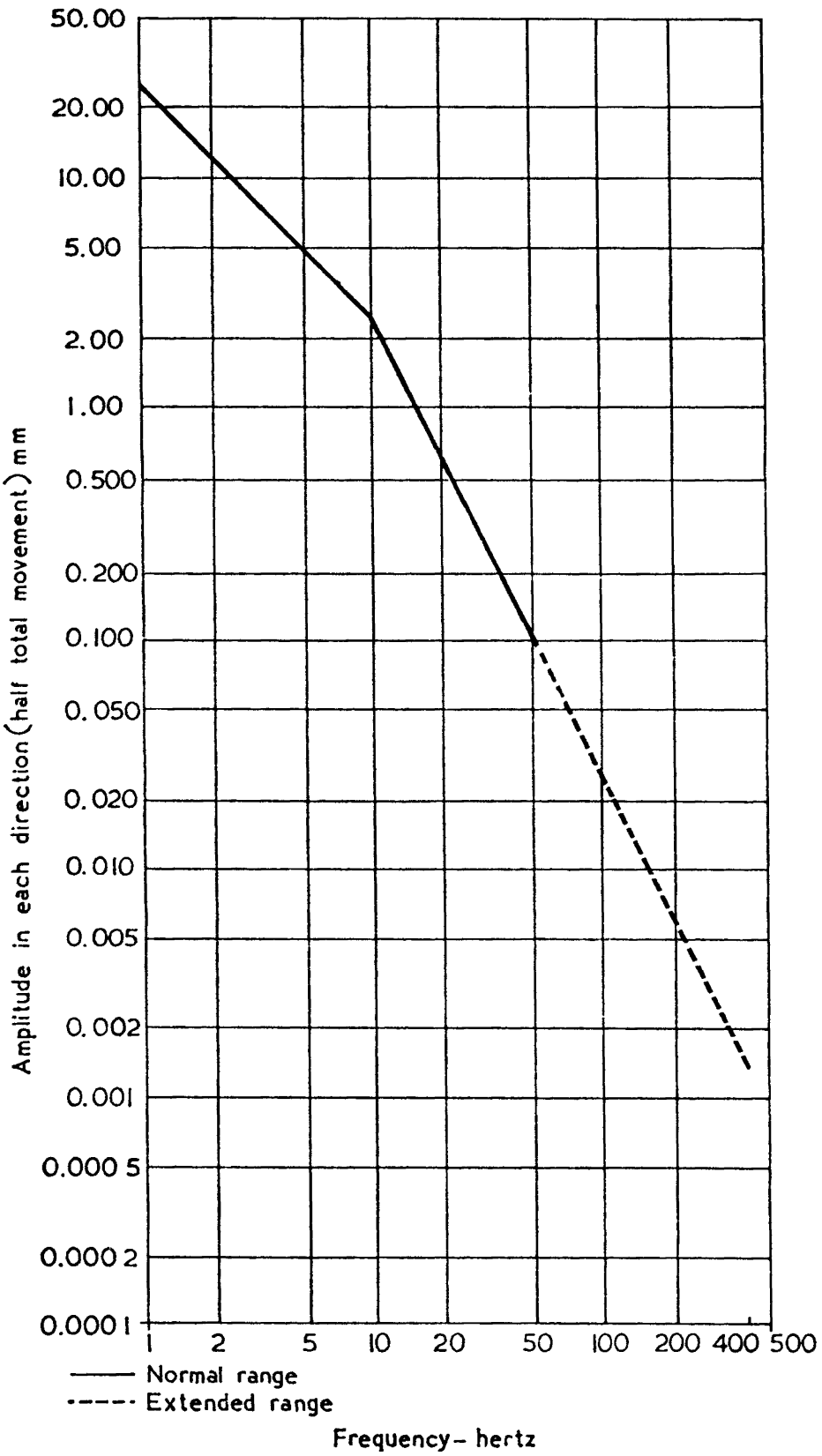

Figure 1 — Relationship between amplitude and frequency

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Appendix A Notes on testing of tachometry systems for accuracy

A.1 Means shall be provided for maintaining a constant speed and/or frequency source over the period of test, and for adjusting that source accurately to any desired value over the effective range of the tachometry system. It will also be necessary in some instances to provide a means of reversal of rotation.

Recommended methods are:

1) A d.c. shunt or compound wound motor having variable field control and reasonable duration of stability.

2) A d.c. or a.c. series wound motor with variable voltage input and a reasonable duration of stability.

3) An a.c. single phase or polyphase induction motor (fixed speed) with an infinitely variable non-backlash gearbox.

4) Variable output signal generator having a reasonable term stability over its operational range.

In combination with **A.1** 1), **A.1** 2) and **A.1** 3) a number of fixed (non-backlash) gear ratio boxes may be used to extend the range of speeds obtainable.

A.2 The accuracy of the system under test may be verified in any of the following ways:

1) Against a tachometer system of known accuracy[3)] driven from the same shaft as that under test.

2) Against a "stroboscope", controlled by a master tuning fork or quartz crystal oscillator, monitoring the same shaft as that under test.

3) By means of a digital frequency meter, operated by a commutator or other means of obtaining a succession of pulses, coupled to the shaft under test.

(When checking an electrical tachometer the associated transmitter itself may provide the pulses.) The foregoing method shall employ a suitable high-precision time reference.

Of the above methods **A.2** 2) and **A.2** 3) are the most accurate and a combination of both is preferred for checking systems to the Class 0.75 accuracy.

Ideally, accuracy should be checked by setting the pointer of the indicator of the system under test to the appropriate scale mark and reading the correct speed from the standard. However with method **A.2** 2) it will be found more convenient to set the correct speed on the stroboscope and read off the resulting deflection from the indicator of the system under test.

NOTE Any method which entails checking over a period in excess of 10 seconds duration is definitely excluded from these recommendations owing to the difficulties of maintaining absolute constancy of speed beyond such a period of time.

[3)] A tachometer system in which the total error and stability is known over its effective range to within one-tenth of the accuracy class of the tachometry system under test.

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