BRITISH STANDARD

BS 7194:1990

Incorporating Amendment No. 1

Specification for

Direct-current and low-frequency electronic measuring instruments with a digital display

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Committees responsible for this British Standard

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Association of Consulting Engineers

Association of Supervisory and Executive Engineers

Department of Energy (Electricity Division)

Department of Trade and Industry (National Physical Laboratory)

Department of Trade and Industry (National Measurement Accreditation Service)

Electrical Power Engineers' Association

Electricity Supply Industry in England and Wales

Engineering Teaching Equipment Manufacturers' Association

GAMBICA (BEAMA Ltd.)

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Institution of Electrical Engineers

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Contents

Foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee and is based on BS 89[1)], the format of which it generally follows for ease of use.

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 22, 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.

[1)] Revision in preparation.

1 Scope

This standard specifies requirements for the performance of electronic measuring instruments with a digital display intended for measuring analogue quantities of voltage and/or current.

It also applies to instruments for indicating other quantities including non-electrical quantities, provided that the relationship between the indicated quantity and the measurand is known.

This standard applies to self-contained instruments having their own enclosure, terminals, etc., and also to instruments for fitting in an enclosure where the enclosure is not provided by the supplier of the instrument [original equipment manufacture (OEM) instruments].

This standard applies only to instruments measuring current and voltage at d.c. and at a.c. at distribution system frequencies and their harmonics. It applies to the digital parts of an instrument having a combined analogue/digital display.

This standard does not specify requirements concerning dimensions of instruments and does not apply to instruments having a digital or coded measurand input. It does not apply to special purpose instruments which are covered by their own British Standards and contains no requirements for the visibility of the display. It also does not apply to accessories.

NOTE 1 The values of a.c. quantities given in this standard are r.m.s. values unless otherwise stated.

NOTE 2 The publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 7194, the definitions given in BS 4727 apply, together with the following.

2.1 General terms

2.1.1
measurand

a quantity subjected to measurement

2.1.2
digital display instrument

a measuring instrument that provides a display in digital form. (Referred to hereinafter as instrument)

2.1.3
indicating instrument

a measuring instrument that displays at any time the value of the measurand without recording it

NOTE The indicated value may be different from the value of the quantity measured by the instrument and may be in units of a different quantity.

2.1.4
electronic measuring instrument

a measuring instrument intended to measure an electrical or non-electrical measurand using electronic means

2.1.5
single function instrument

a measuring instrument intended for the measurement of one kind of measurand only

2.1.6
multi-function instrument

a measuring instrument with a single means of indication intended for the measurement of more than one kind of measurand (e.g. an instrument measuring current, voltage and resistance)

2.1.7
fixed instrument

a measuring instrument designed to be permanently mounted and which is intended to be connected to an external circuit(s) by means of permanently installed conductors

2.1.8
portable instrument

a measuring instrument specifically designed to be carried by hand and to be connected and disconnected by the user

2.1.9
instrument with magnetic screen

a measuring instrument shielded by ferro-magnetic material from the influence of a magnetic field of external origin

2.1.10
instrument with electric screen

a measuring instrument shielded by conductive material from the influence of an electric field of external origin

2.1.11
accessory

an element, group of elements or device associated with the measuring circuit of a measuring instrument in order to confer specified characteristics to the measuring instrument

2.1.12
instrument lead

a lead comprising one or more conductors, specially designed for connecting measuring instruments to external circuits

2.1.13
calibrated instrument lead

an instrument lead whose resistance has a specified value

2.1.14
distortion factor (total harmonic distortion factor) of a measurand

the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the non-sinusoidal measurand

NOTE Ratio = $\frac{H}{M}$

where

H is the value of the harmonic content;

M is the value of the non-sinusoidal measurand.

2.1.15
ripple content of a measurand

the ratio of the fluctuating current to the value of the d.c. component

NOTE Ratio = $\frac{C_f}{C_{dc}}$

where

C_f is the value of the fluctuating component;

C_{dc} is the value of the d.c. component.

2.1.16
peak factor

the ratio of the peak value to the r.m.s. value of a periodic measurand

2.1.17
common mode voltage

that part of a voltage measurand which exists between each of the voltage circuit terminals and a reference point

NOTE This reference point may be the frame terminal, the signal terminal or another defined point.

2.1.18
series mode voltage

an unwanted part of the input voltage which is superimposed on the voltage produced by the measurand

2.2 Description of instruments according to their method of operation

2.2.1
rectifier instrument

a measuring instrument that combines a measuring instrument sensitive to direct current and a rectifying device whereby alternating currents or voltages may be measured

2.2.2
r.m.s. responding instrument

a measuring instrument that, over a specified frequency range, provides an indication which is intended to be proportional to the root-mean-square value of the measurand, even when it contains a d.c. component or is not sinusoidal

2.3 Constructional features of instruments

2.3.1
measuring circuit (of an instrument)

the part of the electrical circuit internal to the instrument, together with the interconnecting leads, if any, which is energized by a voltage or a current, one of these quantities being a prime factor in determining the value of the measurand

2.3.2
current circuit

a measuring circuit through which flows a current that is a prime factor in determining the value of the measurand

NOTE The current may be either directly involved in the measurement or a proportional current supplied by an external current transformer or derived from an external shunt.

2.3.3
voltage circuit

a measuring circuit to which a voltage is applied that is a prime factor in determining the value of the measurand

NOTE The voltage may be either directly involved in the measurement or a proportional voltage supplied by an external voltage transformer or an external voltage divider.

2.3.4
external measuring circuit

the part of the electrical circuit external to the instrument from which the value of the measurand is obtained

2.3.5
auxiliary circuit

a circuit, other than a measuring circuit, required for the operation of the instrument

2.3.6
auxiliary supply

an auxiliary circuit that provides electrical energy

2.3.7
indicating device

the part of a measuring instrument that displays values corresponding to the measurand

2.3.8
electrical zero

the indication given by the instrument when the measurand is either zero or a stated value

2.3.9
electrical zero adjuster

the mechanism by means of which the instrument may be adjusted so that the electrical zero coincides with the appropriate indication

2.3.10
electrical span adjuster

the mechanism by means of which the instrument may be adjusted so that the lower/upper limit of the measuring range coincides with the appropriate indication

2.4 Characteristic features of instruments

2.4.1
span

the algebraic difference between the upper and lower limits of the measuring range which is expressed in units of the measurand

2.4.2
measuring range

the range defined by two values of the measurand within which the limits of error of a measuring instrument are specified

NOTE A measuring instrument may have several measuring ranges.

2.4.3
response time

the time taken for the indication to reach, and remain within, a band centred on the final steady indication, when the measurand is abruptly changed from zero (the unenergized condition) to a value such that the final steady indication is a specified proportion of the span

2.4.4
display update time (rate)

the time interval between successive occasions on which, in response to a changing measurand, the display is changed

NOTE When the time interval is short, it is usual to give the display update rate, being the quantity of updates per second.

2.4.5
sampling time

the time interval during which the value of measurand is being investigated in order to produce the display

2.4.6
sampling rate

the number of times per second that the measurand is investigated in order to produce the display

2.5 Characteristic values

2.5.1
nominal value

a value of a quantity indicating the intended use of an instrument. The intended characteristics of instruments and accessories are also nominal values

2.5.2
rated value

a value of a quantity assigned, generally by a manufacturer, for a specified operating condition

2.5.3
fiducial value

a clearly specified value to which reference is made in order to define the fiducial error

NOTE This value may be, for example, the upper limit of the measuring range, the scale length or another clearly stated value.

2.5.4
fiducial error

the ratio of the absolute error to the fiducial value

2.6 Influence quantity, reference conditions, nominal range of use and preconditioning

2.6.1
influence quantity

any quantity, generally external to the measuring instrument and/or accessory, that may affect its performance

2.6.2
reference conditions

the appropriate set of specified values and specified ranges of values of influence quantities under which the permissible errors of an instrument are specified

NOTE Each influence quantity may have either a reference value or a reference range.

2.6.3
reference value

a specified value of one of a set of reference conditions

2.6.4
reference range

a specified range of values of one of a set of reference conditions

2.6.5
nominal range of use

a specified range of values that an influence quantity can assume without causing a variation exceeding the specified amount

2.6.6
limiting values of an influence quantity

extreme values that an influence quantity can assume without the instrument being damaged or permanently altered in such a way that it no longer satisfies the requirements of its class index

NOTE The limiting values may depend on the duration of their application.

2.6.7
warming-up period

the interval between the energizing of the auxiliary circuit and the instant when the instrument may be used, as specified in the manufacturer's instructions

2.6.8
preconditioning

the action whereby a specified value of the measurand is applied to the measuring circuit prior to carrying out testing or use of the instrument, generally for a specified period

2.7 Errors and variations

2.7.1
(absolute) error

for an instrument, the value obtained by subtracting the true value from the indicated value

NOTE Since the true value cannot be obtained by measurement, a value obtained under specified test conditions and at a specified time is used instead. This value is derived from national measurement standards or measurement standards which have been agreed.

2.7.2
intrinsic error

the error of an instrument when under reference conditions

2.7.3
variation

the difference between the two indicated values for the same value of the measurand of an instrument when a single influence quantity successively assumes two different specified values within the nominal range of use

2.8 Accuracy, accuracy class and class index

2.8.1
accuracy

for a measuring instrument the closeness of the indicated value to the true value

NOTE The accuracy of a measuring instrument is defined by the limits of intrinsic error and by the limits of variations.

2.8.2
accuracy class

a group of measuring instruments which meet certain metrological requirements intended to keep permissible errors and variations within specified limits

2.8.3
class index

the number that designates the accuracy class

NOTE Some instruments may have more than one class index.

3 Classification

Class indices shall be selected from a 1, 2, 5 sequence or a decimal multiple or a submultiple thereof.

4 Reference conditions and intrinsic errors

4.1 Reference conditions

The reference values shall be either:

a) 23 °C as given in Table 1; or

b) 20 °C or 27 °C in which case they shall be marked in accordance with clause **8**.

4.2 Limits of intrinsic error

When the instrument is under the reference conditions given in Table 1 and is used between the limits of its measuring range in accordance with the manufacturer's instructions, the intrinsic error, when measured by the method of **4.2**, and expressed as a percentage of the fiducial value, shall not exceed the limits appropriate to its class index given in Table 1. If a table of corrections is supplied with the instrument it shall not be taken into account in determining the errors.

NOTE 1 Recommended methods of test are given in Table 2.

NOTE 2 The intrinsic error includes other errors such as those due to component drift, etc.

NOTE 3 The maximum permissible error is related to the accuracy class such that the class index is used as the limit of error, expressed as a percentage with positive and negative signs. For example, for a class index of 2, the limits of intrinsic error are ± 2 % of the fiducial value (see Appendix B).

NOTE 4 The fiducial value for an ammeter or a voltmeter corresponds to the following.

a) The upper limit of each measuring range for instruments in which the indication is in units of the measurand. The class index is marked using symbol E-1 given in Table 4 (see clause **8**).

b) The span for an instrument whose indication does not correspond directly to its electrical input quantity. The class index is marked using symbol E-10 given in Table 4 (see clause **8**).

Item b) does not apply to a voltmeter or ammeter designed to be used in conjunction with a shunt, a resistive divider or an instrument transformer. These instruments should be treated in accordance with item a).

5 Nominal range of use and variations

(see Appendix B)

NOTE Recommended methods of test are given in Table 2.

5.1 Nominal range of use

5.1.1 Either the limits of the nominal range of use for influence quantities shall be as given in Table 2 or, when a nominal range of use is specified which is different from that shown in Table 2, it shall include the reference range (or reference value with permitted tolerances) and will normally exceed that range in at least one direction. Such ranges shall be marked in accordance with clause **8**.

5.1.2 For values in the nominal range of use beyond the reference range (or reference value), the permissible variation shall be as stated in Table 2.

Example. For an instrument having a class index of 0.2, the variation (as a percentage of the fiducial value) due to ripple of 20 % on a d.c. measurand shall not exceed:

$$0.2\left(\frac{50}{100}\right) = 0.1$$

Table 1 — Reference conditions and tolerances for testing purposes relating to the influence quantities

Influence quantity		Reference conditions unless otherwise marked	Tolerances for testing purposes, applicable for a single reference value[a]	
			Class index 0.2 and smaller	Class index 0.5 and greater
Ambient temperature		23 °C	± 1 °C	± 2 °C
Humidity		Relative humidity 40 % to 60 %	—	—
Ripple on d.c. measurand (series mode voltage)		Ripple content zero	Ripple content 0.01	Ripple content 0.03
Common mode voltage		Total absence	1 % of the maximum value of the measurand for each range	3 % of the maximum value of the measurand for each range
Distortion of a.c. measurand	Distortion factor	Zero	± 0.01	
	Peak factor	$\sqrt{2}$, approx. 1.414 (sinewave)	± 0.05	
Frequency of a.c. measurand		45 Hz to 65 Hz	± 2 % of the reference value or ± $\frac{1}{10}$ of the reference range for frequency (if any), whichever is the smaller	
Magnetic field of external origin		Total absence	0.04 kA/m[b] at frequencies from d.c. to 65 Hz in any direction	
Electric field of external origin		Total absence	1 kV/m at frequencies from d.c. to 65 Hz in any direction	
Auxiliary supply	Voltage	Nominal value or nominal range	± 5 % of the nominal value	
	Frequency	Nominal value or nominal range	± 1 % of the nominal range	

[a] These tolerances apply when a single reference value is specified in this table or is marked by the manufacturer. For a reference range, no tolerance is allowed.
[b] 0.04 kA/m is approximately the highest value for the Earth's magnetic field.

5.1.3 When the influence quantity is not one of those shown in Table 2, the relevant permissible variation shall not exceed 100 % of the class index.

5.2 Limits of variations

5.2.1 *General.* When an instrument is under reference conditions (see **4.1**) and a single influence quantity is varied, the variation shall not exceed the values given in Table 2, **5.2.2** and **5.2.3**.

5.2.2 ***Variation due to a magnetic field of external origin***

5.2.2.1 When the instrument is not marked with symbol F-30 given in Table 4, the magnetic field strength in the test equipment shall be 400 A/m.

If the instrument is marked with symbol F-30 given in Table 4, the field strength shall be made equal to the value given in the symbol.

5.2.2.2 Under the conditions given in **A.10**, the variation shall not exceed the limits given in Table 2.

5.2.3 *Variation due to an electric field of external origin.* The variation due to an electric field of external origin at d.c. and 45 Hz to 65 Hz, having a strength of 20 kV/m and under the most unfavourable conditions of phase and orientation, shall not exceed 100 % of the class index.

If the instrument is marked with symbol F-34 given in Table 4, the field strength shall be equal to the value given in the symbol.

Table 2 — Limits of the nominal range of use and permissible variations

Influence quantity		Limits of the nominal range of use unless otherwise marked	Permissible variation expressed as a percentage of the class index	Recommended tests in sub-clause
Ambient temperature		(Reference temperature) ±10 °C or (lower limit of reference range) – 10 °C and (upper limit of reference range) + 10 °C	100 %	**A.3**
Humidity		Relative humidity 25 % and 80 %	100 %	**A.4**
Ripple (45 Hz to 65 Hz and 90 Hz to 130 Hz) on d.c. measurand other than r.m.s. responding instruments[a] (series mode voltage)		20 %	50 %	**A.5**
Common mode voltage		100 % of the maximum value of the measurand for each range	2 %	**A.6**
Distortion of a.c. measurand	Distortion[b] factor	20 %	100 %	**A.7**
	Peak factor	1 to 3[c]	100 %	**A.8**
Frequency of a.c. measurand		(Reference frequency) ±10 % or (lower limit of reference range for frequency) – 10 % and (upper limit of reference range for frequency) + 10 %	100 %	**A.9**
Magnetic field of external origin		Field strength 400 A/m	50 %	**A.10**
Electric field of external origin		Field strength 20 kV/m at d.c. and 45 Hz to 65 Hz (see **5.2.3**)	100 %	**A.11**

Table 2 — Limits of the nominal range of use and permissible variations

Influence quantity		Limits of the nominal range of use unless otherwise marked	Permissible variation expressed as a percentage of the class index	Recommended tests in sub-clause
Auxiliary supply	Voltage	(Reference value) ± 10 % or (lower limit of reference range) – 10 % and (upper limit of reference range) + 10 %	50 %	**A.12**
	Frequency	(Reference value) ± 5 % or (lower limit of reference range) – 5 % and (upper limit of reference range) + 5 %	50 %	**A.13**

[a] For an r.m.s. responding instrument that also responds to d.c., no permissible variation can be stated because the ripple is then part of the measurand.

[b] For a.c. quantities, the requirements for instruments relate to r.m.s. values irrespective of the principle of operation of the instrument. However, instruments incorporating rectifier(s) (except r.m.s. responding instruments) usually respond to the rectified (mean) value of the waveform but are scaled to indicate the r.m.s. value of a sinusoidal waveform. If the waveform is not sinusoidal, the indicated value may be seriously in error. However, if the waveform can be adequately characterized, this error is calculable. Requirements for the influence of a distorted waveform on rectified (mean) and peak-sensing instruments are therefore not specified.

[c] The permissible variation due to a peak factor of other than $\sqrt{2}$ (corresponding to a sinewave) is included in the permissible variation due to distortion of the measurand. For instruments having a peak factor capability greater than 3, the manufacturer shall state the following:

a) the instrument peak factor capability producing a variation of 100 % of the class index;

b) the upper and lower limits of the frequency response (bandwidth) which produce an indication of 0.707 ($\sqrt{2}/2$) times the indication at the reference frequency;

c) the effective maximum a.c. amplifier response (slew rate), expressed in volts per second using appropriate SI prefixes.

Peak factor relates to the total peak factor capability of the instrument and includes both the peak factor due to a distorted waveform and the peak factor due to spurious impulses (which may be random or harmonically related to the fundamental frequency) containing negligible average power.

5.3 Conditions for the determination of variations

5.3.1 If a preconditioning period and/or warming-up period are stated by the manufacturer, the instrument shall be preconditioned and warmed-up for the periods which are stated by the manufacturer. The manufacturer shall state the value of the measurand for preconditioning. Neither the preconditioning period nor the warming-up period shall exceed 30 min.

NOTE Instruments should be adequately packed to ensure that, after transport to the user, under normal conditions, they comply with the requirements of this standard relating to their class index.

5.3.2 The variations shall be determined for each influence quantity separately. During each test recommended in Table 2 all influence quantities shall be maintained at their reference conditions except for the influence quantity for which the variation is being determined.

5.3.3 When an influence quantity has a reference value, the influence quantity shall be varied between that value and any value within the limits of the nominal range of use, as given in Table 2, unless otherwise marked in accordance with clause **8**.

5.3.4 When an influence quantity has a reference range, the influence quantity shall be varied from each limit of the reference range to the adjacent limit of the nominal range of use.

6 Electrical and mechanical requirements

6.1 Voltage, insulation and other safety requirements

6.1.1 *General.* Voltage, insulation resistance and construction relating to safety shall be as specified in BS 5458.

In addition, the instrument shall comply with BS 4743.

6.1.2 *Impulse voltage.* Where specified, a test voltage of 5 kV in both positive and negative senses, having the impulse waveform of 1.2/50 μs, shall be applied as follows:

a) between the earth terminal and all the other terminals connected together;

b) between the terminals of each circuit in turn, all other circuits being earthed.

After completion of the impulse voltage test, the instrument shall comply with the requirements appropriate to its class index given in Table 1.

6.2 Response time

When tested by the method of **A.14**, the departure of the displayed value from the final steady value shall not exceed 1.0 % of the span at any time after 2 s following the sudden application of an excitation.

6.3 Self-heating

When tested by the method of **A.15**, the variation shall not exceed a value corresponding to 100 % of the class index. In addition, instruments shall comply with the requirements appropriate to their class index given in Table 1 at any time after completion of the specified preconditioning period (if any) or warming-up period (if any) (see **5.3.1**) having been continuously operated[2)].

6.4 Overloads

6.4.1 *Continuous overload.* When tested by the method of **A.16**, instruments shall:

a) show, after removal of the excitation, a sum of the temporary and any permanent variations in indication not greater than 1 % of the span;

b) continue at the completion of the test to comply with the requirements appropriate to their class index given in Table 1. The overload, however, shall not be repeated.

6.4.2 *Overloads of short duration.* When tested by the method of **A.17**, instruments shall comply with the following:

a) the deviation of the indication from electrical zero, expressed as a percentage of the span, shall not exceed the following value:

1) 0.5 for instruments of class indices 0.2 and smaller;

2) the class index given in Table 1 for instruments of class indices 0.5 and greater;

b) the ammeter or voltmeter, after adjustment of electrical zero, if necessary, shall comply with the requirements appropriate to its class index given in Table 1. The overload, however, shall not be repeated.

6.5 Limiting values of temperature

When tested by the method of **A.18**, instruments shall not incur permanent damage, the absence of which shall be inferred if, on return to reference conditions, the instruments comply with **4.2**, when subjected to the following ambient temperatures:

a) instruments other than those incorporating batteries: – 25 °C to + 40 °C;

b) instruments incorporating batteries: over the battery manufacturer's declared operating temperature range if within – 25 °C to + 40 °C, otherwise – 25 °C to + 40 °C.

6.6 Deviation from electrical zero

When tested by the method of **A.19**, instruments shall show a deviation from electrical zero not exceeding a value corresponding to 50 % of the class index given in Table 1.

6.7 Long term drift

Instruments shall comply with the appropriate limits of intrinsic error specified in **4.2** for a period of 1 year after manufacture when tested as specified therein.

7 Constructional requirements

7.1 Effects of vibration and shock

7.1.1 *Vibration (sinusoidal).* When tested by the method given in BS 2011-2.1Fc, and with the following details, the instrument shall comply with the requirements corresponding to its class index given in Table 1:

a) sweep cycle: 10 Hz, 55 Hz, 10 Hz;

b) displacement amplitude: 0.15 mm;

c) number of sweep cycles: 5;

d) sweep rate: 1 octave per minute.

The direction of vibration shall be at 45° to the plane of the display, i.e. the vibration direction vertical with the instrument inclined at 45°, the rear of the instrument being lower than the front.

7.1.2 *Shock.* When tested by the method given in BS 2011-2.1Ea and with the following details, the instrument shall comply with the requirements corresponding to its class index given in Table 1:

a) peak acceleration: either

1) $15g_n$ (150 m/s^2); or

2) $50g_n$ (500 m/s^2);

b) pulse shape: half-sine;

c) number of shocks: three in both directions of three mutually perpendicular axes (total of 18 shocks);

d) duration of pulse: 11 ms.

[2)] For convenience, a test period of 6 h is considered sufficient.

The instrument shall be mounted so that one of the three shock axes is parallel to the plane of the display.

7.2 Indication of out-of-range values of the measurand

When the value of the measurand is such that it would provide an indication not between the limits of a scale range, a clear indication of this shall be provided. This indication shall not be lingual (e.g. "O/L" = Overload).

NOTE The method of indication is not specified but should not be by blanking the display.

8 Information, general markings and symbols

8.1 Information

The following information shall be given by the manufacturer.

a) Unit(s) of the measurand(s).

b) Manufacturer's name or trade mark or that of the responsible supplier.

c) Type reference, if any.

d) Serial number or date of manufacture (at least the year).

e) Rated value(s).

f) Nature of the measurand(s).

g) Class index(es).

h) Reference value or reference range for temperature.

i) Reference value(s) or reference range(s) for each influence quantity (other than temperature) given in Table 1, if these values differ from those given in Table 1, and the reference values or reference ranges for any other relevant influence quantities not given in Table 1.

j) Nominal ranges of use for the influence quantities given in Table 2, if these values differ from those given in Table 2. Nominal ranges of use for any other relevant influence quantities not given in Table 2.

k) Value of peak acceleration (see **7.1.2**).

l) Instructions for the use of the instrument when necessary.

m) Peak factor (but see footnote b to Table 2 where peak factor exceeds 3).

n) Impedance of the measuring circuit (input impedance).

o) Response time.

p) Display update time (rate).

q) Sampling time and sampling rate.

r) Temperature limits and other requirements for transport, storage and use.

s) Test voltage.

t) For an instrument whose indication does not correspond directly to its electrical input quantity, the relationship between them.

NOTE This does not apply to an instrument having a non-interchangeable accessory.

u) Preconditioning period and/or warming-up period if not negligible and the value(s) of the measurands and auxiliary supply, if any, to be used.

v) Symbol of the accessory for which the instrument has been adjusted, if relevant.

w) Transformation ratio(s) of instrument transformer(s) for which the instrument has been adjusted, if relevant.

x) Value of the total resistance of calibrated instrument leads, if relevant.

y) Impedance of the external measuring circuit, if relevant.

z) Where electromagnetic compatibility is required to be given as a performance criterion, after testing, the effect of the applied conducted or radiated emission on the indication of the instrument shall be given as follows:

1) as a consistent and measurable effect;

2) as a random effect, not repeatable and possibly further classified as a transient effect occurring during the application of the emission;

3) as a permanent or semi-permanent effect remaining after application of the emission has ceased.

NOTE In addition, similar statements should be made giving the effect of radiated and conducted emission from the instrument on apparatus connected to its input. For further information and tests see BS 6667.

aa) Any other essential information.

8.2 Markings, symbols and their locations

8.2.1 *General.* The symbols specified in Table 3 shall be used, where relevant.

For instruments supplied in a case, marking shall be in a position where it is visible when the instrument is in use. Marking on the display or front panel of the case shall not impede the clear reading of the display. For instruments supplied without a case and for small cased instruments, marking shall be included in a separate document with references relating it to the instrument.

When tested by the method of **A.20**, the markings and symbols shall be indelible, and shall remain legible. SI units, together with their prefixes, shall be marked using the symbols given in BS 5775-5.

8.2.2 *Reference values.* If the reference values relating to field strength differ from those given in Table 1, they shall be marked as follows:

a) magnetic field of external origin: symbol F-30 and if relevant F-28 and/or F-29;

b) electric field of external origin: symbol F-34 and if relevant F-27.

8.3 Markings relating to the reference values and nominal ranges of use of influence quantities

8.3.1 When a reference value or reference range is different from that given in Table 1, it shall be marked in accordance with **8.3.3** and **8.3.4**, and shall be distinguished by an underline.

8.3.2 When a nominal range of use differs from that given in Table 2, it shall be marked in accordance with **8.3.3** and **8.3.4**, in conjunction with the reference value or reference range, even where the reference value or reference range would not otherwise be marked.

8.3.3 The limits of the nominal range of use and the reference value or range shall be given in ascending order, separated by a space followed by three dots followed by a space and, at the end, the unit of measurement.

Examples:

35 . . . <u>50</u> . . . 60 Hz denotes a reference value of 50 Hz and a nominal range of use of 35 Hz to 60 Hz.

35 . . . <u>45</u> . . . <u>55</u> . . . 60 Hz denotes a reference range of 45 Hz to 55 Hz and a nominal range of use of 35 Hz to 60 Hz.

8.3.4 When any limit of the nominal range of use is the same as the reference value or the adjacent limit of the reference range, the number indicating the reference value or the limit of the reference range shall be repeated for the limit of the nominal range of use.

Examples:

23 . . . <u>23</u> . . . 37 °C denotes a reference value of 23 °C and a nominal range of use of 23 °C to 37 °C.

20. . . <u>20</u> . . . <u>25</u> . . . 35 °C denotes a reference range of 20 °C to 25 °C and a nominal range of use of 20 °C to 35 °C.

9 Markings and symbols for terminals and connectors

9.1 Marking of terminals

The marking shall be either:

a) applied on or adjacent to the relevant terminal; or

b) if there is insufficient space adjacent to a terminal, on a permanently attached label with details of the terminals and uniquely identifying them, i.e. so that individual terminals cannot be confused.

When tested by the method of **A.20**, the marking shall be indelible and shall remain legible. The marking shall be either of a colour which contrasts with the background or shall be moulded.

Marking shall not be applied to a removable part of a terminal (such as a terminal head).

If markings are applied to a cover over several terminals, it shall not be possible to fit the cover so that the markings become incorrect.

When a diagram of connections is supplied, the marking for a terminal shall be identical to that on the diagram of connections relating to that terminal.

9.2 Earthing (grounding) terminals

Terminals that are required to be connected to a protective earth (ground) for reasons of safety shall be marked with symbol F-43 given in Table 3.

Terminals that are required to be connected to a noiseless earth (ground) to prevent impairment of performance shall be marked with symbol F-44 given in Table 3.

Terminals that are connected to accessible conductive material but which are not necessarily required to be connected to earth (ground) shall be marked with symbol F-42 given in Table 3.

9.3 Measuring circuit terminals

If a terminal of a measuring circuit is intended to be kept at or near to earth (ground) potential, e.g. for safety or functional reasons, it shall either be marked with a capital N, if it is intended to be connected to the neutral conductor of an a.c. supply circuit, or be marked with symbol F-45 given in Table 3 in all other circumstances.

These markings are additional to and shall follow any other markings supplied by the manufacturer for the relevant terminal.

9.4 Special markings for terminals

9.4.1 *Single-range d.c. ammeters and voltmeters.* The positive terminal shall be marked using symbol F-46 given in Table 3.

9.4.2 *Multi-range d.c. ammeters and voltmeters.* The range-selecting terminals shall be marked with the value corresponding to the upper limit of the relevant measuring range. If those terminals are positive terminals, they shall also be marked using symbol F-46 given in Table 3. This marking shall follow the marking for the value of the range. If the common terminal is the positive terminal, it shall be marked using symbol F-46 given in Table 3.

9.4.3 *A.C. ammeters and voltmeters.* The range-selecting terminals of multi-range instruments shall be marked with the value corresponding to the upper limit of the measuring range.

NOTE For single-range instruments no markings are required.

9.5 Markings for plug and socket connectors

The relation between pin numbers and their function shall be shown in a document.

9.6 Markings for permanently attached leads

The free ends of the leads shall be either marked or colour coded and identified in the user instructions.

Table 3 — Symbols for marking instruments and accessories

a) Units, quantities and SI prefixes

Units and quantities		SI prefixes		
Item	Symbol	Item		Symbol
ampere	A	exa	10^{18}	E
decibel	dB	peta	10^{15}	P
hertz	Hz	tera	10^{12}	T
ohm	Ω	giga	10^{9}	G
second	s	mega	10^{6}	M
siemens	S	kilo	10^{3}	k
tesla	T	hecto[a]	10^{2}	h
volt	V	deca[a]	10	da
voltampere	VA	deci[a]	10^{-1}	d
voltampere reactive	var	centi[a]	10^{-2}	c
watt	W	milli	10^{-3}	m
power factor	cos ϕ	micro	10^{-6}	μ
		nano	10^{-9}	n
degree Celsius	°C			
		pico	10^{-12}	p
		femto	10^{-15}	f
		atto	10^{-18}	a

b) Symbols

Nature of measured quantity (B)

No.	Item	Symbol
B-1	D.C. circuit and/or d.c. responding measuring element	(5031)[b]
B-2	A.C. circuit and/or a.c. responding measuring element	(5032)[b]
B-3	D.C. and/or alternating current circuit and/or d.c. and a.c. responding measuring element	(5033)[b]

Safety (C) (see BS 5458)

No.	Item	Symbol
C-1	Test voltage 500 V	(5179)[b]
C-2	Test voltage above 500 V (e.g. 2 kV)	
C-3	Apparatus not subjected to a voltage test	
C-4	High-voltage flash	(5036)[b]
C-7	High-voltage on accessory and/or on instrument (e.g. voltmeter)	

NOTE 1 For convenience, Table 3 a) gives the symbols for units of measurement and their prefixes that are most likely to be used and which are taken from BS 5775-5.

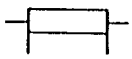
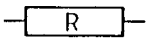
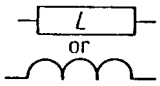
NOTE 2 The symbol of a prefix (if needed) immediately precedes, without a space, the symbol of a unit. If there is a number, it is followed by a space before the prefix (if any) and the unit.

Example: 23 °C, 120 mV.

[a] These items are non-preferred and their use should be avoided.

[b] Numbers in parentheses are the reference numbers of the symbols given in BS 6217.

Table 3 — Symbols for marking instruments and accessories

No.	Item	Symbol
	Accuracy class (E)	
E-1	Class index (e.g. 1) except when the fiducial value corresponds to the span	1
E-10	Class index (e.g. 1) when the fiducial value corresponds to the span	
	General symbols (F) (see also BS 3939 and BS 6217)	
No.	**Item**	**Symbol**
F-23	Shunt	
F-24	Series resistor	
F-25	Series inductor	
F-27	Electric screen	
F-28	Magnetic screen	
F-30	Magnetic field strength expressed in kiloamperes per metre, producing a variation corresponding to the class index (e.g. 2 kA/m)	 kA/m
F-31[a]	Earth (ground) terminal (general symbol)	 (5017)
F-32	Zero (span) adjuster	

No.	Item	Symbol
	General symbols (F)	
F-33	Refer to a separate document	
F-34	Electric field strength expressed in kilovolts per metre, producing a variation corresponding to the class index (e.g. 10 kV/m)	 kV/m
F-35[b]	General accessory	
F-42	Frame or chassis terminal	 (5020)
F-43	Protective earth (ground) terminal	 (5019)
F-44	Noiseless earth (ground) terminal	 (5018)
F-45	Signal low terminal	 (5173)
F-46	Positive terminal	 (5005)
F-47	Negative terminal	(5006)
F-48	Resistance range setting control	Under consideration
F-49	Overload protection device fitted	Under consideration
F-50	Overload protection device reset control	Under consideration

[a] Symbol F-31 is deprecated. One of the more explicit symbols F-42, F-43, F-44 or F-45 should be used instead.
[b] Symbol F-35 denotes that a device is external to an instrument and shall be combined with one of the symbols F-18, F-19, F-20, F-21 or F-22.

Appendix A Recommended tests

A.1 Common pre-test conditions, equipment and adjustments

A.1.1 *Reference conditions*

Either reference conditions shall be in accordance with Table 1 or, where a reference range is specified, tests shall be performed at both limits of the reference range.

A.1.2 *Thermal stability*

All instruments shall be allowed to remain at the reference temperature long enough to eliminate temperature gradients.

NOTE 2 h is usually sufficient.

A.1.3 *Preconditioning time*

There shall be no preconditioning time and/or warming-up time unless marked [see **8.1** u)].

A.1.4 *Electrical zero adjustment*

Before each set of readings, the indication shall be set to electrical zero.

NOTE Refer to the manufacturer's instructions for any special details of this adjustment.

A.1.5 *Test equipment errors*

All tests shall be made using reference instruments having intrinsic errors not more than those corresponding to one-quarter of the class index of the instrument under test.

NOTE However, the use of reference instruments with intrinsic errors not more than those corresponding to one-tenth of the class index of the instrument under test is strongly recommended.

If possible, when testing for variations, avoid applying the influence quantity (e.g. temperature) to the reference instrument. Otherwise, ensure that the reference instrument is not affected by more than one-quarter of the permissible variation given in Table 2 of the instrument under test when both are subjected to the same influence quantity (e.g. change of frequency).

Allowance shall be made for reference instrument uncertainty to ensure that all instruments are within their error limits at the time of shipment. The errors of the reference instrument shall be added algebraically to the permissible variations given in Table 2 when checking an instrument and the resulting sum shall be used for the limit for that test.

A.1.6 *Multi-range and multi-function instruments*

The basic range of each of the instrument measuring ranges shall be checked for accuracy and linearity. The instrument shall be checked for accuracy at the upper limit of the measuring range.

NOTE The basic range is that range with an attenuation/gain, between the measurand input and the analogue to digital converter nearest to unity.

A.1.7 *Test leads*

The test leads shall be either:

a) as specified by the manufacturer; or

b) if no test leads are specified, the size and placement of leads shall be such that they do not influence the test results.

A.1.8 *Bi-polar instruments*

Instruments that indicate in both polarities shall be tested for each polarity separately.

A.2 Intrinsic error

A.2.1 *Procedure*

If relevant, set electrical zero.

Apply sufficient excitation to bring the indication sequentially to each of at least five approximately equally-spaced indications (B_x) including the lower and upper limits of the measuring range. Record the values of excitation (B_R) as shown by the reference instrument.

A.2.2 *Computation*

The intrinsic error, E, in per cent, shall be computed for each selected scale mark as follows:

$$E = \left(\frac{B_X - B_R}{A_F} \right) 100$$

where A_F is the fiducial value.

A.3 Variation due to ambient temperature

A.3.1 *Procedure*

A.3.1.1 Set zero and record the excitation (B_S), as shown by the reference instrument, under reference conditions to bring the indication to each of at least five approximately equally-spaced indications including the upper and lower limits of the measuring range. If a reference range for temperature is specified, the upper limit of the reference range shall be used.

A.3.1.2 Subject the instrument to a temperature equal to the upper limit of the nominal range of use until thermal stability is attained but for not less than 2 h. Record the excitations (B_X) to produce the same indications as in **A.3.1.1**.

A.3.1.3 Condition the instrument at the reference temperature until thermal stability is attained but for not less than 2 h. Record the excitations (B_T) to produce the same indications as in **A.3.1.1**. If a reference range for temperature is specified, the lower limit of the reference range shall be used.

A.3.1.4 Subject the instrument to a temperature equal to the lower limit of the nominal range of use below the reference temperature until thermal stability is attained but for not less than 2 h. Record the excitations (B_Y) to produce the same indications as in **A.3.1.1**.

A.3.2 ***Computation***

The variation, in *V,* in per cent, at the upper limit of the nominal range of use shall be computed for each selected indication, as follows:

$$V = \left(\frac{B_T - B_X}{A_F} \right) 100$$

where A_F is the fiducial value.

A similar computation shall be made for the readings at the lower limit of the nominal range of use, as follows:

$$V = \left(\frac{B_T - B_Y}{A_F} \right) 100$$

If the absolute values of the variations above and below the reference temperature are not equal, the variation due to temperature shall be the greater of the values.

A.4 Variation due to humidity

A.4.1 ***Procedure***

A.4.1.1 Set zero and record the excitation (B_A), as shown by the reference instrument, under reference conditions, to bring the indication to at least five approximately equally-spaced indications, including the upper and lower limits of the measuring range.

A.4.1.2 Subject the instrument to a relative humidity between 25 % and 30 % for at least 96 h.

A.4.1.3 Set zero and record the excitations (B_B) to produce the same indications as in **A.4.1.1**.

A.4.1.4 Subject the instrument to a relative humidity between 75 % and 80 % for at least 96 h.

A.4.1.5 Set zero and record the excitations (B_C) to produce the same indications as in **A.4.1.1**.

A.4.2 ***Computation***

The variation, *V,* in per cent, due to humidity at each selected indication shall be the maximum absolute value of the variation computed as follows:

$$V = \left(\frac{B_A - B_B}{A_F} \right) 100 \qquad \text{or}$$

$$V = \left(\frac{B_A - B_C}{A_F} \right) 100$$

where A_F is the fiducial value.

A.5 Variation due to ripple on d.c. measurand (series mode voltage)

A.5.1 ***Procedure***

A.5.1.1 Connect a reference instrument, having a negligible ripple error, and apply a d.c. excitation to produce an indication on the instrument under test at about 80 % of the upper limit of its measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.5.1.2 While holding the d.c. excitation constant, superimpose a 45 Hz ripple voltage or current equal to either the marked value or 20 % of the value of the d.c. excitation. Slowly increase the frequency to 65 Hz to find the frequency that produces the maximum change in indication. Then change the d.c. excitation to produce the same indication as in **A.5.1.1**. Record the excitation (B_X) as shown by the reference instrument.

A.5.1.3 Repeat **A.5.1.2** using a ripple frequency between 90 Hz and 130 Hz and record the excitation (B_Y) in the same manner.

NOTE When the ripple component of the excitation causes a changing or blurred display, the mean value of the display should, where possible, be taken as the indication.

A.5.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to ripple on the d.c. measurand shall be the maximum deviation computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F} \right) 100 \qquad \text{or}$$

$$V = \left(\frac{B_R - B_Y}{A_F} \right) 100$$

where A_F is the fiducial value.

A.6 Variation due to common mode voltage

A.6.1 ***Apparatus***

The test apparatus shall be as shown in Figure 1.

WARNING. Under the conditions of these tests, some accessible conductive parts may be dangerous to touch.

A.6.2 ***Procedure***

A.6.2.1 Connect the protective earth terminal a) (if any) and the frame terminal b) (if any) of the instrument under test together and to the pole of the auxiliary supply which is not fused in the instrument.

NOTE If both poles are not fused, the connection may be made to either pole.

If the instrument under test uses mains as its auxiliary supply, the effect of an earth on the mains supply shall be removed by using an isolating transformer d).

A.6.2.2 If the instrument under test has neither a protective earth terminal nor a frame terminal, carry out the test for variation due to common mode voltage using a connection to the auxiliary supply only.

A.6.2.3 If the instrument under test has neither a protective earth terminal nor a frame terminal and uses an internal battery or the measurand as its auxiliary supply, do not carry out the test for variation due to common mode voltage.

A.6.2.4 Connect the signal source f) and the source of common mode voltage, as in their normal mode of use, with signal low, frame, case and protective earth terminals, etc., earthed.

A.6.2.5 With the common mode voltage source removed from the circuit using switch i), adjust the signal source f) to produce an indication of 90 % of the maximum indication, in sequence, on each function and range.

A.6.2.6 Resistor R1 shall have a value of 1 kΩ for voltage ranges and 10 Ω, for current ranges.

A.6.2.7 Connect the source of common mode voltage into circuit using switch i) and set it to an r.m.s. voltage equal to the maximum indication (d.c. or a.c.) on each range and function. For current ranges the common mode voltage shall be 10 V.

A.6.2.8 Slowly change the frequency of the common mode voltage from 45 Hz to 65 Hz and from 90 Hz to 130 Hz.

A.6.2.9 Take the variation as the greatest change in the indication of the instrument under test.

A.6.2.10 The test shall be carried out with R1 in position g) and in position h).

A.7 Variation due to distortion of a.c. measurand

A.7.1 *Procedure*

A.7.1.1 Connect a reference instrument, having a negligible waveform error, and apply sufficient sinusoidal excitation (maximum distortion), in accordance with Table 1, to produce an indication on the instrument under test equal to 80 % of the upper limit of the measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.7.1.2 Superimpose either the marked value or 20 % of the value of the fundamental waveform of third harmonic upon the fundamental waveform and adjust the amplitude of the distorted waveform to produce the same r.m.s. value, on the reference instrument, as was previously noted. Vary the phase difference between the fundamental and the third harmonic to achieve maximum influence on the instrument under test. Then change the amplitude of the distorted wave to produce the same indication as in **A.7.1.1**. Record the excitation (B_X) as shown by the reference instrument.

A.7.2 *Computation*

The variation, V, in per cent, due to distortion of a.c. measurand shall be computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F} \right) 100$$

where A_F is the fiducial value.

A.8 Variation due to peak factor of the measurand

A.8.1 *Apparatus*

The test apparatus shall be as shown in Figure 2.

A.8.2 *Procedure*

A.8.2.1 Set the oscillator a) to the required test frequency and an amplitude so as to produce an indication at about 80 % of the upper limit of the measuring range of the instrument under test f).

A.8.2.2 Ensure that the pulse generator b) has no output. Check, using the oscilloscope d), that the output waveform is sinusoidal.

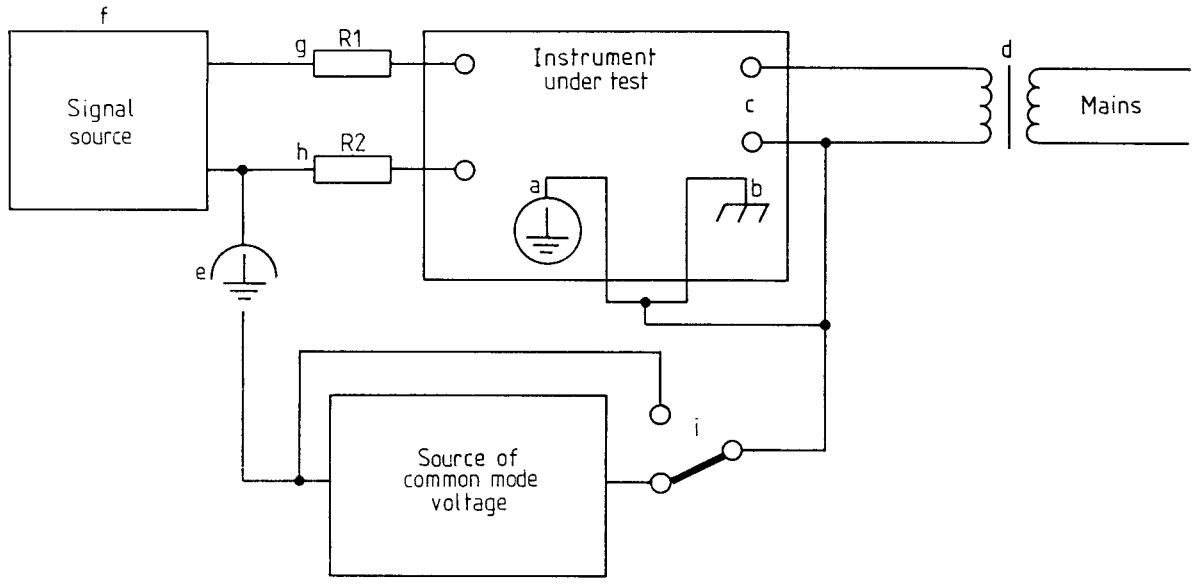
A.8.2.3 Record the indication (B_S) on the reference voltmeter (ammeter) e)[3)] and the indication (B_A) on the instrument under test f).

A.8.2.4 Adjust the pulse generator b) so that, when triggered by the oscillator a), it produces one pulse per cycle of the oscillator waveform.

A.8.2.5 Adjust the pulse duration to be between one-fifth and one-third of the period of the oscillator (the phase relationship is not important).

A.8.2.6 Using the oscilloscope d), adjust the pulse amplitude to produce a maximum amplitude of 2.12 ($3/\sqrt{2}$) times the peak amplitude of the sinewave that was displayed in **A.8.2.2**.

[3)] An a.c. digital voltmeter (ammeter), having a rated upper limit of frequency of at least 10 times the test frequency and used at an indication not exceeding one-quarter of the upper limit of its measuring range will be suitable.



a Protective earth terminal (if any)
b Frame or chassis terminal (if any)
c Auxiliary supply terminals (e.g. mains connector)
d 1:1 isolating transformer
e Noiseless (signal) earth terminal
f A.C. or d.c. signal source
g, h } Alternative positions for R1
i Switch to remove source of common mode voltage

Figure 1 — Test apparatus for variation due to common mode voltage

A.8.2.7 Check the indication on the reference voltmeter (ammeter) e) and adjust the oscillator a) and pulse generator b) output amplitudes to produce the same indication (B_S) as in **A.8.2.3**, maintaining the ratio of 2.12 : 1, between the peak amplitude of the waveform, including the pulse, and the peak amplitude of the sinewave without the pulse.

A.8.2.8 Record the indication (B_B) of the instrument under test f).

A.8.2.9 If the instrument under test is an ammeter, the reference ammeter e) and the ammeter under test f) shall be connected in series and the measuring oscilloscope d) shall be connected via a current probe.

NOTE It may be found that the circuit earth (ground) connection needs to be at the junction of the test and reference voltmeters (ammeters).

A.8.3 *Computation*

The variation, *V*, in per cent, of the fiducial value due to a peak factor of three shall be computed as follows:

$$V = \left(\frac{B_A - B_B}{B_A}\right)\left(\frac{100}{A_F}\right)$$

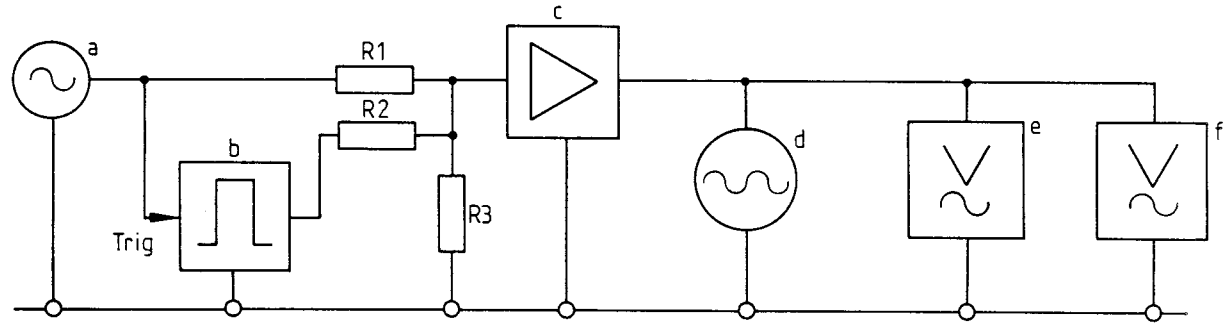
where A_F is the fiducial value.

A.9 Variation due to frequency of a.c. measurand

A.9.1 *Procedure*

A.9.1.1 Using a reference instrument having a negligible error due to frequency, apply an excitation either at the reference frequency or at any frequency within the reference range of the instrument under test, to produce an indication at about 80 % of the upper limit of measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.9.1.2 Slowly vary the frequency of the excitation between the limits of the nominal range of use for frequency shown in Table 2, keeping the amplitude constant as shown by the reference instrument. Determine the frequency that produces the greatest change in indication of the instrument under test. Record this indication (B_X).



a Low distortion sinewave oscillator
b Triggered pulse generator
c Audio frequency power amplifier
d Measuring oscilloscope
e Reference voltmeter (ammeter)
f Voltmeter (ammeter) under test
R1, R2, R3 Signal combining network
R1 = R2 = 10R3
R3 ≈ 1 kΩ

Figure 2 — Test apparatus for variation due to peak factor of the measurand

A.9.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to frequency of a.c. measurand quantity shall be the greatest of the values computed for each selected indication as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100$$

where A_F is the fiducial value.

A.10 Variation due to magnetic field of external origin

A.10.1 ***Procedure***

A.10.1.1 Apply an excitation to the instrument under test, under reference conditions, to produce an indication at about 80 % of the upper limit of its measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.10.1.2 Subject the instrument under test (but not the reference instrument) to a magnetic field of external origin of 400 A/m produced by a current of the same kind and frequency as the measurand. The field shall be produced by a coil of 1 m mean diameter, of square cross section and with a radial thickness which is small compared with the diameter, In this coil, 400 ampere-turns will produce a field of approximately 400 A/m. Place the instrument under test in the centre of the coil. Determine the variation by incrementally rotating the coil and changing the phase of the external magnetic field to produce the greatest change in indication. Adjust the excitation to produce the same indication of the instrument under test as in **A.10.1.1**. Record the excitation (B_X) as shown by the reference instrument.

A.10.1.3 An instrument having any external dimension exceeding 250 mm shall be tested in a coil of mean diameter not less than four times the maximum dimension of the instrument. The current shall be such as to produce a magnetic field having, at its centre, the value specified in **A.10.1.2**.

Reduce the magnetic field for frequencies between 1 kHz and 20 kHz by the factor 1/*f*, where *f* is the frequency in kilohertz.

NOTE Above 20 kHz no test is required.

A.10.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to external magnetic field shall be the maximum deviation computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100$$

where A_F is the fiducial value.

A.11 Variation due to electric field of external origin

A.11.1 ***Procedure***

A.11.1.1 Apply sufficient excitation to produce an indication at approximately the middle of the measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.11.1.2 Centre the instrument between a pair of circular, parallel isolated discs. The diameter of the discs shall be at least 20 % greater than the maximum dimension of the instrument under test. The separation of the discs shall be at least twice the maximum dimension of the instrument under test.

A.11.1.3 Apply a d.c. voltage sufficient to produce an electric field between the discs as specified in **5.2.3** and Table 2. The supply producing the electric field shall be connected to earth (ground) at its mid-point.

A.11.1.4 With the instrument housing, if conductive, and the signal low terminal at earth potential, apply sufficient excitation to produce an indication the same as in **A.11.1.1**. Record the excitation (B_X).

A.11.1.5 Repeat **A.11.1.4** with the instrument oriented to produce the greatest variation.

A.11.1.6 Repeat **A.11.1.3**, **A.11.1.4** and **A.11.1.5** using an a.c. voltage having a frequency between 45 Hz and 65 Hz applied between the discs to produce an electric field of 20 kV/m. For instruments marked with symbol F-34 given in Table 3 (see **5.2.3**) the external electric field to be used for this test shall be the value marked on the instrument instead of the 20 kV/m specified in this test. The supply producing the electric field shall be connected to earth (ground) at its mid-point.

A.11.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to electric field of external origin shall be the greatest of the values computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100$$

where A_F is the fiducial value.

A.12 Variation due to auxiliary supply voltage

A.12.1 ***Procedure***

A.12.1.1 Energize the instrument at its rated supply voltage and reference frequency or a voltage and frequency within the reference range and apply sufficient excitation to produce an indication at about 80 % of the upper limit of the measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.12.1.2 Decrease the supply voltage to the lower limit of the nominal range of use and record the excitation (B_X) so as to produce the same indication as in **A.12.1.1**.

A.12.1.3 Increase the supply voltage to the upper limit of the nominal range of use and record the excitation (B_Y) so as to produce the same indication as in **A.12.1.1**.

A.12.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to auxiliary supply voltage shall be the greater of the values computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100 \qquad \text{or}$$

$$V = \left(\frac{B_R - B_Y}{A_F}\right) 100$$

where A_F is the fiducial value.

A.13 Variation due to auxiliary supply frequency

A.13.1 ***Procedure***

A.13.1.1 Energize the instrument either at its rated supply voltage and rated frequency or within the reference range of frequency and apply sufficient excitation to produce an indication at about 80 % of the upper limit of the measuring range. Record the excitation (B_R) as shown by the reference instrument.

A.13.1.2 Decrease the supply frequency to the lower limit of the nominal range of use and record the excitation (B_X) to produce the same indication as in **A.13.1.1**.

A.13.1.3 Increase the supply frequency to the upper limit of the nominal range of use and record the excitation (B_Y) to produce the same indication as in **A.13.1.1**.

A.13.2 ***Computation***

The absolute value of the variation, *V,* in per cent, due to auxiliary supply frequency shall be the greater of the values computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100 \qquad \text{or}$$

$$V = \left(\frac{B_R - B_Y}{A_F}\right) 100$$

where A_F is the fiducial value.

A.14 Response time

A.14.1 Suddenly apply a constant value of excitation that will produce a steady indication of approximately 80 % of the span.

A.14.2 Measure and record the time in seconds required for the indication to come to a steady indication as specified in **6.2**.

A.14.3 Repeat **A.14.1** and **A.14.2** five times and take the average.

A.15 Self-heating

A.15.1 *Procedure*

A.15.1.1 Condition the instrument with its non-interchangeable accessories, if any, under reference conditions, without excitation or the auxiliary supply, for at least 4 h.

A.15.1.2 Apply the auxiliary supply for a period equal to the warming-up period (if any) (see **5.3.1**).

A.15.1.3 Apply a constant value of excitation to give an indication of about 90 % of the upper limit of the measuring range.

Record the excitation (B_R) after 1 min but before 3 min after applying the excitation to the instrument.

A.15.1.4 After 30 min but before 35 min, re-adjust the excitation to produce the same indication as in **A.15.1.3**. Record the excitation (B_X).

A.15.2 *Computation*

The variation, *V,* in per cent, due to self-heating shall be computed as follows:

$$V = \left(\frac{B_R - B_X}{A_F}\right) 100$$

where A_F is the fiducial value.

A.16 Continuous overload

A.16.1 *Procedure*

A.16.1.1 Carry out the test under reference conditions. Record the span of the instrument (B_{SP}).

A.16.1.2 Set zero and apply an overload equal to 120 % of the upper limit of the electrical input quantity for a period of 2 h.

A.16.1.3 Reduce the excitation to zero. Immediately after a period equal to the response time measure and record the deviation of the indication from electrical zero (B_{TD}).

A.16.1.4 Approximately 2 h after the completion of **A.16.1.3** set zero and repeat the intrinsic error test given in **A.2**.

A.16.2 *Computation*

The temporary effect of continuous overload, O_I, in per cent, of the span shall be computed as follows:

$$O_I = \left(\frac{B_{TD}}{B_{SP}}\right) 100$$

A.17 Overloads of short duration

A.17.1 *Procedure*

A.17.1.1 Apply overloads as follows.

a) The values of current and voltage shall be the product of the relevant factor given in Table 4 and the value of the upper limit of the electrical input quantity.

b) The number of overloads applied shall be as specified in Table 4.

c) The duration of overloads applied shall be as specified in Table 4. Apply the full duration of each overload except where an automatic cut-out (fuse), fitted to the instrument, has interrupted the circuit in less than the time specified in Table 4.

d) Where an automatic cut-out (fuse) is used, reset or replace it before the application of the next overload.

A.17.1.2 1 h after the completion of **A.17.1.1** record the deviation from electrical zero (B_O) in the units of the measurand.

A.17.1.3 Set zero and report the intrinsic error test given in **A.2**.

A.17.2 *Computation*

The deviation from zero, *D,* in per span shall be computed as follows:

$$D = \left(\frac{B_O}{B_{SP}}\right) 100$$

where B_{SP} is the span.

A.17.3 *Indication of out-of-range values of the measurand*

On each range of each function, a value of the measurand shall be applied such that it would provide an indication not between the limits of that range. Check that a clear indication of this condition is produced. This test is not applied where a change of range is automatically produced.

A.18 Limiting values of temperature

A.18.1 *Procedure*

A.18.1.1 Insert the instrument into a pre-cooled chamber, at the lower limiting value of temperature ± 2 °C, and energize it at a value corresponding to 80 % of the upper limit of the measuring range. Continue for at least 8 h after the chamber has regained a stable temperature.

A.18.1.2 After the completion of **A.18.1.1**, raise the temperature as quickly as possible and, in any case, in not more than 2 h, to the upper limiting value of temperature ± 2 °C and continue for at least 16 h after a stable temperature has been reached. Continue to energize the instrument throughout the test.

A.18.1.3 After the completion of **A.18.1.2**, return the instrument to reference conditions and maintain these conditions for not less than 2 h, the instrument being de-energized.

A.18.1.4 Set electrical zero and carry out the intrinsic error test given in **A.2**.

Table 4 — Overloads of short duration

Instrument	Current factor	Voltage factor	Number of overloads	Duration of each overload	Interval between successive overloads
				s	s
Ammeters	10	—	9	0.5	60
	10	—	1	5	—
Voltmeters	—	2	9	0.5	60
	—	2	1	5	—

A.18.2 ***Computation***

Computation shall be in accordance with **A.2.2**.

A.19 Deviation from electrical zero

A.19.1 ***Procedure***

A.19.1.1 Carry out the test under reference conditions. Record the span of the instrument (B_{SP}).

A.19.1.2 Energize the instrument for 30 s at the upper limit of the measuring range.

A.19.1.3 Reduce the excitation quickly to zero without any overshoot.

A.19.1.4 Measure and record the deviation of the indication from electrical zero (B_X) 15 s after the excitation has been reduced to zero.

A.19.2 ***Computation***

The deviation from zero, D, in per cent, shall be computed as follows:

$$D = \left(\frac{B_X}{B_{SP}} \right) 100$$

A.20 Permanence of marking

A.20.1 Rub a portion of the marking lightly for 15 s with a clean cloth soaked with petroleum spirit.

A.20.2 Repeat **A.20.1** substituting water for the petroleum spirit.

A.20.3 Examine the marking to determine its legibility.

Appendix B Permissible errors and variations

B.1 When an instrument is operated under reference conditions, it is permitted to have an error (the intrinsic error) no greater than is implied by its class index, for example, for a class 0.5 instrument, the errors should not exceed 0.5 % of the fiducial value.

B.2 However, when an instrument is operated outside its reference conditions for a particular influence quantity (but under reference conditions for all the other influence quantities), it is permitted to have a change in its error (a variation) when that influence quantity is changed up to the limit of its nominal range of use. The value of the permissible variation is expressed as a percentage (usually 100 %) of the permissible intrinsic error.

B.3 The same value of variation is permitted over the whole of the nominal range of use up to both of its limits but the sign need not be the same.

B.4 For example, an instrument having a class index of 0.5 and a reference temperature of 40 °C, marked as 40 °C in accordance with **8.3.1**, is permitted to have an intrinsic error of ± 100 % of the class index at the reference temperature and over the testing tolerance of ± 2 °C (see Table 1) around 40 °C.

B.5 In addition, over the nominal range of use for temperature of 30 °C to 50 °C [40 °C ± 10 °C (see Table 2)], this instrument is permitted to have a variation of ± 100 % of the class index around the value of the error that it had at the reference temperature of 40 °C. It is therefore possible for the instrument to have a smaller error at a temperature, within the nominal range of use, than it had at the reference temperature.

B.6 Figure 3(a) shows how the error of this instrument is permitted to alter with temperature.

B.7 If the error at the reference temperature (the intrinsic error) had been at its maximum permitted value of + *c,* the total permitted error over the temperature ranges 30 °C to 38 °C and 42 °C to 50 °C would have been between zero and + 2*c*. Similarly, if the intrinsic error had been – *c,* the total permitted error would have been from zero to – 2*c*.

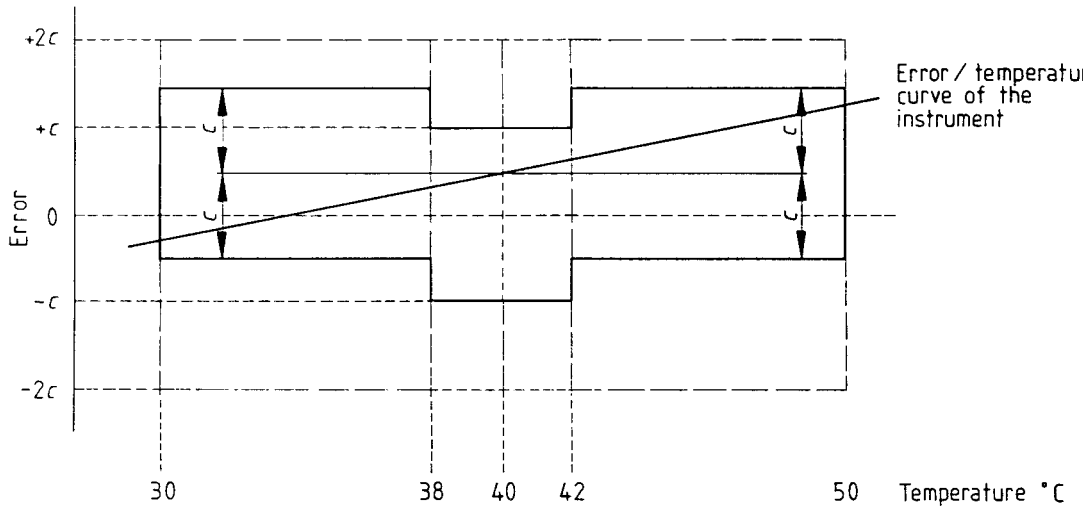
B.8 When the reference condition of a particular influence quantity is a reference range, over the parts of the nominal range of use which are outside the reference range, the permissible variation is centred on the value of the error at the adjacent limit of the reference range.

B.9 Figure 3(b) is an example of an instrument having a class index of 0.5 and which is marked in accordance with **8.3.3** for a reference range for temperature + 10 °C to + 30 °C and a nominal range of use for temperature – 30 °C to + 50 °C, i.e. – 30 . . . 10 . . . 30 . . . 50 °C. The instrument is permitted to have an intrinsic error of ± 100 % of the class index over the temperature range + 10 °C to + 30 °C.

B.10 In addition, over the nominal range of use of – 30 °C to +10 °C, a variation is permitted of ± 100 % of the class index centred on the error that the instrument had at + 10 °C. Similarly, a variation of ± 100 % of the class index centred on the error which the instrument had at + 30 °C is permitted over the nominal range use from + 30 °C to + 50 °C.

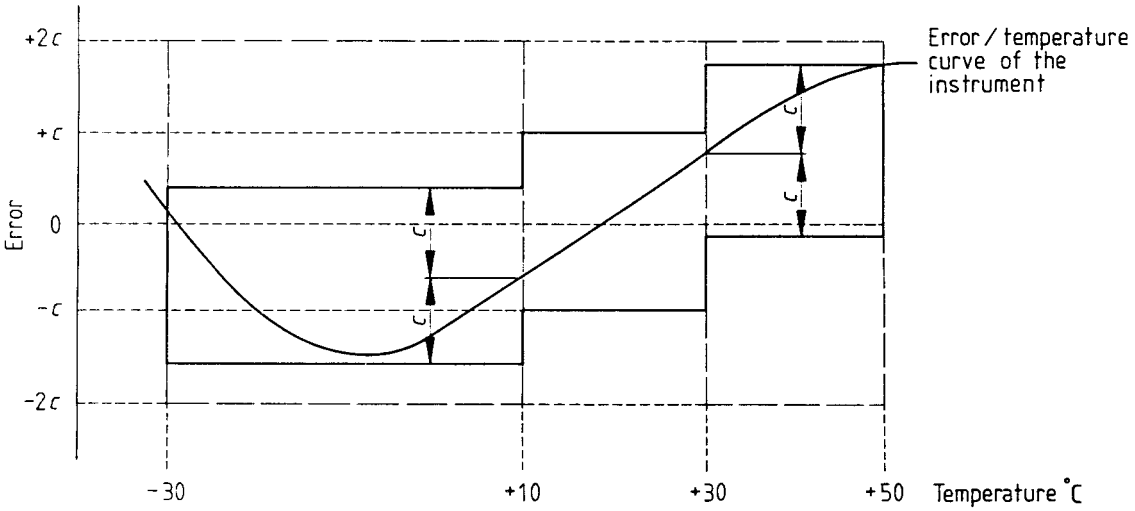
B.11 If, as is likely in practice, more than one influence quantity is simultaneously outside the reference condition, the resultant error is unlikely to exceed the sum of the separate permissible errors and may be smaller than any of them, as the resulting errors may to some extent cancel each other.

B.12 Information about the simultaneous effect of several influence quantities can usually only be determined by carrying out tests for particular combinations of values of influence quantities. The manufacturer may sometimes be able to provide this information.



c is the class index.

(a) The reference value is 40 °C and the nominal range of use (see table 2) is 30 °C to 50 °C



c is the class index.

(b) The reference range is +10 °C to +30 °C (different from table 1) and the nominal range of use is −30 °C to +50 °C (different from table 2).

Figure 3 — Effect of temperature

Publications referred to

BS 89, *Specification for direct acting indicating electrical measuring instruments and their accessories*[4)].

BS 2011, *Basic environmental testing procedures.*

BS 2011-2.1Ea, *Shock.*

BS 2011-2.1Fc, *Vibration (sinusoidal).*

BS 3939, *Guide for graphical symbols for electrical power, telecommunications and electronics diagrams.*

BS 4727, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms.*

BS 4743, *Specification for safety requirements for electronic measuring apparatus.*

BS 5458, *Specification for safety requirements for indicating and recording electrical measuring instruments and their accessories.*

BS 5685, *Electricity meters.*

BS 5685-1, *Specification for Class 0.5, 1 and 2 single-phase and polyphase, single rate and multi-rate watt-hour meters.*

BS 5775, *Specification for quantities, units and symbols.*

BS 5775-5, *Electricity and magnetism.*

BS 6217, *Guide to graphical symbols for use on electrical equipment.*

BS 6667, *Electromagnetic compatibility for industrial-process measurement and control equipment.*

[4)] Referred to in the foreword only.

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