BS 5164:1975



Specification for

# Indirect-acting electrical indicating and recording instruments and their accessories

Confirmed January 2011

UDC 621.317.7.087.6

# Co-operating organizations

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

Associated Offices Technical Committee
Association of Consulting Engineers*
Association of Manufacturers of Domestic Electrical Appliances
Association of Mining Electrical and Mechanical Engineers
Association of Supervisory and Executive Engineers*
British Electrical and Allied Manufacturers' Association
British Electrotechnical Approvals Board for Household Equipment
British Non-Ferrous Metals Federation
British Radio Equipment Manufacturers' Association
British Railways Board
British Steel Corporation
Crown Agents for Oversea Governments and Administrations
Department of Employment (HM Factory Inspectorate)
Department of the Environment
Department of Trade and Industry*
Electric Cable Makers' Confederation
Electrical Contractors' Association
Electrical Contractors' Association of Scotland
Electrical Research Association
Electricity Supply industry in England and Wales*
Electronic Engineering Association
Engineering Equipment Users' Association*
Institution of Electrical Engineers*
Institution of Electrical and Electronics Technician Engineers
Lighting Industry Federation Limited
Ministry of Defence*
National Inspection Council for Electrical Installation Contracting
Oil Companies Materials Association
Post Office*
South of Scotland Electricity Board

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 Industrial Measuring and Control Apparatus Manufacturers' Association
National Physical Laboratory (Department of Trade and Industry)
Electrical Power Engineers' Association
Scientific Instrument Manufacturers' Association
Department of Trade and Industry (British Calibration Service)

This British Standard having been approved by the Electrical Industry Standards Committee, was published under the authority of the Executive Board on
28 February 1975



The following BSI references relate to the work on this standard:
Committee reference ELE/13
Draft for comment 69/27008

**ISBN 0 580 08269 5**

**Amendments issued since publication**

| Amd. No. | Date of issue | Comments |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

# Contents

# Foreword

This British Standard has been prepared under the authority of the Electrical Industry Standards Committee. It deals with electrical instruments in which the indicating or recording device is driven by a motor or other device controlled electromechanically or electronically by the measured quantity, in contradistinction to direct-acting instruments in which the indicating or marking device is mechanically connected to and actuated by the moving element.

It is the first British Standard dealing with indirect-acting electrical instruments to be published, and is based, wherever possible, on IEC Publication 484 "*Indirect acting measuring instruments*", in the preparation of which the UK has fully participated. While the international recommendation covers instruments of both the electrical balance and mechanical balance types, the British Standard has been restricted to the former, because the small interest in the mechanical balance type in the UK does not justify the complication of incorporating it satisfactorily.

In accordance with international practice, the concept of accuracy class has been used throughout this British Standard. The performance of instruments is characterized by a number, termed the class index, which designates the upper limit of instrument error, expressed in per cent when the instrument is used under reference conditions.

Instruments of the direct-acting type are dealt with in BS 89 "*Direct-acting electrical indicating instruments*", Part 1: "*Single purpose direct acting electrical indicating instruments and their accessories*" and BS 90 "*Direct-acting electrical recording instruments and their accessories*".

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 34, 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 Scope

**1.1** This British Standard specifies requirements for indirect-acting electrical instruments using a null balance method which need an auxiliary electrical power supply.

These instruments may indicate the value of the measured quantity or record the value of the measured quantity as a function of time. Instruments may combine both these functions.

**1.2** This standard also applies to electrically operated measuring equipments, provided that the electrically operated measuring instrument (receiver) only is considered and that the relationship between the non-electrical and the electrical quantity is known.

**1.3** This standard does not apply to:

a) devices comprising a direct-acting indicating and/or recording instrument energized by a measuring amplifier;

b) electrically operated measuring equipment when the relationship between the non-electrical and the electrical quantity is not known;

c) control apparatus even though it includes indicating or recording instruments;

d) indirect-acting electrical instruments in which the measured quantity is presented in the form of digits, codes, punched cards, etc.;

e) position follower instruments;

f) recording instruments in which the chart movement is a function of a quantity other than time;

g) integrating instruments or auxiliary integrating devices incorporated in instruments within the scope of this standard.

**1.4** This standard does not contain requirements for protection against environmental conditions.

**1.5** This standard does not specify requirements concerning dimensions of instruments or detailed requirements concerning terminal markings and diagrams of connection.

NOTE The titles of the British Standards referred to in this standard are listed on the inside back cover.

## 2 Definitions

For the purpose of this British Standard, the following definitions and those of BS 4727-1:Group 04 apply.

### 2.1 General terms

**2.1.1**
**electrically operated measuring instrument (receiver)**

an electrically operated measuring instrument used as the indicating and/or recording means of an electrically operated measuring equipment

**2.1.2**
**integrating instrument**

an instrument which indicates and/or records the time integral of a measured quantity

**2.1.3 accessory**

Circuit element (instrument transformer, resistor, impedance, etc.) which is associated with the measuring instrument either in a permanent or in a non-permanent manner.

**2.1.3.1**
**interchangeable accessory**

an accessory having its own properties and accuracy, these being independent of those of the instrument with which it may be associated

NOTE An accessory is considered to be interchangeable when its rated characteristics are known and marked and are sufficient to enable its errors and variations to be determined without using the associated instrument. For example, a shunt whose adjustment takes into account an instrument current which is not negligible and which is known is considered to be interchangeable.

**2.1.3.2**
**accessory of limited interchangeability**

an accessory adjusted to take into account the electrical characteristics of a type of instrument, e.g. when the instrument current is not negligible in comparison with the current of a shunt

in these circumstances, the standard applies to any combination of instrument and accessory of the relevant types of a manufacturer unless he states otherwise. Each component of the combination has its own class index

instruments intended to be used with these accessories are also considered to have limited interchangeability

**2.1.3.3**
**non-interchangeable accessory**

an accessory adjusted during manufacture to take into account the electrical characteristics of a specific instrument. The standard then applies to the particular combination of instrument and accessory and the accessory has no class index of its own

**2.1.4**
**instrument with contacts**

an instrument in which the moving element operates contacts when it arrives at certain positions

**2.1.5**
**instrument with magnetic screening**

an instrument shielded against the influence of external magnetic fields by ferromagnetic material

**2.1.6**
**instrument with electrostatic screening**

an instrument provided with screens which are intended to protect it against the influence of external electric fields

**2.1.7**
**self-contained instrument**

an instrument in which all accessory apparatus necessary to cause the indication to correspond with the value of the measured quantity is permanently connected and either enclosed in or permanently attached to the instrument case

**2.1.8**
**multipurpose instrument**

an instrument intended for the measurement of more than one kind of electrical quantity, e.g. an instrument measuring current and voltage

**2.1.9**
**distortion factor**

the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the nonsinusoidal quantity

**2.1.10**
**percentage ripple content**

the percentage ripple content of a d.c. measured quantity is

$$\frac{\text{peak value} - \text{d.c. component}}{\text{d.c. component}} \times 100$$

**2.1.11**
**continuous service**

use of an instrument and/or accessory continuously at its rated current, rated voltage and rated frequency without its failing to comply with all the relevant clauses of this standard

**2.1.12**
**measured quantity input circuit**

the circuit, internal to the instrument, which, when energized by a voltage or a current, being a function of the measured quantity, is the prime factor in producing the differential quantity by which the actuating and positioning of the indicating or recording device is determined

NOTE This term is herein abbreviated to "input circuit".

**2.1.13**
**measured quantity external circuit**

the complete circuit, external to the instrument, from which is obtained a measured quantity or a quantity proportional thereto

NOTE This term is herein abbreviated to "external circuit".

**2.1.14**
**auxiliary circuit**

an internal circuit, other than the input circuit, necessary for the operation of the instrument

**2.1.15**
**auxiliary power supply**

the power supply which energizes the auxiliary circuit

**2.2 Description of indirect-acting instruments**

**2.2.1 According to their method of operation**

**2.2.1.1**
**potentiometric instrument**

an instrument in which an input voltage is compared with a voltage of controlled value, e.g. by a measuring potentiometer, having a setting corresponding to the position of the indicating or recording device

**2.2.1.2**
**bridge instrument**

an instrument in which the input quantity (resistance or impedance) is connected in at least one arm of a measuring bridge and is compared with a reference resistor or impedance, the adjustment of the bridge being related to the position of the indicating or recording device

**2.2.2 According to the recording mechanism**

**2.2.2.1**
**single instrument**

an instrument having only one servomechanism

**2.2.2.2**
**multiple instrument**

an instrument having more than one servomechanism and being able to measure simultaneously different quantities corresponding to different external circuits

**2.2.2.3**
**single-channel instrument**

an instrument, the input circuit(s) of which is (are) intended for connection to one external circuit

**2.2.2.4**
**multiple-channel instrument**

an instrument, the input circuit(s) of which is (are) intended for connection successively to different external circuits by cyclic switching

**2.2.3 According to the form of chart**

**2.2.3.1**
**strip chart recording instrument**

an instrument in which the chart is a strip driven as a function of time by the chart-driving mechanism, the chart being automatically stored or emerging from the instrument through an aperture

**2.2.3.2**
**drum chart recording instrument**

an instrument in which the chart is wrapped as a single turn around a cylindrical drum and driven as a function of time by the chart-driving mechanism

**2.2.3.3**
**disc chart recording instrument**

an instrument in which the chart is a disc driven as a function of time by the chart-driving mechanism

**2.2.4 According to the method of recording**

**2.2.4.1**
**ink recording instrument**

an instrument in which the record is made with ink

**2.2.4.2**
**stylus recording instrument**

an instrument in which the record is made by a stylus requiring no ink

**2.2.4.3**
**printing instrument**

an instrument in which the record is made by a printed mark

**2.2.4.4**
**projection recording instrument**

an instrument in which there is no direct contact between the recording device and the chart. The record is made, for example, by projecting a beam of light

**2.2.5 According to the kind of record**

**2.2.5.1**
**continuous line recording instrument**

an instrument in which the record (each record) is a continuous line

**2.2.5.2**
**dotted line recording instrument**

an instrument in which the record (each record) comprises a series of successive point impressions

**2.3 Constructional parts**

**2.3.1 Mechanisms**

**2.3.1.1**
**servomechanism**

the device which, when supplied by the auxiliary power supply, actuates the indicating and/or recording device

**2.3.1.2**
**indicating device**

that part of an instrument which, by means of the index, indicates on the scale a value of a measured quantity

**2.3.1.3**
**recording device**

that part of an instrument which records on the chart a value of a measured quantity

**2.3.1.4**
**chart-driving mechanism**

an assembly including a movement and gearing for driving the chart as a function of time

**2.3.1.5 Movement**

**2.3.1.5.1**
**spring-driven hand-wound clockwork**

an escapement mechanism motivated by a hand-wound mainspring

**2.3.1.5.2**
**spring-driven electrically wound clockwork**

an escapement mechanism motivated by an electrically wound mainspring

**2.3.1.5.3**
**synchronous self-starting motor without running reserve**

a self-starting a.c. motor normally running in synchronism with the supply frequency when the voltage is within the nominal range of use

**2.3.1.5.4**
**synchronous self-starting motor with running reserve**

a self-starting a.c. motor normally running in synchronism with the supply frequency but which, during a period of failure or of low voltage of the auxiliary power supply, runs with an escapement mechanism motivated by an electrically wound mainspring

**2.3.1.5.5**
**impulse-driven motor**

a device for driving the chart in steps

**2.3.1.5.6**
**direct current motor**

a self-starting motor supplied with direct current

**2.3.1.6**
**input circuit selector**

the mechanism by means of which the external circuits are successively connected to the input circuit(s) in a multiple-channel instrument

**2.3.2 Chart and record**

**2.3.2.1**
**chart**

a strip or disc generally provided with printed lines with or without figures, from which are obtained values of the measured quantity as a function of time, possibly by the use of a reference reading rule

**2.3.2.2**
**record(s)**

the line(s) or marks made on the chart by the recording device

**2.3.2.3**
**chart division**

the distance between two adjacent chart scale lines

**2.3.2.4**
**chart numbering**

the series of numbers designating the chart lines

**2.3.3 Zero and zero adjuster**

**2.3.3.1**
**electrical zero**

the equilibrium position which the indicating or recording device will approach when the auxiliary circuit is energized and the measured quantity is zero. This may or may not coincide with the zero of the scale

**2.3.3.2**
**electrical zero adjuster**

the mechanism by means of which the instrument may be adjusted so that the electrical zero coincides with the appropriate mark, the auxiliary circuit being energized and the indicating device to recording device adjustment being correct

**2.3.3.3**
**zero suppression ratio**

the value of the measured quantity corresponding to the lower limit of the effective range expressed as a percentage of the effective range

**2.3.3.4**
**indicating device to recording device adjuster**

for instruments which both indicate and record, the device by means of which it is possible to adjust the relative position of the indicating device and the recording device

**2.3.3.5**
**chart time-setting device**

the device which enables the chart to be moved so that the recording device records at the appropriate chart time line

**2.4 Electrical and dynamic characteristics**

**2.4.1**
**span**

the difference, having regard to sign, between the values of the measured quantity at both limits of the effective range

**2.4.2**
**dead band**

the range within which the measured quantity may be varied without initiating a movement of the indicating or recording device

**2.4.3**
**resistance of the external circuit**

the resistance of the external circuit as seen from the input terminals of the instrument

**2.4.4**
**resistance of the input circuit**

the resistance of the input circuit as seen from the input terminals of the instrument

**2.4.5 dynamic response**

All the data which characterise the performance of an instrument when the measured quantity is varied.

**2.4.5.1**
**step response time**

the time required for the indicating or recording device to come from one equilibrium position to another after an abrupt change in the measured quantity from one constant value to another

**2.4.5.2**
**total response time**

the step response time when the abrupt change of the measured quantity corresponds to the total scale length under specified external resistance conditions, where relevant

**2.4.5.3**
**overshoot**

the difference between the extreme indicated or recorded value and the steady reading when the measured quantity is abruptly changed from one constant value to another

**2.4.5.4**
**residual deflection**

the deflection which remains after the measured quantity has been reduced to a value corresponding to the electrical zero

**2.4.5.5**
**frequency response for a continuous line recording instrument**

the frequency range(s) of a sinusoidally varying measured quantity to which the instrument will respond within specified limits of amplitude and/or phase

**2.4.5.6**
**writing speed**

the speed of the recording device relative to the chart

**2.4.6**
**warming-up time**

the interval between the energizing of the auxiliary circuit and the time when the instrument complies with the accuracy requirements of this standard

**2.4.7**
**preliminary adjustment**

the adjustments specified by the manufacturer in order to permit the instrument to comply with the requirements of this standard

**2.4.8 Parasitic voltages**

**2.4.8.1**
**series mode (series voltage)**

an alternating parasitic voltage produced by an external cause which appears between the input terminals

**2.4.8.2**
**common mode (voltage between input circuit and earth)**

a parasitic voltage (alternating or direct) which appears between the input circuit and the frame of the instrument

**2.4.8.3**
**parasitic voltage interference factor**

the parasitic voltage as determined according to **2.4.8.1** or **2.4.8.2** divided by the span expressed in terms of voltage

**2.5 Rated values**

**2.5.1**
**rated value(s)**

value (or one of the values) which occur in the designation of the instrument. This applies to the input and the auxiliary circuits and to the chart drive speed

**2.5.2**
**nominal circuit voltage (circuit insulation voltage)**

the highest circuit voltage to earth on which the instrument will be used and which may determine its insulation test

**2.5.3 Rated values of shunts**

**2.5.3.1**
**rated current**

the rated value of current which flows through the combination of shunt and instrument

**2.5.3.2**
**rated voltage drop**

the nominal difference in potential appearing at the potential terminals of the shunt when the rated current flows through the combination of shunt and instrument

**2.5.4**
**rated chart speed**

the value(s) of the chart speed assigned by the manufacturer

**2.5.5**
**rated input values of the auxiliary power supply**

the value(s) assigned by the manufacturer to the input of the auxiliary power supply

**2.5.6**
**rated upper limit of the frequency response**

the upper limit of the frequency response, in hertz, at which the indicated or recorded peak value of a sinusoidally varying measured quantity does not differ by more than 10 % from the actual peak value

**2.5.7**
**rated running time of a clockwork chart-driving mechanism**

the running time, starting from the fully wound condition, assigned by the manufacturer, to which is related the requirements of this standard. This definition is also applicable to the running reserve of a synchronous self-starting motor with running reserve

**2.5.8**
**rated time per point for a multiple-channel instrument**

the time between two successive measurements

**2.5.9**
**rated duration of cycle for a multiple-channel instrument**

the time taken for one cycle of the input circuit selector

**2.5.10**
**rated dotting time for a single-channel instrument**

the time between the dotting of two consecutive points on the chart

**2.5.11**
**maximum current and maximum voltage**

values of current and voltage assigned by the manufacturer as those which the instrument will withstand indefinitely without damage

**2.6 Influence quantities and reference conditions**

**2.6.1**
**reference value**

a single value of an influence quantity at which (within the tolerances stated in clauses **4**, **5** and **6**) the instrument or accessory or both complies with the requirements concerning intrinsic errors

**2.6.2**
**reference range**

a range of values of an influence quantity within which the instrument or accessory or both complies with the requirements concerning intrinsic errors

**2.6.3**
**reference chart**

the chart used for determining the errors of an instrument. The characteristics of the chart (perforations, disposition of lines, etc.) conform with those assigned by the manufacturer

**2.6.4**
**reference reading rule**

numbered rule supplied with the instrument and used for reading the markings of the recording device on the chart

**2.7 Errors and variations**

**2.7.1 Errors and variations related to the measured quantity**

**2.7.1.1**
**variation related to the measured quantity**

the difference between the indicated or recorded values of a measured quantity when an influence quantity assumes successively two different specified values

**2.7.1.2**
**fiducial value**

a value to which the errors of an instrument and/or accessory are referred in order to specify their accuracy. The fiducial value corresponds to:

a) the upper limit of the effective range when the zero is at one end of the scale or outside the scale;

b) the sum of the electrical values, irrespective of sign, corresponding to the two limits of the effective range when the electrical zero is displaced within the scale;

c) the upper limit of the effective range if means are provided for electrically compressing part of the scale;

d) the rated value for interchangeable accessories and accessories of limited interchangeability.

**2.7.1.3**
**error (variation) expressed as a percentage of the fiducial value**

one hundred times the quotient of the absolute error (variation) and the fiducial value

**2.7.1.4**
**error (variation) expressed as a percentage of the chart scale length**

one hundred times the quotient of the absolute error (variation) and the chart scale length, the values being expressed in the same units of length

**2.7.2 Errors and variations related to time-keeping**

**2.7.2.1**
**absolute error**

the difference between the duration corresponding to the chart travel between the recordings of two specific events and the true time which has elapsed between the two events

**2.7.2.2**
**relative error**

the ratio of the absolute error and the true value of elapsed time

**2.7.2.3**
**variation related to time-keeping**

the difference in chart speed when an influence quantity assumes successively two different specified values

**2.7.2.4**
**error (variation) expressed as a percentage of true elapsed time**

one hundred times the ratio of the absolute error (variation) in time-keeping and the true elapsed time

**2.8 Accuracy, accuracy class, class index**

**2.8.1**
**accuracy**

the accuracy of a measuring instrument or of an accessory with respect to the measured quantity and, additionally for a recording instrument, with respect to time-keeping is defined by the limit of intrinsic error and the limits of variations due to influence quantities

**2.8.2**
**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 relevant clauses of this standard

**2.8.3 class index**

The number which designates the accuracy class. Some instruments may have more than one class index.

**2.8.3.1**
**measuring class index**

the number which designates the accuracy class related to the measured quantity. It is applicable to the variation as well as to the intrinsic error

**2.8.3.2**
**time-keeping class index**

the number which designates the accuracy class related to the time-keeping of a recording instrument. It is applicable to the variation as well as to the intrinsic error

## 3 Classification

Instruments and their accessories specified in this standard are classified as set out in **3.1** to **3.4**.

**3.1 Instruments according to the presentation of the measured quantity**

indicating instruments

recording instruments

indicating and recording instruments.

**3.2 Instruments according to accuracy class**

**3.2.1** Related to the measured quantity in one of the following classes:

0.1, 0.25, 0.5, 1.

NOTE If other classes of accuracy are needed, they should be chosen from those specified for direct-acting electrical indicating instruments.

**3.2.2** Related to time-keeping for recording instruments in one of the following classes:

0.02, 0.05, 0.1, 0.2, 0.5, 1, 2.5, 5.

**3.3 Instruments according to the auxiliary power supply**

direct current

alternating current.

**3.4 Accessories according to accuracy class**

Interchangeable accessories and accessories of limited interchangeability are classified into one of the following accuracy classes:

0.02, 0.05, 0.1, 0.2, 0.5.

Non-interchangeable accessories may also satisfy the requirements of this standard but have no accuracy class of their own (see **2.1.3.3**).

## 4 Permissible intrinsic errors and reference conditions for instruments related to the measured quantity

**4.1 Permissible intrinsic errors.** When the instrument, associated with its non-interchangeable accessory if any, is under the reference conditions given in Table 2, Table 3 and Table 4, and is used between the limits of the effective range, the intrinsic error shall not exceed the limits given in Table 1. The error shall be expressed as a percentage of the fiducial value.

Values stated in a table of corrections supplied with the instrument shall not be taken into account in determining the errors.

**Table 1 — Limits of intrinsic error of instruments related to the measured quantity expressed as a percentage of the fiducial value**

| **Measuring class index** | 0.1 | 0.25 | 0.5 | 1 |
|---|---|---|---|---|
| **Limit of error** | ± 0.1 % | ± 0.25 % | ± 0.5 % | ± 1.0 % |

**4.2 Conditions under which intrinsic errors of instruments shall be determined**

**4.2.1** Prior to preconditioning and before the determination of the intrinsic errors, the instrument shall be at the ambient temperature. This temperature shall be the reference temperature (see Figure 3) within the stated tolerances. The internal relative humidity shall be that of the ambient.

The instrument shall be operated in accordance with the manufacturer's instructions and the auxiliary circuits shall be energized.

**4.2.2** The instrument shall be left in circuit under the conditions and for the time specified in Table 2 unless otherwise stated by the manufacturer.

For a multiple instrument, all the measuring circuits shall be left in circuit under the conditions and for the time specified in Table 2.

**4.2.3** The amplifier gain shall be adjusted as specified by the manufacturer. The resistance of the external circuit shall be within the limits stated by the manufacturer.

**4.2.4** After the preconditioning specified in Table 2 and before the application of the measured quantity, the indicating and/or recording device shall, where means are provided, be adjusted as specified in **4.2.4.1** to **4.2.4.4**.

**4.2.4.1** For indicating instruments, the index shall be set to the appropriate mark on the scale.

**4.2.4.2** For continuous line recording instruments, the recording device shall be set on the appropriate chart line, the chart being advanced a distance of approximately 5 mm by hand if necessary.

**4.2.4.3** For dotted line recording instruments, the recording device shall be set on the appropriate chart line. It shall be considered to be set when two consecutive dots have been printed on the appropriate line.

**4.2.4.4** For instruments which both indicate and record, both the indicating device and the recording device shall be set to the appropriate mark and chart line.

**Table 2 — Preconditioning of instruments**

| Test conditions | Instruments of measuring classes | | Auxiliary power supply |
|---|---|---|---|
| | 0.1 . . . 0.5 | 1 | All instruments |
| Voltage (as percentage of rated voltage) | 100 | 100 | 100 |
| Current (as percentage of rated current) | 100 | 80 | — |
| Frequency | Reference | Reference | Reference |
| Minimum time between connection into circuit and determination of errors | Any time (for convenience limited to 2 h) | $^1/_2$ h | 1 h |

**4.2.5** The errors shall be determined for increasing and decreasing values of the measured quantity.

**4.2.5.1** For a continuous line recording instrument, the chart being driven, the measured quantity is applied to the instrument under test and to a reference instrument, and changed in such a way as to avoid overshoot until the required value of the measured quantity is reached.

**Table 3 — Reference conditions for the influence quantities related to the measured quantity**

| Influence quantity | | | Reference conditions unless otherwise stated | Tolerance permitted for testing purposes applicable to a single reference value[a] |
|---|---|---|---|---|
| Ambient temperature | | | 20 °C | Instruments of classes 0.1 . . . 0.5: ± 1 °C<br>Instruments of class 1: ± 2 °C |
| Relative humidity | | | 50 % | 40 % to 60 % |
| Position of supporting plane | | | Vertical | ± 5° |
| Measured quantity | Direct current | Percentage ripple content | Zero | 1 % |
| | Alternating current | Frequency | 50 Hz | ± 1 % |
| | | Waveform | Sinusoidal | Distortion factor: 5 % |
| External magnetic induction | | | Total absence of external induction | Value of induction of terrestrial magnetic field |
| Series mode influence (a.c.) | | | Zero | For mains frequency or above: 1 % of the value of the peak to peak equivalent (in mV) of the span |
| Common mode influence | | a.c. | Zero | |
| | | d.c. | Zero | |
| Auxiliary power supply | | Voltage | Rated voltage | ± 1 % |
| | | Frequency | 50 Hz | ± 2 % |
| Input circuit earthing conditions | | | As stated by the manufacturer | — |

[a] For a reference range, no tolerance is necessary.

**Table 4 — Additional reference conditions related to the measured quantity for recording instruments**

| Influence quantity | Reference conditions unless otherwise stated | Tolerance permitted for testing purposes applicable to a single reference value[a] |
|---|---|---|
| Chart | Reference chart | — |
| Quantity of ink (if applicable) | 50 % of the pen capacity | 40 % to 60 % |
| Quality of ink (if applicable) | As specified by the manufacturer | — |
| Supply voltage of recording device (if applicable) | Rated voltage | ± 2 % |
| [a] For a reference range, no tolerance is necessary. | | |

**4.2.5.2** For a dotted line recording instrument, the required value is applied to the instrument under test and to a reference instrument.

**4.2.6** Recording instruments having means for indicating the value of the measured quantity.

When a recording instrument is provided with an indicating device, the difference between the value recorded on the reference chart and the value indicated on the scale shall not exceed the value corresponding to the measuring class index at any point within the effective range.

## 5 Permissible intrinsic errors and reference conditions related to time-keeping

Errors in time-keeping are determined by reference to the chart speed.

**5.1 Permissible intrinsic errors.** When the instrument is under the reference conditions given in Table 6, the error shall not exceed the limits of intrinsic error given in Table 5 as a function of the time-keeping class index, at any time within the rated running time.

**5.2 Conditions under which the intrinsic error shall be determined**

**5.2.1** Prior to preconditioning and before the determination of the intrinsic error, the requirements of **4.2.1** shall apply.

**Table 5 — Limits of intrinsic error related to time-keeping expressed as a percentage of the true elapsed time**

| Time-keeping class index | 0.02 | 0.05 | 0.1 | 0.2 | 0.5 | 1 | 2.5 | 5 |
|---|---|---|---|---|---|---|---|---|
| Limit of error | ± 0.02 % | ± 0.05 % | ± 0.1 % | ± 0.2 % | ± 0.5 % | ± 1.0 % | ± 2.5 % | ± 5.0 % |

**Table 6 — Reference conditions for the influence quantities related to time-keeping**

| Influence quantity | | Reference conditions unless otherwise stated | Tolerance permitted for testing purposes applicable to a single reference value[a] |
|---|---|---|---|
| Ambient temperature | | 20 °C | ± 2 °C |
| Position of supporting plane | | Vertical | ± 5° |
| Running time (spring-driven clockwork or synchronous motor with running reserve) | | Rated running time | — |
| Synchronous motor or Impulse-driven motor | Voltage | Rated voltage | ± 2 % |
| | Frequency | Rated frequency | When the frequency is not equal to its rated value, the relevant correction shall be made |
| | Waveform | Reference waveform assigned by the manufacturer | In accordance with the manufacturer's instructions |
| [a] For a reference range, no tolerance is necessary. | | | |

**5.2.2** Any test period shall not include periods of acceleration or deceleration of the chart and shall be of such duration that the determination of the time-keeping error is capable of being made to at least the uncertainty demanded by the time-keeping class index.

**5.2.3** The chart speed is determined from the chart travel between the time marks of two abrupt changes of the measured quantity with a known time lapse between them.

**5.2.3.1** Where chart time lines are provided, they shall be used in determining the time-keeping error.

**5.2.3.2** For a synchronous or impulse-driven chart-driving mechanism allowance shall be made for any deviation of the frequency of the chart-driving mechanism supply from its rated frequency.

## 6 Permissible intrinsic errors and reference conditions for accessories

**6.1 Interchangeable accessories.** The intrinsic errors are expressed in terms of a percentage of the fiducial value, the accessory being under the following reference conditions:

a) of temperature, frequency and waveform given in Table 3 except that the errors of shunts shall be determined on direct current unless the frequency is stated;

b) of voltage or current not exceeding the rated value.

For shunts in which the current taken by the measuring instrument is smaller than the rated current multiplied by the class index of the shunt and divided by 300, the current of the measuring instrument may be ignored.

The error shall not exceed the limits given in Table 7 as a percentage of the fiducial value.

**Table 7 — Limits of intrinsic error of an accessory expressed as a percentage of the fiducial value**

| **Class index** | 0.02 | 0.05 | 0.1 | 0.2 | 0.5 |
|---|---|---|---|---|---|
| **Limit of error** | ± 0.02 % | ± 0.05 % | ± 0.1 % | ± 0.2 % | ± 0.5 % |

**6.2 Accessories of limited interchangeability**

**6.2.1** The intrinsic error shall be within the limits of error as stated in Table 7.

Determination of the intrinsic errors shall be carried out as specified in **6.2.1.1** to **6.2.1.3**.

**6.2.1.1** The accessory is connected to an instrument of the associated type and the errors determined according to clause **4**, for all the possible combinations of the accessory and the instrument.

**6.2.1.2** The instrument is tested alone, and its intrinsic errors are determined under the same reference conditions, for the same measuring range and the same indicated and/or recorded values.

**6.2.1.3** The intrinsic errors of the accessory are taken as being equal to the difference (taking account of the signs) between the errors determined in **6.2.1.1** and those determined in **6.2.1.2**.

**6.2.2** Instruments intended to be used with accessories of limited interchangeability may necessitate special adjustments of certain elements. Measurement of, for example, the resistance, impedance and consumption of such circuits shall be carried out on the basis of the characteristics given by the manufacturer.

**6.2.3** For an instrument of limited interchangeability which cannot be tested without the accessory and has no class index of its own, the determination of intrinsic errors is carried out according to **6.2.1.1** only and the class index of the combination is marked on the accessory in accordance with **11.3.2** or **11.4.2**.

**6.3 Non-interchangeable accessories.** The requirements of clause **4** are applicable to the combination of instrument and accessory. There are no requirements relating to limits of error applicable to the accessory alone and there is no separate class index.

## 7 Permissible limits of variations

**7.1 Variations related to the measured quantity**

**7.1.1** *Limits of variations*. When the instrument is under the reference conditions given in Table 3 and Table 4 and a single influence quantity is varied in accordance with **7.1.2**, the value of the resultant variation, expressed as a percentage of the fiducial value, when determined in accordance with **7.1.2.2** shall not exceed:

the value shown for the influence quantities listed in Table 8;

the limits stated in **7.1.4** to **7.1.10** for the other influence quantities.

The variations are expressed in the manner given in **4.1** when stating the intrinsic errors of the same type of instrument, i.e. as a percentage of the fiducial value.

**7.1.2** ***Conditions under which the variations shall be determined***

**7.1.2.1** The variations shall be determined for each influence quantity. During each test all other influence quantities shall be maintained at their reference conditions.

**7.1.2.2** The determination of the variations associated with the influence quantities listed in Table 8 shall be made at two points on the scale.

a) Between 40 % and 60 % of the upper limit of the effective range. When these values are not contained within the effective range (as with suppressed-zero instruments) the test point shall be taken as being near the lower limit of the effective range.

b) Between 80 % and 100 % of the upper limit of the effective range.

Certain influence quantities may also require measurements at the zero scale mark.

For instruments with the zero within the effective range, tests shall be carried out at one point on each side of zero.

**7.1.2.3** A variation is determined by means of two successive measurements for the two values of the influence quantity given in **7.1.2.4**, the variation being the difference between these two measurements. Each of these two measurements is made for increasing and decreasing values, by noting the mean value of the indicated and/or recorded quantity.

**7.1.2.4** The degree of variation is assessed as specified in **7.1.2.4.1** and **7.1.2.4.2**.

**7.1.2.4.1** When a reference value is assigned to an influence quantity, the influence quantity may be varied between that value and any value within the limits of the nominal range of use as given in Table 8.

**Table 8 — Normal values of the limits of the nominal range of use and allowable variation expressed as a percentage of the measuring class index**

| Influence quantity | | | Limits of nominal range of use unless otherwise stated | Allowable variation expressed as a percentage of the measuring class index |
|---|---|---|---|---|
| Ambient temperature | | | Reference temperature ± 10 °C | Instruments of class 0.1: 100 %<br>Instruments of classes 0.25 . . . 0.5: 40 %<br>Instruments of class 1: 30 % |
| Position of supporting plane | | | Reference position ± 10° in any direction | 100 % |
| Measured quantity | d.c. | Percentage ripple content | Reference value ± 2 % | 100 % |
| | a.c. | Frequency | Reference value ± 10 % | 100 % |
| Auxiliary power supply | | Voltage | Reference voltage + 5 %, – 15 % | 50 % |
| | | Frequency | Reference frequency ± 5 % | 50 % |

**7.1.2.4.2** When a reference range is assigned to an influence quantity, the nominal range of use shall include the whole of the reference range and shall exceed it at least in one direction. The influence quantity is varied between each of the limits of the reference range and any value in that part of the nominal range of use adjacent to the chosen limit of the reference range.

**7.1.2.5** Where influence quantities not listed in Table 8 are applicable, the normal values of the limits of the nominal range of use shall be stated by the manufacturer.

**7.1.3** ***Variation due to external magnetic fields***

**7.1.3.1** The instrument is placed in the centre of a coil of 1 m mean diameter, of small cross-sectional area and small radial thickness compared with the diameter and passing such a current as will produce, at the centre of the coil, the magnetic flux density specified in **7.1.3.2** or **7.1.3.3**.

An instrument having any maximum external dimension exceeding 250 mm shall be tested in a circular coil of mean diameter not less than 4 times the maximum dimensions of the instrument, the excitation being maintained at the values specified in **7.1.3.2** or **7.1.3.3**.

NOTE 400 ampere turns will produce a flux density of approximately 0.5 mT at or near the centre of a plane circular coil, 1 m in diameter, in the absence of ferromagnetic material, e.g. the instrument under test.

**7.1.3.2** For instruments marked with the symbol F–30 of Table 13 the total current in the test equipment described in **7.1.3.1** is chosen so that, in the absence of the instrument under test, a magnetic flux density is produced having a value, in millitesla, as shown in the symbol. When under the influence of this field, the variations shall not exceed 100 % of a value corresponding to the measuring class index.

**7.1.3.3** When the instrument is not marked with the symbol F–30 of Table 13, the total current in the test equipment described in **7.1.3.1** is chosen so that in the absence of the instrument under test a magnetic field is produced having a magnetic flux density of 0.5 mT. When under the influence of this field, the variation shall not exceed 100 % of a value corresponding to the measuring class index.

**7.1.3.4** The induction shall be provided by a current of the same kind and frequency as the input circuit supply. A separate test shall be made using a current of the same kind and frequency as the auxiliary power supply if it is different from the input circuit supply. When the input circuit is intended to be used on both d.c. and a.c., the influence of the magnetic field is produced in turn by a direct current and an alternating current. The induction shall be such as to have the most unfavourable combination of phase or polarity and orientation. The values stated in **7.1.3.2** and **7.1.3.3** are reduced for frequencies between 1 kHz and 20 kHz by the factor 1/*f*, where *f* is the frequency in kilohertz. Above 20 kHz no test is specified and the conditions may be agreed between the manufacturer and the user.

The values of a.c. fields shall be r.m.s values.

**7.1.4** ***Variation due to mounting on ferromagnetic supports***

**7.1.4.1** All instruments bearing the symbol Fe (*x*), where (*x*) is the thickness of the ferromagnetic panel in millimetres (see Table 9), shall meet the requirements of clause **4** when mounted on a ferromagnetic panel of the thickness specified. It is not required that they be tested for the effect of mounting on other panels.

**7.1.4.2** All instruments bearing the symbols Fe, NFe or Fe.NFe (see Table 9) shall meet the requirements of clause **4** when mounted on a panel of the nature specified and of any thickness.

**7.1.4.3** Panel mounting instruments not marked with a symbol in accordance with Table 9, when used on a ferromagnetic panel having a thickness of 3 ± 0.5 mm, shall not have a variation exceeding 50 % of a value corresponding to the measuring class index.

**7.1.4.4** Portable instruments not marked in accordance with Table 9 are exempt from the test of **7.1.4.3**.

**Table 9 — Variation due to mounting on a ferromagnetic panel**

| Symbol | Reference conditions | | Test conditions | | Limit of variation |
|---|---|---|---|---|---|
| | Nature of panel | Thickness (mm) | Nature of panel | Thickness (mm) | |
| Fe (*x*) | Ferrous | (*x*) ± 0.5 | No test required | | See **7.1.4.1** |
| Fe | Ferrous | Any thickness | Ferrous | Any thickness | See **7.1.4.2** |
| NFe | Non-ferrous | Any thickness | Non-ferrous | Any thickness | See **7.1.4.2** |
| Fe.NFe | Any panel | Any thickness | Any panel | Any thickness | See **7.1.4.2** |
| No symbol | Non-ferrous | Any thickness | Ferrous | 3 ± 0.5 | See **7.1.4.3** and **7.1.4.4** |

**7.1.5** *Variation due to mounting on supports of conductive material.* Unless otherwise shown by marking with the symbol F–33 of Table 13, instruments shall meet the requirements of clause **4** when mounted on a support of high conductivity.

**7.1.6** *Variation due to external circuit impedance.* The manufacturer shall state the value of the external circuit impedance which will produce a variation, of 50 % of a value corresponding to the measuring class index.

**7.1.7** ***Variation due to parasitic voltage interference***

**7.1.7.1** The series and common mode interference factors shall be stated by the manufacturer. If either of these factors is not the same for all ranges of the instrument, the maximum and minimum values of the ranges between which the particular factor may be used shall be stated.

NOTE 1 Series and common mode interference often occur together.

NOTE 2 The value of the interference factor is inversely related to the effect of the interference. Care must be taken not to use the interference factor as a measure of insensitivity to any parasitic voltage. Parasitic voltage sources often have high impedances.

**7.1.7.2** For the test, alternating parasitic voltages shall be derived from the auxiliary power supply source and the phase relationship between the auxiliary power supply and the parasitic voltage shall be adjusted to obtain the maximum effect.

The determination of the effect of a parasitic voltage shall be made with a measured quantity input corresponding to about the midpoint of the effective range. The instrument shall be under reference conditions.

**7.1.7.3** *Series mode.* A parasitic alternating voltage having a frequency equal to that of the auxiliary power supply shall be injected in series with the measured quantity. The earthing and test circuit conditions, including connections to the internal screen, if any, shall be as stated by the manufacturer. If there is no earth terminal, the manufacturer shall state which conductive part of the instrument may be used as an earthing point. The value of the alternating parasitic voltage which produces a variation in the indicated or recorded value corresponding to 50 % of the measuring class index shall be determined.

This test shall be repeated using a parasitic alternating voltage having a frequency equal to twice that of the auxiliary power supply.

The values of the series mode interference factor calculated from these values of parasitic alternating voltage shall not be less than those stated by the manufacturer.

**7.1.7.4** *Common mode.* A parasitic alternating voltage having a frequency equal to that of the auxiliary power supply shall be injected between the input circuit and earth using the circuit shown in Figure 1(a). The case of the instrument shall be earthed. Unless otherwise stated by the manufacturer, the screen, if any, shall be earthed.

The value of the alternating parasitic voltage which produces a variation in the indicated or recorded value corresponding to 50 % of the measuring class index shall be determined.

This test shall be repeated using the circuit shown in Figure 1(b).

These tests shall be repeated using a parasitic direct voltage in place of the parasitic alternating voltage.

The values of the common mode interference factor calculated from these values of parasitic voltage shall not be less than those stated by the manufacturer.

The value of the nonreactive resistor, R, in Figure 1 shall be 10 Ω unless otherwise specified by the manufacturer. The polarity of the parasitic direct voltage shall be stated by the manufacturer, if relevant.

**7.1.7.5** By agreement between the manufacturer and the user, the manufacturer may state the values of interference factor for other frequencies of the parasitic voltage.

**7.1.7.6** The interference may cause an increase in the dead band. Any increase shall not exceed a value corresponding to 100 % of the measuring class index.

**7.1.8** *Continuous load.* All instruments, together with their accessories, shall comply with the requirements appropriate to their measuring and time-keeping class indices when they are continuously loaded at the upper limit(s) of their effective range(s) under reference conditions.

**7.2 Variations related to time-keeping**

**7.2.1** *Limits of variations.* When the instrument is under the reference conditions as given in Table 6 and a single influence quantity is varied in accordance with **7.2.2**, the variation, expressed as a percentage of the rated chart speed, shall not exceed a value corresponding to 100 % of the time-keeping class index.

**7.2.2** *Conditions under which the variations shall be determined.* The variations shown in Table 10 shall be determined for each influence quantity. During each test, one influence quantity shall be varied between the reference value and any value within the limits of the nominal range of use, all the other influence quantities being maintained at their reference conditions.

**7.2.2.1** Where influence quantities not listed in Table 10 are applicable, the normal values of the limits of their nominal ranges of use shall be stated.

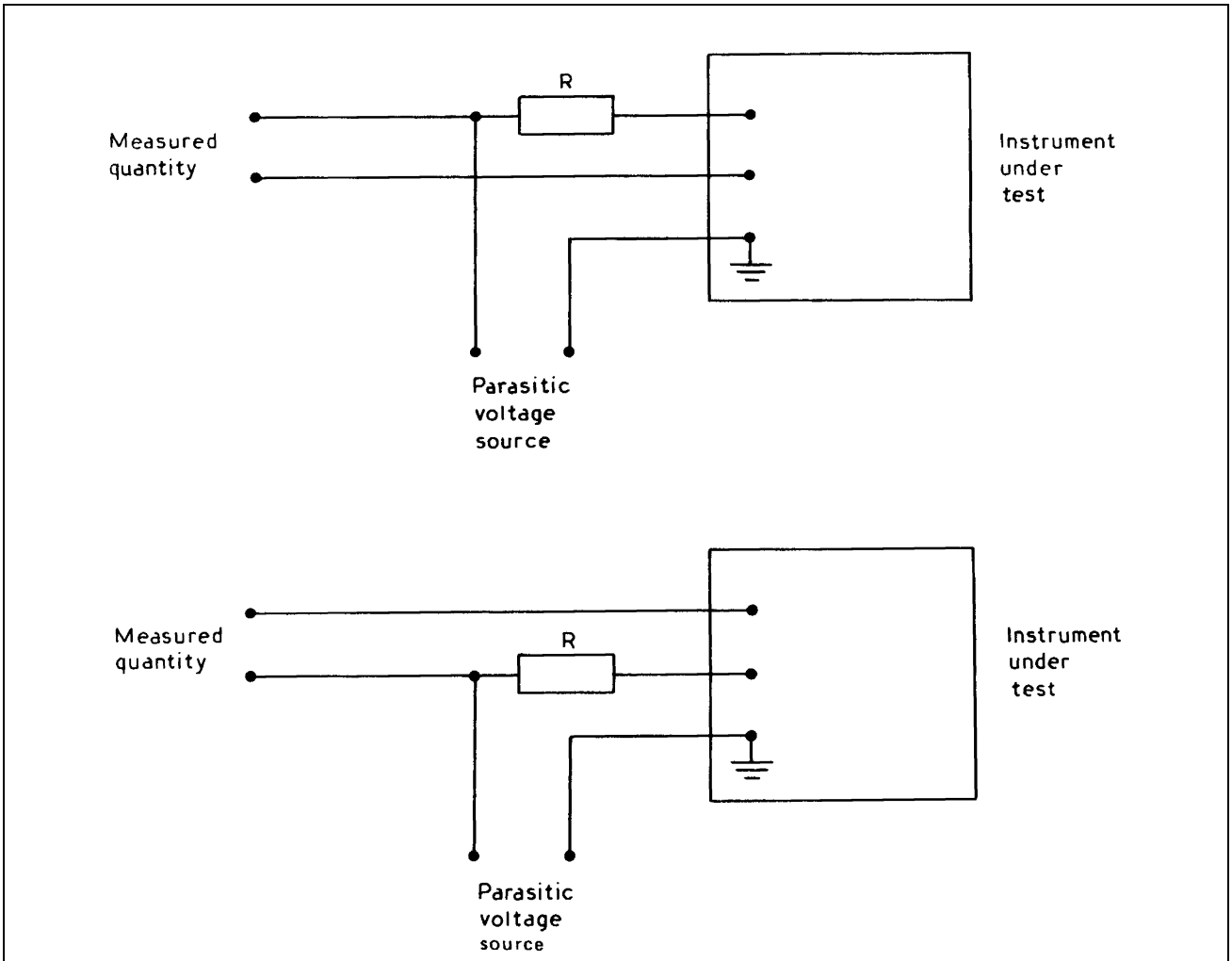



**Figure 1 — Common mode test circuits**

**Table 10 — Normal values of the limits of the nominal range of use related to time-keeping**

| Influence quantity | Limits of nominal range of use unless otherwise marked | Applicable to |
|---|---|---|
| Ambient temperature | Reference temperature ± 10 °C | Spring-driven clockwork |
| Voltage of the auxiliary power supply | Rated voltage + 5 %, – 15 % | Synchronous motor, impulse-driven motor or d.c. motor |
| Position of supporting plane | Reference position + 5° in any direction | All mechanisms |

## 8 Permissible limits of variations for accessories

**8.1** The variation shall be expressed as a percentage of the fiducial value.

**8.2** The variations produced by the influence of temperature, frequency or voltage shall not exceed a value corresponding to 50 % of the class index, the nominal range of use being as given in Table 8.

## 9 Electrical and mechanical requirements of instruments and accessories

**9.1 Overshoot.** With the instrument under reference conditions and operating in accordance with the manufacturer's instructions, the measured quantity input shall be suddenly changed from a value which produces a steady indication or record at the lower limit of the effective range to a value which produces a steady indication or record of $^2/_3$ of the total scale length.

**9.1.1** For continuous line recording instruments, the overshoot shall not exceed 200 % of a value corresponding to the measuring class index, expressed as a percentage of the span.

**9.1.2** For dotted line recording instruments, the sudden change in value of the measured quantity shall be applied immediately after the impression of a dot; the error associated with the next dot shall not exceed a value corresponding to the measuring class index, expressed as a percentage of the span.

**9.1.3** For indicating instruments, the overshoot shall not exceed the limit stated by the manufacturer. When no limit is stated by the manufacturer, the requirements of **9.1.1** apply.

**9.2 Total response time**

**9.2.1** For indicating or continuous line recording single instruments, the total response time shall not exceed the value stated by the manufacturer.

**9.2.2** For dotted line recording single instruments, the total response time shall not exceed $^2/_3$ of the rated dotting time. It is determined by applying an abrupt change in the measured quantity input as specified in **9.1** immediately after the impression of a dot. The error associated with the next dot shall not exceed a value corresponding to the measuring class index.

**9.2.3** For multiple-channel instruments the total response time shall not exceed $^2/_3$ of the rated time per point. It is determined by applying an abrupt change in the measured quantity as specified in **9.1** by means of the input circuit selector. Measured quantity inputs shall be applied to successive input circuits such that the recording device will traverse 95 % of the total scale length between successive measurements.

**9.3 Limit of dead band**

**9.3.1** The dead band shall not exceed 100 % of the value corresponding to the measuring class index at any point within the effective range unless otherwise stated by the manufacturer.

**9.3.2** The dead band shall be determined at three points corresponding to about 10 %, 50 %, and 90 % of the effective range, using the following method for each point.

The measured quantity shall be slowly increased from a value corresponding to at least 5 times the measuring class index below the point to the point. The intrinsic error shall be determined. The measured quantity shall then be increased to a value corresponding to at least 5 times the measuring class index above the point and slowly reduced to the point. The intrinsic error shall be determined.

The algebraic difference of these errors determines the magnitude of the dead band at the point.

**9.4 Excessive input**

**9.4.1** *Continuous excessive measured quantity input.* The instrument, being under reference conditions, shall withstand the continuous simultaneous application to each input circuit of 120 % of the rated value of the input circuit(s). Immediately after the removal of the excessive input, the instrument shall comply with all the relevant clauses of this standard. For convenience of testing, the duration of the excessive input may be limited to 2 h.

**9.4.2** *Short-term excessive measured quantity input.* The instrument, being under reference conditions, shall withstand for one minute the simultaneous application to each input circuit of 200 % of the rated value of the input circuit(s). Five minutes after the removal of the excessive input, the instrument shall comply with the relevant clauses of this standard.

**9.5 Frequency response.** Two tests shall be made with the instrument under reference conditions using a sinusoidally varying measured quantity, the mean value of which corresponds to approximately the midpoint of the effective range and the peak-to-peak amplitude corresponding to approximately:

a) $^1/_{10}$ of the effective range,

b) $^2/_3$ of the effective range.

For each of the above tests, the indicated or recorded amplitude shall be within 10 % of the theoretical value at the frequency or within the range of frequencies stated by the manufacturer. Each test shall occupy at least one complete cycle of the sinusoidal variation.

**9.6 Inking**

**9.6.1** *Maximum width of the recorded line or dot.* Under reference conditions, the width of the recorded line or dot shall not exceed a value calculated from the formula:

$$W = \frac{cL}{300} + 0.2$$

where

$W$ is the width of the recorded line or dot (mm)

$c$ is the measuring class index

$L$ is the chart scale length (mm)

**9.6.2** *Recording at the upper limit of the frequency response.* During the test specified in **9.5**, continuous line recording instruments shall be capable of making an unbroken record when the chart is driven at the maximum rated chart speed.

**9.6.3** *Recording after a period of inoperation.* After a period of 72 h with the chart and recording device stationary, during which time the instrument has remained within its nominal range of use for temperature, humidity and position, the recording device shall function correctly without priming or other attention.

**9.7 Temperature limits of operation**

**9.7.1** Unless otherwise specified by agreement between the manufacturer and the user, instruments shall not be damaged under continuous load conditions when the ambient temperature varies between:

0 °C to + 40 °C for ink recording instruments,

– 10 °C to 40 °C for other methods of recording and for indicating instruments.

**9.7.2** Unless otherwise marked, instruments shall be capable of being stored, in accordance with the manufacturer's instructions, in an ambient temperature range of – 20 °C to + 50 °C without suffering permanent damage.

**9.8 Voltage and insulation resistance tests**

**9.8.1** ***General***

**9.8.1.1** Instruments having an enclosure wholly or partially made of insulating material shall be wrapped in a metal foil approaching the terminals of the instrument to within a distance of not more than 20 mm for test voltages up to and including 10 kV. For higher test voltages, the distance shall be so dimensioned that no flashover occurs between the foil and the terminals.

**9.8.1.2** The accessible components of the mechanical zero adjuster, the indicating device adjuster, the indicating to recording device adjuster, the range changing switch and the protective earth terminal, if any, shall be maintained at the same potential as the enclosure. Wrapping in a metal foil is advisable.

**9.8.1.3** On instruments with accessible conducting parts which are not part of any electrical circuit, the voltage tests and insulation resistance test shall be carried out both as type tests and routine tests. On instruments which require to be wrapped in a metal foil, voltage tests shall be carried out as type tests only.

**9.8.1.4** By agreement between the manufacturer and the user, instruments may be subjected to an appropriate moisture conditioning as specified in BS 2011 before performing insulation resistance tests.

**9.8.2** ***Voltage tests***

**9.8.2.1** *General.* Voltage tests shall be performed with a test voltage of substantially sinusoidal waveform: its frequency shall be between 45 Hz and 65 Hz. The test voltage source shall be such that, when applying half the test voltage to the instrument, the voltage drop observed is less than 10 % of that voltage.

The test voltage shall be applied gradually and maintained for one minute. During the voltage test, no breakdown or flashover shall occur.

**9.8.2.2** *Application of test voltage.* The test voltage shall be applied between:

all measuring circuits connected together, and

the accessible conducting parts, the foil, the protective earth terminal (if any) and the auxiliary circuits (if any) connected together.

If it is impracticable to connect the measuring circuits together, for example because changeover switches are incorporated in the instrument or because the circuits have different nominal circuit voltages (circuit insulation voltages), each circuit shall be tested separately while the others are connected to the accessible conducting parts.

Instruments and their accessories intended for use with restrictions on earthing conditions shall be exempt from the above tests and shall be marked with the symbol C–3 (see Table 13).

The values of the test voltages corresponding to the nominal circuit voltages (circuit insulation voltages) of the circuit(s) under the test are shown in Table 11.

When the nominal circuit voltage (circuit insulation voltage) of a current-measuring instrument is not shown, it shall be tested at 2.0 kV.

**Table 11 — Value of test voltage**

| Test voltage (kV r.m.s.) | Nominal circuit voltage (circuit insulation voltage) of the circuit(s) under test (V) | Number placed in star in accordance with 11.1 |
|---|---|---|
| 0.5 | Up to and including 50 | No number |
| 2.0 | Above 50, up to and including 650 | 2 |
| 3.0 | Above 650, up to and including 1 000 | 3 |
| 5.0 | Above 1 000, up to and including 2 000 | 5 |
| Nearest higher whole number of kV derived from the equation $\frac{2U + 1\,000}{1\,000}$ kV | Above 2 000 | Number calculated as shown in column 1 |
| No voltage test (see **9.8.2.2**) | | 0 |

NOTE The value of 50 V will be replaced by the upper limit of extra low voltage when this value has been finally decided.

**9.8.2.3** *Instruments with more than one measuring circuit.* A further test shall be made by applying a test voltage between the circuits. The test voltage shall be one of the following:

a) twice the nominal circuit voltage (circuit insulation voltage) with a minimum of 500 V when the circuits are intended to be connected to the same voltage or phase;

b) a voltage chosen according to Table 11 when the circuits are intended to be, or are likely to be, connected to different voltages or phases;

c) a voltage of 500 V between the independent measuring circuits of electrically operated measuring instruments unless otherwise agreed between the manufacturer and the user.

**9.8.2.4** *Voltage test on auxiliary circuits.* A voltage test shall be applied to auxiliary circuit(s). The test voltage shall be applied between:

the auxiliary circuit, and

the accessible conducting parts, the foil, the protective earth terminal, if any, and the other circuits connected together.

The value of the test voltage is determined by the nominal circuit voltage (circuit insulation voltage) of the auxiliary circuit under test in accordance with Table 11 but the symbol (see Table 13) for this test voltage is not marked. Auxiliary circuits having a nominal circuit voltage (circuit insulation voltage) of 50 V or less, are not subject to this test.

**9.8.2.5** *Repetition of voltage tests.* For repetition tests which are performed on unused instruments in the condition as supplied, the following applies, unless otherwise agreed between the manufacturer and the user:

a) instruments the test voltage of which does not exceed 2 kV may be subject to the necessary number of tests, each of them being performed at 100 % test voltage;

b) for instruments the test voltage of which exceeds 2 kV, two tests are permitted (i.e. one repetition), each of them being performed at 100 % test voltage.

**9.8.3** *Insulation resistance test.* Unless otherwise stated by the manufacturer, all circuits shall be connected together and the insulation resistance between the circuits and the enclosure or the foil shall be measured one minute after applying a nominal 500 V d.c. supply. The value of insulation resistance shall be not less than 5 MΩ.

## 10 Constructional requirements for instruments and accessories

The construction of the instrument shall be mechanically sound, suitable for its purpose, and such as to give reasonable assurance of permanence in all mechanical, electrical, magnetic and time-keeping respects.

**10.1 Sealing.** When an indicating instrument is sealed, access to the measuring element and to the components within the case shall not be possible without removal of the seal.

**10.2 Scales**

**10.2.1** ***Scale division***

**10.2.1.1** For indicating instruments, reference shall be made to BS 3693. The design of the scale should preferably be such that it can be read to a resolution equal to 50 % of a value corresponding to the measuring class index. Other designs of scales may be used by agreement between the manufacturer and the user.

**10.2.1.2** For recording instruments, the chart scale divisions related to the measured quantity shall correspond to 1 or 2 or 5 times the unit to be measured or that unit multiplied or divided by 10 or 100.

**10.2.2** *Limits of the effective range.* When the effective range does not correspond to the total scale length or the total chart scale length, the limits of the effective range shall be clearly marked unless the value of the divisions or the nature of the scale marks or chart scale lines enables the effective range to be identified without ambiguity.

**10.3 Preferred values**

**10.3.1** *Upper limit of the effective range.* The upper limit of the effective range should preferably be chosen from the following values:

1, 1.2, 1.5, 2, 2.5, 3, 4, 5, 6, 8

or their decimal multiples or submultiples.

**10.3.2** *Rated voltage drop of shunts.* The rated voltage drop of shunts should preferably be 75 mV but may be one of the following values:

50, 60, 100, 150, 300 mV.

**10.3.3** ***Values of chart speed***

**10.3.3.1** The rated chart speeds of strip chart and drum recording instruments should preferably be chosen from the following:

5, 10, 20, 30, 40, 60, 120, 240 mm/min or mm/h.

**10.3.3.2** The rated chart speeds of disc recording instruments should preferably be chosen from the following:

1 revolution in 1 day or 7 days.

**10.3.4** *Minimum rated running-time of a clockwork chart-driving mechanism.* These shall be assigned by the manufacturer.

NOTE Due account should be taken of the chart speed and of the intended application.

**10.4 Earth terminals.** When, for safe and/or correct operation, conducting parts of an instrument are to be connected to earth potential, a terminal shall be provided and shall be marked with the symbol F–31 of Table 13.

## 11 Markings and symbols for instruments and accessories

Markings and symbols shall be legible and indelible.

**11.1** *Diagram of connections for terminals.* If so required for the correct use of the instrument and its accessories, a diagram of connections shall be supplied and the terminals shall be clearly and indelibly marked to show the correct method of operation.

NOTE Consideration is being given to the publication of a British Standard for terminal markings for instruments covered by this standard which will take into account current internationally agreed practice.

**11.2 Markings and symbols for instruments.** For most of these markings the symbols given in Table 13 are used. See also BS 1991-6.

The following information shall be given:

1) Manufacturer's name or mark

2) Symbol of the unit of the measured quantity or, for power factor recorders, "cos φ", "sin φ" or, for phasemeters, "φ" (electrical degrees)

3) Serial number

4) Measuring class index

5) Time-keeping class index

6) Nature of the measured quantity and number of measuring elements

7) Test voltage

8) The method of operation (potentiometer or bridge)

9) Nature of chart-driving mechanism

10) Chart speed(s)

11) Rated values of the auxiliary power supply

12) Rated running time

13) The manufacturer's type reference, if any

14) Rated value(s) or ratio(s) of instrument transformer(s) for which the instrument is calibrated

15) Symbol showing that some essential information is given in a separate document, if relevant

16) On an instrument having a protective earth terminal, the symbol F–31 shall be marked near the terminal

17) Number of channels of a multiple-channel instrument

18) Rated values of the measured quantity

19) Symbol for position of supporting plane, where relevant

20) Symbol for any accessory for which the instrument has been calibrated

21) Value of any accessory for which the symbol has been marked in accordance with (20) above, including the resistance of leads, if relevant

22) Indication of the external magnetic field for which the variation is a value corresponding to the measuring class index, if relevant

23) Symbol showing the panel for which the instrument has been calibrated, if relevant

24) Value of the impedance of the external circuit when knowledge of it is necessary for the damping and overload tests

25) Upper limit of the frequency response, if relevant

26) The necessary data for testing the instrument if the marking of the scale or chart scale does not coincide with the measured quantity (e.g.: mV for full scale deflection).

**11.2.1** The markings and symbols specified in **11.2.1.1** and **11.2.1.2** shall appear in any associated document.

Item 3) of **11.2** (serial number) is required in the associated document only if it is necessary to relate that document to a particular instrument.

**11.2.1.1** *For indicating instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear in the associated document:

items 1), 2), 3), 4), 13).

**11.2.1.2** *For recording instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear in the associated document:

items 1), 2), 3), 4), 5), 13).

**11.2.2** The markings and symbols specified in **11.2.2.1** and **11.2.2.2** shall appear on the instrument and shall be visible when the instrument is in use.

**11.2.2.1** *For indicating instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear on the instrument:

items 1), 2), 3), 4), 6), 7), 8), 11), 13), 14), 15), 16), 17), 18), 20), 21), 26).

**11.2.2.2** *For recording instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear on the instrument:

items 1), 2), 3), 4), 5), 6), 7), 8), 9), 11), 13), 14), 15), 16), 17), 18), 20), 21), 26).

**11.2.3** Markings and symbols as specified in **11.2.3.1** and **11.2.3.2** shall appear on the instrument or in a separate document.

**11.2.3.1** *For indicating instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear on the instrument or in a separate document:

items 19), 22), 23), 24), 25).

**11.2.3.2** *For recording instruments.* Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear on the instrument or in a separate document:

items 10), 12), 19), 22), 23), 24), 25).

**11.3 Markings and symbols for shunts.** Shunts shall bear the markings and symbols specified in **11.3.1**, **11.3.2** and **11.3.3**.

**11.3.1** *Interchangeable shunts.* The following information shall be given:

1) Manufacturer's name or mark
2) Serial number for shunts of classes 0.02 . . . 0.1
3) Class index
4) Rated current
5) Rated voltage drop
6) Test voltage, when in a separate enclosure
7) Reference to the diagram of connections if necessary.

**11.3.2** *Shunts of limited interchangeability.* The following information shall be given:

1) Manufacturer's name or mark
2) Serial number for shunts of classes 0.02 . . . 0.1
3) Class index
4) Manufacturer's type reference of the associated instrument
5) Rated current of the shunt and the instrument combined
6) Test voltage when in a separate enclosure
7) Reference to the diagram of connections if necessary.

**11.3.3** *Non-interchangeable shunts.* The following information shall be given:

1) Manufacturer's name or mark
2) Identification of the instrument with which it is to be used (e.g. by the same serial number as the instrument)
3) Rated current
4) Test voltage, when in a separate enclosure
5) Reference to the diagram of connections if necessary.

**11.4 Markings and symbols for series resistors and impedances.** Series resistors and impedances shall bear the markings and symbols specified in **11.4.1**, **11.4.2** and **11.4.3**.

**11.4.1** *Interchangeable series resistors and impedances.* The following information shall be given:

1) Manufacturer's name or mark
2) Serial number for accessories of classes 0.02 . . . 0.1
3) Class index
4) Rated voltage
5) Reference value or reference range of frequency when it differs from 45 Hz to 65 Hz

6) Value of resistance or impedance at the reference frequency, if relevant

7) Test voltage, when in a separate enclosure

8) Reference to the diagram of connections if necessary.

**11.4.2** *Series resistors and impedances of limited interchangeability.* The following information shall be given:

1) Manufacturer's name or mark

2) Serial number for accessories of classes 0.02 . . . 0.1

3) Class index

4) Manufacturer's type reference of the associated instrument

5) Rated voltage(s) of the accessory and the instrument combined

6) Reference value, or reference range of frequency, when it differs from 45 Hz to 65 Hz

7) Test voltage, when in a separate enclosure

8) The reference to the diagram of connections if necessary.

**11.4.3** *Non-interchangeable series resistors and impedances.* The following information shall be given:

1) Manufacturer's name or mark

2) Identification of the instrument with which it is to be used (e.g. by the same serial number as the instrument)

3) Rated voltage(s) of the accessory and instrument combined

4) The test voltage, when in a separate enclosure

5) Reference to the diagram of connections if necessary.

NOTE The requirements of **11.4** also apply to other accessories used with instruments as far as they are consistent with the characteristics of these accessories.

### 11.5 Markings related to the reference conditions and nominal ranges of use for instruments and accessories

**11.5.1** The reference values or reference ranges corresponding to each influence quantity shall be marked if different from those given in Table 3, Table 4 and Table 6. These markings shall be made on the instrument or accessory or in a document supplied with them, using the unit symbol given in Table 13 or BS 1991.

**11.5.2** The nominal range of use shall be marked if different from that given in Table 8 and Table 10.

**11.5.3** When the reference value or the reference range is marked it shall be identified by underlining.

**11.5.4** The following examples (see Table 12) show the significance of the various markings for temperature or frequency.

## 12 Categories of test

**12.1** All instruments or accessories, in the condition as supplied from the manufacturer, and purporting to comply with the requirements of this standard shall satisfy the prescribed conditions and, in particular, shall meet the requirements of the tests detailed herein.

**12.2** Tests under two categories are required, type tests and routine tests. (see **A.4** of Appendix A.)

**12.2.1** Type tests consist of all the tests necessary to ensure that an instrument meets all the relevant clauses of this standard.

These tests are only intended to be applied to a single sample of each design or to a small number of samples.

**12.2.2** Routine tests consist of tests which are performed on all instruments.

**Table 12 — Examples of marking related to the reference conditions and nominal ranges of use for instruments and accessories**

| Indication | Example | Meaning |
|---|---|---|
| No marking | | Reference value: 20 °C (see Table 5)<br>Nominal range of use: 10 °C to 30 °C (see Table 8)<br>Similarly for other influence quantities |
| One number | 25 °C | Reference value: 25 °C<br>Nominal range of use: 15 °C to 35 °C (see Table 8) |
| Three numbers | 20 ... 25 ... 30 °C | Reference value: 25 °C<br>Nominal range of use: 20 °C to 30 °C<br>(Nominal range of use different from that specified in Table 8) |
| Three numbers | 15 ... 45 ... 65 Hz | Reference range: 45 Hz to 65 Hz<br>Nominal range of use: 15 Hz to 71.5 Hz (the upper limit of the nominal range of use is that specified in Table 8 but the lower limit is different) |
| Four numbers | 15 ... 20 ... 25 ... 30 °C | Reference range: 20 °C to 25 °C<br>Nominal range of use: 15 °C to 30 °C (permissible variations from 15 °C to 20 °C and from 25 °C to 30 °C) |
| Four numbers | 15 ... 15 ... 55 ... 65 Hz | Reference range: 15 Hz to 55 Hz<br>Nominal range of use: 15 Hz to 65 Hz (permissible variations from 55 Hz to 65 Hz) |

**Table 13 — Symbols for marking instruments and accessories**

(If other units and prefixes are needed, see BS 1991)

| No. | Item | Symbol |
|---|---|---|
| *A Principal units and their principal multiples and sub-multiples* | | |
| A–1 | kiloampere | kA |
| A–2 | ampere | A |
| A–3 | milliampere | mA |
| A–4 | microampere | μA |
| A–5 | kilovolt | kV |
| A–6 | volt | V |
| A–7 | millivolt | mV |
| A–8 | microvolt | μV |
| A–9 | megawatt | MW |
| A–10 | kilowatt | kW |
| A–11 | watt | W |
| A–12 | megavar | MVAr |
| A–13 | kilovar | kVAr |
| A–14 | var | VAr |
| A–15 | megahertz | MHz |
| A–16 | kilohertz | kHz |
| A–17 | hertz | Hz |
| A–18 | megohm | MΩ |
| A–19 | kilohm | kΩ |
| A–20 | ohm | Ω |
| A–21 | milliohm | mΩ |
| A–22 | tesla | T |
| A-23 | millitesla | mT |
| A-24 | degree (temperature) | °C |

**Table 13 — Symbols for marking instruments and accessories**

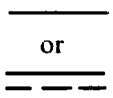
| No. | Item | Symbol |
|---|---|---|
| *B Types of supply and number of measuring elements* | | |
| B–1 | Direct current circuit |   |
| B–2 | Alternating current circuit (single phase) |  |
| B–3 | Direct and alternating current circuit |  |
| B–4 | Three-phase alternating current circuit (general symbol) |  |
| B–5 | Three-phase alternating current-circuit with unbalanced load (general symbol) |  |
| B–6 | One measuring element for 3-wire network |  |
| B–7 | One measuring element for 4-wire network |  |
| B–8 | Two measuring elements for 3-wire network with unbalanced loads |  |
| B–9 | Two measuring elements for 4-wire network with unbalanced loads |  |
| B–10 | Three measuring elements for 4-wire network with unbalanced loads |  |
| *C Safety* | | |
| C–1 | 500 V |  |
| C–2 | Above 500 V, expressed in kilovolts (e.g. 2 kV) |   |
| C–3 | Apparatus not subjected to a voltage test |   |

**Table 13 — Symbols for marking instruments and accessories**

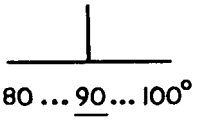
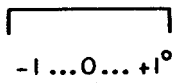
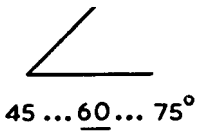
| No. | Item | Symbol |
|---|---|---|
| *D Positions of use* | | |
| D–1 | Instrument to be used with the supporting surface vertical |  |
| D–2 | Instrument to be used with the supporting surface horizontal |  |
| D–3 | Instrument to be used with the supporting surface inclined (e.g. 60°) from the horizontal plane |  |
| D–4 | Example for instrument to be used as D–1, nominal range of use 80° . . . 100° |  |
| D–5 | Example for instrument to be used as D–2, nominal range of use – 1° . . . + 1° |  |
| D–6 | Example for instrument to be used as D–3, nominal range of use 45° . . . 75° |  |
| *E Accuracy classes* | | |
| E–1 | Class index (e.g. 1.5) with errors expressed as a percentage of the fiducial value | 1.5 |
| E–2 | Not allocated | |
| E–3 | Not allocated | |
| E–4 | Not allocated | |
| *F General symbols* | | |
| F–1 | Not allocated | |
| F–2 | Not allocated | |
| F–3 | Not allocated | |
| F–4 | Not allocated | |
| F–5 | Not allocated | |
| F–6 | Not allocated | |
| F–7 | Not allocated | |
| F–8 | Not allocated | |
| F–9 | Not allocated | |
| F–10 | Not allocated | |
| F–11 | Not allocated | |
| F–12 | Not allocated | |
| F–13 | Not allocated | |

**Table 13 — Symbols for marking instruments and accessories**

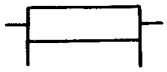
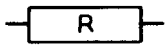
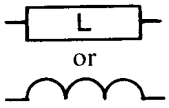
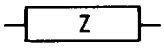
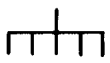
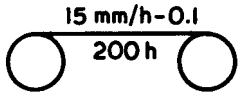
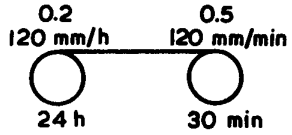
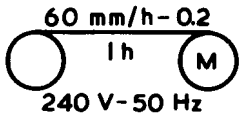
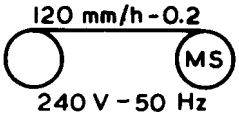
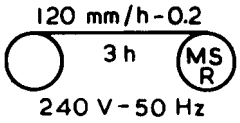
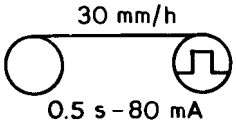
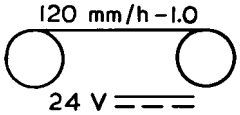
| No. | Item | Symbol |
|---|---|---|
| F–14 | Not allocated | |
| F–15 | Not allocated | |
| F–16 | Not allocated | |
| F–17 | Not allocated | |
| F–18 | Not allocated | |
| F–19 | Not allocated | |
| F–20 | Not allocated | |
| F–21 | Not allocated | |
| F–22 | Not allocated | |
| F–23 | Shunt |  |
| F–24 | Series resistor |  |
| F–25 | Series inductor |  |
| F–26 | Series impedance |  |
| F–27 | Not allocated | |
| F–28 | Not allocated | |
| F–29 | Not allocated | |
| F–30 | Magnetic induction expressed in millitesla, resulting in a variation having a value corresponding to 100 % of the measuring class index (e.g. 0.5 mT) |  |
| F–31 | Protective earth terminal |  |
| F–31A | Measuring earth terminal |  |
| F–32 | Zero adjuster |  |
| F–33 | Refer to a separate document |  |
| F–34 | Not allocated | |
| F–35 | Not allocated | |
| F–36 | Not allocated | |
| F–37 | Ferrous panel of thickness *x* mm | Fe (*x*) |

**Table 13 — Symbols for marking instruments and accessories**

| No. | Item | Symbol |
|---|---|---|
| F–38 | Ferrous panel of any thickness | Fe |
| F–39 | Non-ferrous panel of any thickness | NFe |
| F–40 | Any panel of any thickness | Fe.NFe |
| *H Chart-driving mechanisms (the values shown are only examples)* | | |
| H–1 | Spring-driven, hand wound clockwork<br>Rated chart speed: 15 mm/h<br>Rated running time: 200 h<br>Time-keeping accuracy class: 0.1 |  |
| H–2 | Spring-driven, hand wound clockwork with two rated chart speeds<br>Rated chart speeds: 120 mm/h and 120 mm/min<br>Rated running time: 24 h and 30 min respectively<br>Time-keeping accuracy class: 0.2 at 120 mm/h<br>0.5 at 120 mm/min | [a]<br>  |
| H–3 | Spring-driven, electrically wound clockwork<br>Rated chart speed: 60 mm/h<br>Supply: 240 V – 50 Hz<br>Rated running time: 1 h<br>Time-keeping accuracy class: 0.2 | [b]<br>  |
| H–4 | Synchronous motor<br>Rated chart speed: 120 mm/h<br>Supply: 240 V – 50 Hz<br>Time-keeping accuracy class: 0.2 |  |
| H–5 | Synchronous motor with running reserve<br>Rated chart speed: 120 mm/h<br>Supply: 240 V – 50 Hz<br>Running reserve: 3 h<br>Time-keeping accuracy class: 0.2 | [b]<br>  |
| H–6 | Impulse-driven motor<br>Rated chart speed: 30 mm/h<br>Current supply: 80 mA<br>Impulsing rate: 0.5 s (i.e. 2 impulses/s) |  |
| H–7 | Other forms of chart-driving mechanism |  |
| H–8 | d.c. motor<br>Rated chart speed: 120 mm/h<br>Supply: 24 V d.c.<br>Time-keeping accuracy class: 1.0 | [c]<br>  |

NOTE For other symbols, see BS 3939.

[a] These symbols differ in detail from those internationally agreed.
[b] These symbols differ from those internationally agreed.
[c] This symbol has no international equivalent.

## Appendix A Concepts

This standard includes certain new concepts (e.g. fiducial value) which have been defined in clause **2** and which permit a better understanding of the qualities of measuring equipment.

It is necessary to describe more fully some of the established and some of the new concepts in order to indicate their uses.

**A.1 Effective range: fiducial value.** The present standard requires that the limits of the effective range must be recognizable without ambiguity. The methods whereby this may be achieved have been left to the discretion of the manufacturer. The two methods shown in Figure 2 and Figure 3 are only examples.

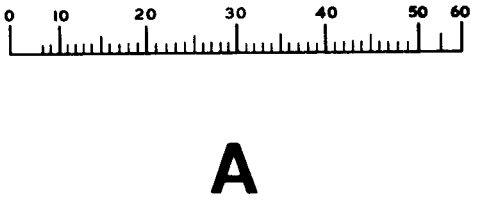



**Figure 2 — Effective range 8 A to 50 A (sub-division omitted outside effective range)**

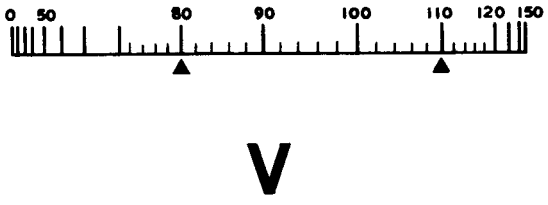



**Figure 3 — Effective range 80 V to 110 V (Effective range ▲ . . . ▲)**

The limits of the effective range and the fiducial value are not dependent on the zero mark, which may be at either end of the scale, displaced within the scale, or non-existent.

The accuracy requirements are applicable only within the effective range, and are not necessarily related to the zero position. It has therefore been necessary to introduce a term which is used to define the limits of errors and the variations. The term *fiducial value* has been adopted, and its definition is given in **2.7.1.2**.

Table 14 gives examples for the fiducial value for particular cases:

**Table 14 — Examples of limits of effective range and fiducial value**

| Type of instrument | Limits of the effective range | | Fiducial value |
|---|---|---|---|
| Ammeter | 10 | 100 | 100 A |
| Voltmeter | – 60 | + 60 | 120 V |
| Millivoltmeter | – 15 | + 35 | 50 mV |
| Frequency meter | 375 | 425 | 425 Hz |
| Suppressed-zero voltmeter | 180 | 260 | 260 V |

**A.2 Rated values: influence quantities: reference conditions.** Rated values are generally applicable to the measured quantity or to a component of it (see **2.5.1**). Other quantities which may affect the indication are termed "influence quantities" e.g. temperature, position, etc.

This distinction is required so as to differentiate between the intrinsic error of the instrument and the variations. In practice, instruments are rarely used under the conditions for which they have been adjusted or calibrated. In consequence each of the quantities which influence the performance of the instrument must be defined so that the conditions under which the calibration has been made can be effectively reproduced. Collectively, the values specified for the influence quantities constitute the "reference conditions".

**A.3 Reference range: nominal range of use**

**A.3.1** The intrinsic errors of an instrument are those which are determined when the instrument is under reference conditions.

**A.3.2** When an influence quantity may have a significant effect on the measurement, the reference value assigned to that quantity has a small associated tolerance. However, when the influence quantity has little effect on the performance of the instrument, the small tolerance can effectively be enlarged so as to permit a reference range being assigned to the influence quantity

**A.3.3** This standard also assigns to each of the influence quantities a nominal range of use within which the variation shall not exceed a specified amount when the instrument is used beyond the reference range or outside the tolerance on the reference value. In general this is a function of the class index. The method of determination of the variation requires that influence quantities are varied one at a time, the others being maintained at their reference conditions.

**A.3.4** The errors and the variations, when determined in accordance with the foregoing, characterize the accuracy of the instrument.

**A.3.5** The above considerations are exemplified as follows:

a) *Effect of temperature on an instrument whose reference temperature is indicated in accordance with **11.5** and Table 13*

40 °C

In this example, this standard (see Table 3 and Table 13) defines the limits of the nominal range of use as 30 °C to 50 °C, and permits a tolerance of ± 2 °C about the reference temperature (for instruments of classes 1 . . . 5).

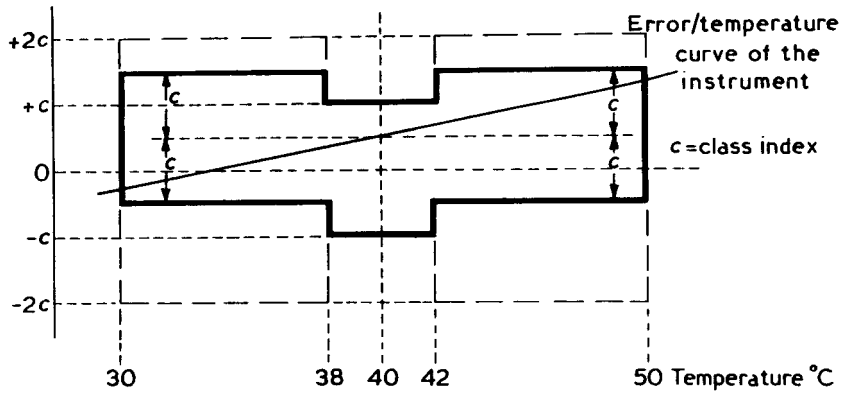



**Figure 4 — Effect of temperature. Reference value 40 °C**

The solid boundary shown in Figure 4 represents the error limits within the nominal range of use, expressed as multiples of the class index. The indication corresponding to any point within the effective range is only correct within a tolerance represented by a point within the boundary line, i e.

from 38 °C to 42 °C the effect of temperature is negligible;

from 30 °C to 38 °C and from 42 °C to 50 °C a variation is permitted the maximum value of which is equal to the class index.

The broken boundary lines represent the greatest allowable extent of the variation if the error under reference conditions is at its allowable limit.

b) *Effect of temperature on indication of an instrument whose reference temperature range and nominal range of use are designated by four numbers in accordance with **11.5** and Table 13.*

– 30 . . . + 10 . . . + 30 . . . + 50 °C

In this example, the reference range is from + 10 °C to + 30 °C and the nominal range of use from – 30 °C to + 50 °C.

The solid boundary shown in Figure 5 represents the error limits within the nominal range of use expressed in multiples of the class index. The indication corresponding to any point within the effective range is only correct within a tolerance represented by a point within the boundary line i.e.

from + 10 °C to + 30 °C the effect of temperature is restricted to the amount specified by the class index;

from – 30 °C to + 10 °C and from + 30 °C to + 50 °C a variation equal to the class index is permitted beyond the error at the adjacent limit of the reference range.

The broken boundary lines represent the greatest allowable extent of the variation if the error over the reference range is at its allowable limits.

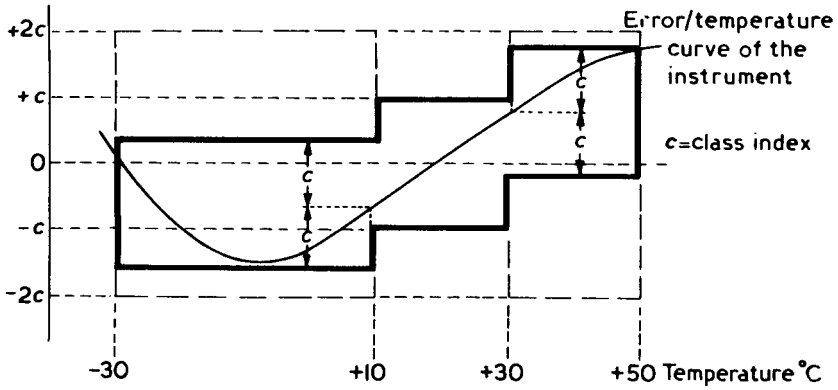



**Figure 5 — Effect of temperature**

Reference range + 10 °C to + 30 °C

Nominal range of use – 30 °C to + 50 °C

c) *Effect of frequency on an instrument, e.g. a voltmeter, whose reference range and nominal range of use are indicated by three numbers in accordance with* ***11.5*** *and Table 13.*

15 . . . 45 . . . 65 Hz

In this example the reference range lies between 45 Hz and 65 Hz and the nominal range of use between 15 Hz and 71.5 Hz:

The upper limit of the nominal range of use not being specified, it is therefore, in accordance with Table 8, taken as 10 % higher than the adjacent limit of the reference range, i.e.

65 Hz + 6.5 Hz = 71.5 Hz

10 % of 65 Hz being 6.5 Hz

The solid boundary shown in Figure 6 represents the error limits within the nominal range of use, expressed in multiples of the class index.

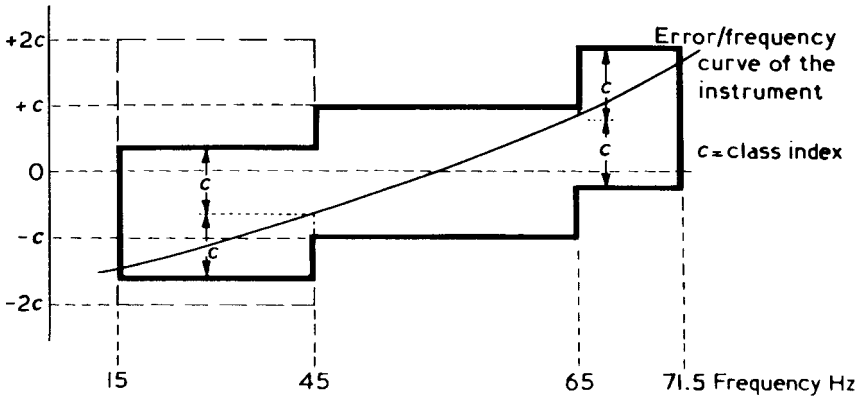



**Figure 6 — Effect of frequency**

Reference range 45 Hz to 65 Hz

Nominal range of use 15 Hz to 71.5 Hz

from 45 Hz to 65 Hz, the effect of frequency is restricted to the amount allowed by the class index;

from 15 Hz to 45 Hz and from 65 Hz to 71.5 Hz, a variation of one class index is permitted beyond the error at the adjacent limit of the reference range.

The broken boundary line in Figure 6 represents the greatest allowable extent of the variation if the error over the reference range is at its allowable limits.

The curve in Figure 6 represents the variations as a function of the frequency for one measured value within the effective range. The permissible variations may be applied only with reference to the intrinsic errors found at the reference range limit of 45 Hz and 65 Hz.

**A.4 Categories of test**

| | | |
|---|---|---|
| a) | Limits of intrinsic error related to the measured quantity (clauses **4** and **6**) | routine test |
| b) | Limits of intrinsic error related to time-keeping (clause **5**) | routine test |
| c) | Limits of variation related to the measured quantity due to other influence quantities (see **7.1** and clause **8**) | type test |
| d) | Limits of variation related to time-keeping due to other influence quantities (see **7.2**) | type test |
| e) | Overshoot (see **9.1**) | type test |
| f) | Total response time (see **9.2**) | type test |
| g) | Limit of dead band (see **9.3**) | type test |
| h) | Continuous load (see **7.1.8**) | type test |
| i) | Excessive input (see **9.4**) | type test |
| j) | Frequency response (see **9.5**) | type test |
| k) | Inking (see **9.6**) | type test |
| l) | Temperature limits of operation (see **9.7**) | type test |
| m) | Voltage tests (see **9.8.2**) | routine test |
| n) | Insulation resistance (see **9.8.3**) | type test |

**A.5 Combination of several influence quantities.** It follows from clauses **7** and **8** that if the value of one influence quantity is changed from its reference condition to some other value within its nominal range of use, the error of an instrument may exceed the value designated by the class index. If two or more influence quantities are simultaneously changed, the variations may be in the same or different senses but it is very unlikely that the resultant error will be as great as the sum of the individual permitted variations. Under these circumstances, the manufacturer should be consulted as to the probable maximum error.

**A.6 Maintenance of accuracy in service.** An instrument that is known to have suffered accidental mechanical or electrical damage should, of course, be checked as soon as possible, even if the damage is not apparent, in order to ascertain whether and to what extent the accuracy has been affected.

Since any instrument, however well cared for, is liable to changes of accuracy with time, the attention of users is drawn to the necessity for periodical checking at appropriate intervals.

*blank*

# Publications referred to

This standard makes reference to the following British Standards:
BS 89, *Direct-acting electrical indicating instruments.*
BS 89-1, *Single purpose direct-acting electrical indicating instruments and their accessories.*
BS 90, *Direct-acting electrical recording instruments and their accessories.*
BS 1991, *Letter symbols, signs and abbreviations.*
BS 1991-6, *Electrical science and engineering.*
BS 2011, *Methods for the environmental testing of electronic components and electronic equipment.*
BS 3693, *Recommendations for the design of scales and indexes.*
BS 3939, *Graphical symbols for electrical power, telecommunications and electronics diagrams.*
BS 4727, *Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms.*

# BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

**Revisions**

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

**Buying standards**

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

**Information on standards**

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

**Copyright**



BSI
389 Chiswick High Road
London
W4 4AL